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Meet Central American Challenges"

TECHNOLOGY IMPERATIVES IN CENTRAL AMERICAN AGRICULTURE

Centro-America, Panamá and Dominican Republic

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TECHNOLOGICAL IMPERATIVES IN CENTRAL AMERICAN AGRICULTURE

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♠ *This study was conducted by Carlos A. Benito for the Program of Generation and Transfer of Technologies of the Inter-American Institute of Cooperation in Agriculture (IICA). The author has benefited from the comments of Eduardo Lindarte and David Kaimovitz. The information for the development of the typology of producers was gathered by Roberto Rodriguez, Estela Marina Hernandez, Edgardo Barrios Escorcia, David E. Castañón, and other researchers*

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*by Carlos A. Benito**

EXECUTIVE SUMMARY

Production Slowdown and Productivity Decline in Central American Agriculture

1. Agricultural GDP grew at a modest .6% p.a. during the 1980's, while it has grown near 3% p.a. during the 1970's. The sources of growth during the 1980's were labor, chemical, inputs, and mechanical power, which compensated for the small expansion of cultivated land, and the decline in livestock heads, as well for the significant <u>decline in total factor productivity (TFP)</u>.

2. Labor productivity declined .6% p.a. during the 1980's. The main source of this decrease was an .08% p.a. decline in the land/labor ratio which was partially offset by a modest 0.2% p.a. growth of land productivity. But not all countries in the region experienced a decline in labor productivity: Costa Rica, Panama and the Dominican Republic had positive growth.

3. The major reasons for the significant decline in TFP in Central American were: changes in international demand, which in turn affected the commodity mix; and a slow adjustment in economic institutions and policies. For the region as a whole the real exchange rate didn't increase, real rate of interests remain low, and as a consequence the real wage rate didn't fall substantially. At the same time the international prices of fertilizers continue to decline in terms of the exportable and importable prices of Central America. As a consequence increasing uses of chemicals and mechanization, combined with poor allocative efficiency, have reduced long run yields and are posing a threat for agricultural sustainability.

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Agricultural Adjustment Across Producer Groups

4. Changes in agricultural production and productivity varies across group of

producers and countries. In order to investigate their ongoing adjustments and their technical imperatives during the 1990's and the first decades of the 21st. century a typology of producers for Central America was developed. The overriding criterion of the classification is trade, in order to take into consideration the existing pattern of comparative advantages, and the changes in commodity mix induced by changes in external markets and exchange rate policies. But producers are also differentiated by their factor ratios, their access to land and markets, and the effect of their factor ratios and allocative efficiency on agricultural sustainabil ity.

5. Based on the above criteria producers of Centro-America and Panama were classified into three major groups: producers of exportables, producers of importables, and others producers. Producers of exportables are sub-classified into producers of traditional exportables which are not in crisis (bananas and coffee), producers of exportables which are in crisis (sugar cane, cotton, tobacco, and others), and producers of non-traditional exportables (vegetables, fruits, flowers, ornamentals, and spices). The main objective of this sub-classification is to account for trade induced changes within the structure of producers.

6. Producers of importables are sub-classified into commercial farmers and marginal peasants. Commercial farmers in turn are subdivided according to their factor ratios between mechanical-intensive and input-intensive farmers. Commercial farmers grow grains, and some of them fruits and vegetables for domestic markets. Marginal peasants farm very small and poor plots of land with labor intensive techniques. Some of them face wide bands for their selling and buying prices, and other who don't face price bands have very costly access to credits and modern inputs. They mainly produce corn, beans and cassava.

7. Other producers include cattle ranchers, dairy farms, and frontier farmers. Cattle ranchers and dairy farms are pooled together because of the particular imperatives of animal production. In Central America, beef is an exportable commodity while milk is an importable one. Frontier farmers produce tradable and non-tradable crops and animals. They are identified in a separate category because they farming practices pose a threat to agricultural sustainability.

Economic and Institutional Scenarios for Technical Change

8. Central American direction in the generation and transfer of agricultural technologies will depend on prospective changes in external demands, on the dynamic of its population, and on the likelihood of institutional and policy changes. Forecasting these directions is a formidable challenge since, changes in institutions and policies on the other hand can be affected by the availability of new technical alternatives, out-migration, and the political economy of interna-

tional financing.

9. A likely scenario for the 1990's and the 2000's will be one of slightly declining prices for exportables and importables, with international adjustment financing, and continuous in-payments from workers remittances.

10. The actual forthcoming of institutional and technical changes in Central America will depend on the supply of institutional changes. Resolving the conflicts which changes in prices, population growth, and soil degradation are generating among vested-interest groups implies additional costs for policy makers. They will be prepared to deliver changes in trade, exchange rate, and credit regimes, in organization of research, in the conservation of resources, and in access to human capital, if they were able to avoid a reduction in political support. The cultural endowments of the region, in particular political ideologies have made institutional change very costly so far. **Advances in social sciences, education, and the cooperative contribution of international organizations will have to play an important role as exogenous factors shifting the supply of institutional innovations in the direction of new income streams, the encouragement of conflict resolution, and sustainability.**

Technological Imperatives for Different Groups of Producers

11. **For Exportables Not in Crisis**. Maintaining competitiveness in bananas and coffee markets will require to increase land productivity controlling bananas black sigatoca, coffee rust, and coffee bean borer. In the case of coffee, and for countries like Costa Rica it will be necessary to reduce labor costs but minimizing the impact of chemicals on land sustainability..

12. **For Exportables in Crisis**. Research institutions shall reallocate part of their resources to other commodities, and refocus the remaining resources in improving management and sustainability in the production of cotton, tobacco, sugar cane and other traditional commodities.

13. **For Non-Traditional Exportables**. The imperative is to transfer bio-technologies and post-harvesting technologies within a framework of flexible production systems, and taking advantage of techniques used in U.S. and Mexico.

14. **For Mechanical-Intensive Importables**. The major imperative is to reduce the unitary cost of production of grains.

15. **For Input-Intensive Importables**. The technical imperatives for producers of vegetables and fruits for domestic markets, are to increase yields, to improve packaging systems, and to develop grades and quality control standards.

16. **For Marginal Peasants**. Giving the high transaction costs for having access to credit, the imperative is to develop technical packages tailored to their particular conditions: more labor efficient techniques for poor farmers; expanding their

production mix toward vegetable gardens, poultry and fish production, and even milk production, as to improve their consumption basket. An additional imperative is to develop or improve low-input techniques, minimum tillage, and soil conservation practices for hillsides and other fragile lands.

17. Not technical fix will increase the farm income of marginal peasants in a substantial amount. For a majority of these peasants the long run solution is to increase the earning power of their younger generations, and the ultimate answer is a massive program of investment in human capital

18. **For Cattle Ranchers and Dairy Farms.** The main imperatives are to increase pastures and animal productivity, and to free land for crops. For these purpose are necessary research and transfers programs for forage production and utilization, management production using records, reproductive management, reducing calfhood mortality, and producing and handling of clean milk. These imperatives are specially relevant for Honduras, Nicaragua, and the Dominican Republic.

19. **For Frontier Farmers.** The most important imperatives are institutional in nature: assigning property rights and developing lease contractual regimes which transforms migratory farming into permanent farming systems, reduce overgrazing, and prevent irrational deforestation. However, some of the technical imperatives for marginal peasants will apply to frontier farmers.

I. PRODUCTION SLOWDOWN AND PRODUCTIVITY DECLINE IN CENTRAL AMERICAN AGRICULTURE

Changes in Factor Use and Total Factor Productivity

1.1 Agricultural product grew only at an average annual rate of .6% during the 1980's. This was a significant slowing of agriculture activities when compared with the 3% p.a. growth of the 1970's (see table I.1). While agricultural growth during the 1970's was explained both by factors growth and total factor productivity (TFP) growth, the slowing of the 1980's is largely the result of a significant decline in TFP[1].

1.2 While accumulation of domestic capital, that is land and livestock, explained a 19% of agricultural output growth during the 1970's, it represented a negative contribution during the 1980's, because of the slow expansion of the land frontier and the decline in livestock heads. The contribution of imported resources, that is chemicals and mechanization, as well of agricultural labor were the most significant sources during the 1980's; however the combined productivity of all resources, domestic and imported, had a negative contribution.

Changes in Labor and Land Productivity

1.3 In correspondence with the above pattern labor productivity in agriculture grew at 2.3% p.a. during the 1970's and declined at .6% p.a. during the 1980's. The source of labor productivity growth in the 1970's was a 2.3% p.a. growth of land productivity, since land intensity remained constant. During the 1980's land productivity grew at a modest .2% p.a., partially offsetting the .8% p.a. decline in the land-labor ratio (see table I.2).

1.4 This growth in output per hectare of cultivated land during the 1970's was the consequence of improved infrastructure, mainly irrigation, and above all the adoption of land-saving technologies, mainly fertilizers and improved seed and plant varieties. Although cultivated land, both in annual and permanent crops, has been growing in Central America, agricultural labor has increased faster. Indeed the decline in labor productivity during the 1980's is mainly a consequence of the decline in land availability per agricultural worker.

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1. This paper is not a full fledged attempt at growth accounting in the tradition of Denison, but it combines the growth accounting framework and a statistical based approach. For a description of the methodology see A. S. Englander and A. Mittelstadt (1988) and Y. Hayami and V. Ruttan (1985).

Table I.1

CENTRAL AMERICA: ACCOUNTING FOR CHANGES IN AGRICULTURAL OUTPUT

Centro-America, Panama, and Dominican Republic

	From 1970 to 1980		From 1980 to 1987			
			Case 1 ‡		Case 2 ■	
Changes in Agric. GDP per year (%)	3.0	(100)	0.6	(100)	0.6	(100)
Percent Explained by:						
Domestic Resources						
Land	0.1	2	0.0	5	0.0	6
Livestock	0.5	17	-0.1	-8	-0.1	-9
Labor	0.5	19	0.7	93	0.4	57
Imported Resources						
Fertilizers	0.8	27	0.5	58	0.5	72
Tractors	0.3	12	0.2	20	0.2	24
Productivity (TFP)‡‡	0.8	23	-0.7	-68	-0.4	-50

Source: Own estimations based on production elasticities from Hayami, Y. and V. W. Ruttan, Agricultural Development, JHU, Baltimore, 1985

‡‡ Source of change unexplained by domestic and exported factors, e.g. changes in irrigation, land degradation, changes in allocative efficiency, and errors of measurement. It is known as TFP or total factor productivity.

‡ Case 1: According to FAO statistics for agricultural labor force

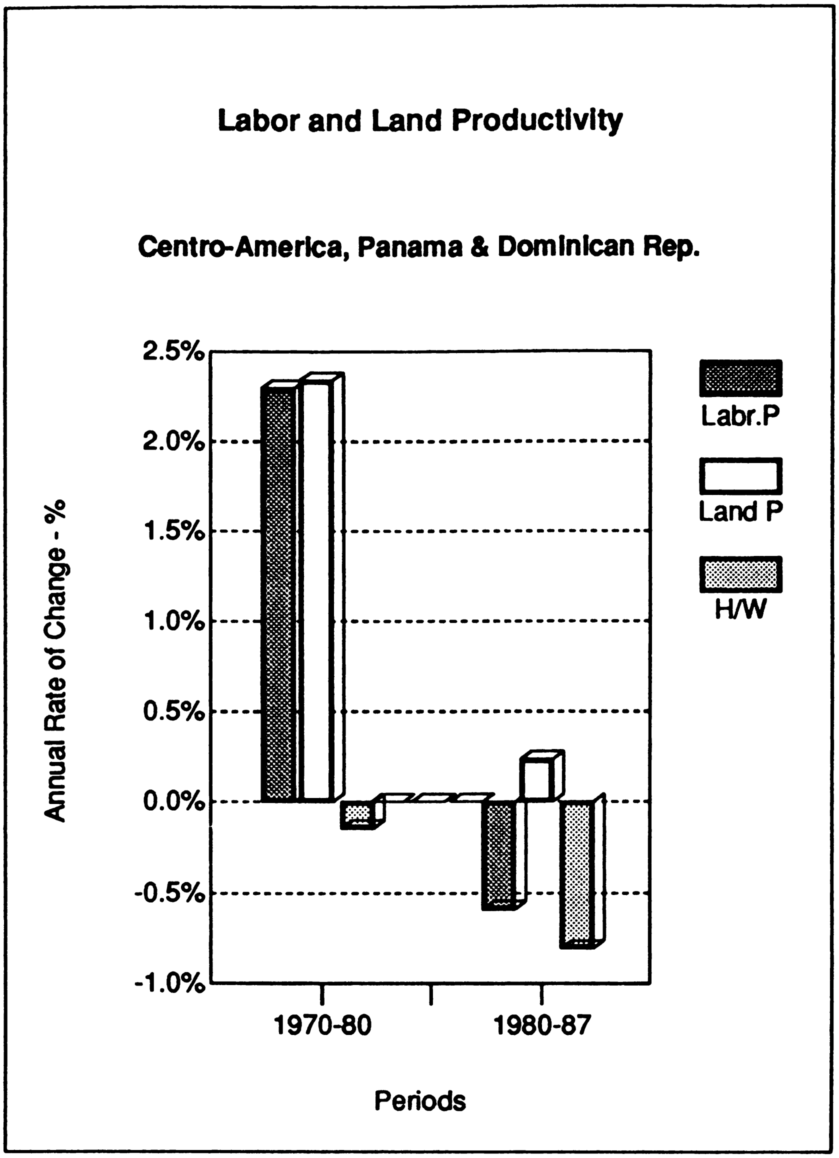
■ Case 2: Assuming 50% of FAO's statistics on labor force

Table I.2
CENTRAL AMERICA: AGRICULTURAL PRODUCTIVITY
Distribution by Countries - 1970-87
Dollars of 1980

		VALUES			GROWTH RATE %	
		1970	1980	1987	1970-80	1980-87
CENTRAL AMERICA						
Labor Productiviy	Doll/Worker	1295	1587	1521	2.3	-0.6
Land Productivity	Doll/HA	656	809	823	2.3	0.2
Land/Labor Ratio	HA/Worker	2.0	2.0	1.8	0.0	-0.8
GUATEMALA						
Labor Productiviy	Doll/Worker	1376	1872	1649	3.6	-1.2
Land Productivity	Doll/HA	860	1205	1144	4.0	-0.1
Land/Labor Ratio	HA/Worker	1.6	1.6	1.4	-0.4	-0.7
EL SALVADOR						
Labor Productiviy	Doll/Worker	1095	1454	1431	3.2	-0.2
Land Productivity	Doll/HA	1114	1367	1164	2.3	-2.1
Land/Labor Ratio	HA/Worker	1.0	1.1	1.2	0.8	2.3
HONDURAS						
Labor Productiviy	Doll/Worker	803	940	857	1.7	-1.3
Land Productivity	Doll/HA	287	349	399	2.1	2.2
Land/Labor Ratio	HA/Worker	2.8	2.7	2.1	-0.4	-2.9
NICARAGUA						
Labor Productiviy	Doll/Worker	1508	1250	1099	-1.7	-1.7
Land Productivity	Doll/HA	398	386	386	-0.3	0.0
Land/Labor Ratio	HA/Worker	3.8	3.2	2.0	-1.4	-1.7
COSTA RICA						
Labor Productiviy	Doll/Worker	2164	2651	2928	2.3	1.5
Land Productivity	Doll/HA	984	1252	1397	2.7	1.6
Land/Labor Ratio	HA/Worker	2.2	2.1	2.1	-0.4	-0.1
PANAMA						
Labor Productiviy	Doll/Worker	1248	1488	1782	1.9	2.7
Land Productivity	Doll/HA	492	562	670	1.4	2.1
Land/Labor Ratio	HA/Worker	2.5	2.6	2.7	0.5	0.6
DOMINICAN REPUBLIC						
Labor Productiviy	Doll/Worker	1406	1695	1794	2.1	0.9
Land Productivity	Doll/HA	836	928	988	1.8	1.0
Land/Labor Ratio	HA/Worker	1.7	1.8	1.8	1.0	-0.1

Source: Own estimations; Data sources in Appendix

Figure I.2



Labor and Land Productivity
Centro-America, Panama & Dominican Rep.
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
-0.5%
-1.0%
Annual Rate of Change - %
Labr.P
Land P
H/W
1970-80
1980-87
Periods

Differences in Land and Labor Productivity Across Countries

1.5 While all countries in the region, but Nicaragua, experimented a growth in labor productivity during the 1970's, not all countries experimented a decline in labor productivity during the 1980's. Labor productivity grew in Costa Rica, Panama, and the Dominican Republic during the 1980's. Furthermore, only Guatemala and El Salvador had a decline in land productivity during the 1980's, but most countries, with the exception of El Salvador and Panama, experimented a decline in the land/labor ratio. In these two countries the economic active population in agriculture declined in absolute terms.

Sources of Productivity Change in Agriculture

1.6 The evolution of TFP in Central American is a response to changes in international demand conditions which have affected the commodity mix; to economic policies which have affected the direction of technical change; and to the effect of the resulting factor intensity on agricultural sustainability.

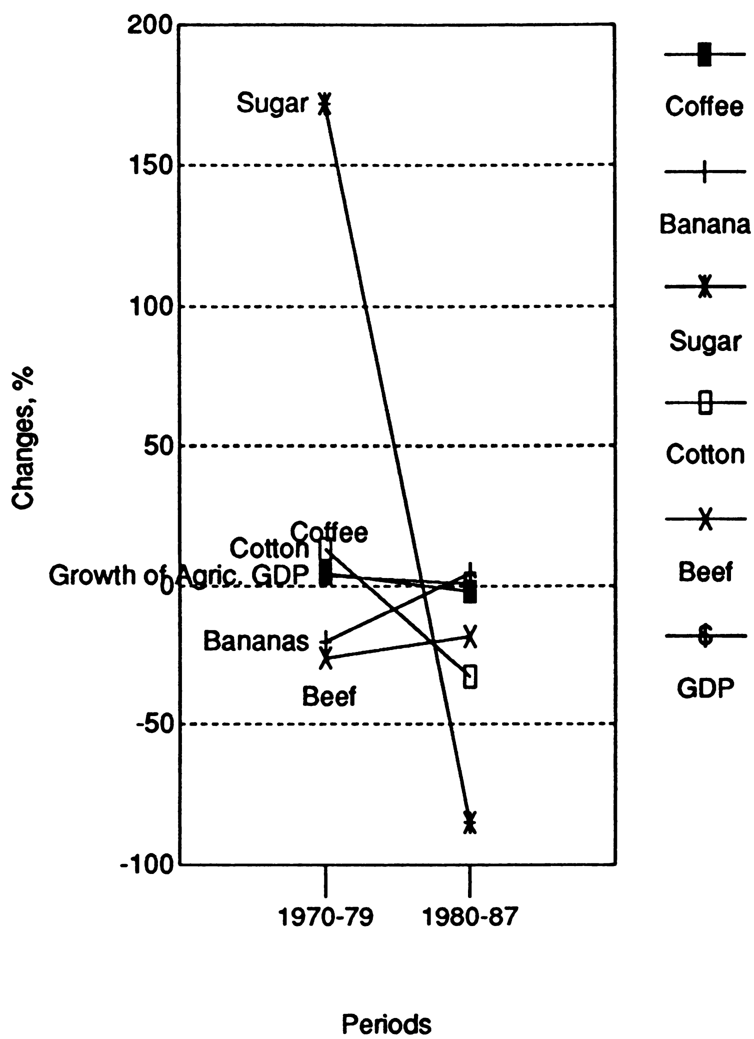
1.7 The price of traditional exportable commodities of Central America experienced an outstanding bonanza during the 1970's in relation to their long run trend. But during the 1980's the price of beverages like coffee, of foods like sugar and beef, and of non foods like cotton and tobacco declined substantially. Only banana prices remained stable (See table A20). In the case of row sugar this price decline was compounded by the reduction of U.S. market quotas for Central American countries. These price changes induced a substitution away from sugar cane, cotton, tobacco, and livestock toward importables like sorghum, corn, and beans, and toward non-traditional exportables like fruit, vegetables, flowers, ornamental plants and spices.

1.8 Given the stability in the land-labor ratio, the price bonanza of the 1970's, reinforced by a policy of low real exchange rates (or national currencies overvaluation), and low real interest rates, induced a substitution of chemicals for land and of mechanical power for labor (see table II.4). The adoption of more land saving technologies was made possible by the adaptation of improved seed varieties to the area. The adoption of labor saving technologies was not consistent with the relative abundance of labor, but it was induced by low exchange rates and subsidized credits.

1.9 The decline in the demand for exportable commodities during the 1980's and the world wide credit crisis of this period, induced some degree of structural adjustments in Central American countries. This partial adjustment had some significance in Costa Rica, Panama and the Dominican Republic, but it still was a very modest change. The increases in the real exchange rate were not sufficient to eliminate deficits in the current account which continued to grow in annual terms, even when workers remittances from foreign countries were increasing. Workers migration to countries like U.S. increased during the 1970's; the outflow continued during the 1980's as a result of high population growth in the case of the

Price Changes and Agricultural Growth

Central America



Dominican Republic, and also as result of military and political conflicts in Nicaragua and El Salvador.

1.10 Under-adjustment in the institutions of these countries were made possible because of the continuous in-payments from official grants and official loans from the U.S., Canada, the European Community and the Soviet Union. These grants and loans were justified by political and social considerations.

1.11 The increasing scarcity of land during the 1980's induced the substitution of land by labor, of fertilizers by labor, and of fertilizers for land once again. The substitution of chemicals for land was reinforced by an increase in the ratio between commodity prices (both exportables and non-importables) and fertilizer prices (an exportable). This decline in the relative price of fertilizers, was intensified by the overvaluation of national currencies which created a bias toward imports of inputs. The same overvaluation combined with still low real interest rates is also an explanation for the continuous substitution of mechanical power for man-power.

1.12 The substitution of capital for land and labor, that is the continuous imports of fertilizers and tractors, however did not translate into total factor productivity growth during the 1980's as it has happened during the previous decade. There were two major reasons for the decline in TFP. First, the long run negative effect of mechanization and higher uses of chemicals on yields: land compactation and pest resistance to chemicals were beginning to reduced yields. Second, the virtual reduction in the availability of more efficient varieties of seeds and plants to be combined with chemicals.

1.13 Certainly, still there exist technological gaps both in crops, pastures, and livestock production. However research and transfer agencies in the region have not been able to respond yet (supply side restriction), nor the necessary adjustment in institutions have taken place as to develop the right incentives for farmers to adopt new techniques (demand side restrictions). This mismatch between technology transfer and adoption is farther complicated by the differentiation between users of agricultural technologies: commodity and social differentiations.

II. AGRICULTURAL ADJUSTMENT ACROSS PRODUCERS

Trade and the Structure of Agricultural Producers

2.1 Agricultural producers in Central America are differentiated by their commodities mix, by their factor ratios, by their access to land and output markets, and by the effect of their factor rations and allocative efficiency on agricultural sustainability. Most agricultural producers operate within the tradable sector and they are classified in two major groups, those in the exportable sector of agriculture and those in the importable sector, that is, producers of import substitution crops.

2.2 **Producers of Exportables and Importables:** The differentiation between exportable and importable commodities depends on what are the external market conditions which are influencing the domestic price of the commodity. In the case of Central America the farm gate prices of exportable commodities, say sugar cane or bananas, depends on the world excess demand (or export demand) to the country. The farm gate prices of importable commodities like corn and beans, depend of the world excess supply (or import supply) to the country. External trade shocks or deep changes in the real exchange rate could transform the nature of a commodity, for example beef production could move from and exportable into an importable sector (de Melo and Robinson, 1982). The typology used here assume a relative stability in the comparative advantages of the Central American countries, and therefore a stability in the commodity nature. However the typology allows for producers movements within commodity groups, say from traditional to non-traditional exportables, or from exportables to importables.

2.3 **Commercial Farmers and Marginal Peasants:** Depending on their access to land and output markets, producers in the importable sector are classified into three major categories. First, commercial producers operating medium and large farms who, besides adopting yield increasing technologies, they have adopted labor saving technologies; they are called mechanical-intensive producers. Second, commercial producers operating small farms who have adopted land saving technologies; here called input-intensive producers. Third, poor peasants with small plots of poor land without access to credit nor technical assistance, here called marginal producers.

2.4 The distinction between commercial producers and marginal peasants within the importable sector is needed for three major reasons. One, for identifying technological imperatives, and associated investment in human capital programs, necessary to **reduce structural poverty**. Another, to identify technological imperatives for insuring **sustainability**, since many of these peasants operate in fragile lands. Finally, to improve **competitiveness** among commercial farmers, for example developing techniques which reduce unitary costs for mechanical-intensive producer, and improving the yields of input-intensive farmers producing

foods and feeds.

2.5 There exists in Central America and the Dominick Republic a distribution of marginal peasants depending on their constraints to growth. One group is integrated by farmers facing a large band between selling and buying price of cereals, beans or cassaba. Although the commodities that they produce are tradables, their economies are isolated from the impact of real exchange rates. For these peasants the best economic strategy is production for home consumption, and from the perspective of this study they belong to the non-tradable sector. Another groups of marginal farmers are not subject to large price bands and are net seller of foods. However they have limited or non access to credit markets. As a consequence they cannot hire labor during soil preparation or harvesting, or they cannot buy improved seeds and chemicals. For these farmers, increases in the real exchange rate implies an income effect through the surplus they sell, but their supply cannot increase sufficiently in response to higher real prices.

2.6 **Cattle Ranches and Dairy Farms**: Beef production in Central America in general corresponds to the exportable sector, while milk production corresponds to the importable sector. However, in this study cattle ranches and dairy farms are considered in a separate category for the purpose of differentiating the specific technological imperatives of crop from livestock production, and for pondering the likely substitution between cultivated land and permanent pastures. Animal husbandry and pasture improvements have specific technological requirements, although their markets are also ruled by the real exchange rate.

2.7 **Frontier Farmers**: The typology is closed with a group of farmers opening new lands at the expense of forests or other wilderness. Most of them do not use imported capital like inputs and tractors, but invest in national capital like livestock, operate medium and large size farms, and use extensive methods of production. Their commodity mix include exportable and importable goods, from beef to sorghum and corn. Some of these farmers have high transportation costs in order to access markets, becoming *de facto* members of the non-tradable sector. These producers are grouped into a separate category in order to identify technological imperatives for **sustainability** in the region. This function, was an additional reason for the grouping of marginal peasants; a large proportion of them farm on steep lands and other fragile environments. Their identification and measurement will provide information on the importance of controlling deforestation, reducing migratory agriculture, and diffusing soil conservation and more productive farming systems for sloping hillsides and other fragile environments.

2.8 **Dynamic within the Structure**: The economic opportunities of exportable producers are determined mainly by changes in prices, tariffs, non-tariffs barriers in external markets. Their competitiveness depends on land prices and wages at home, on their production and post-harvesting technologies, on their marketing organizations, and on the real exchange rate and export taxes. Changes in international prices during the 1980's, and changes in the export quota regimes of administrated markets have **reduced their competitiveness** and induced a substitution process away from crops like sugar cane, cotton, tobacco and beef; it has also generated a latent demand for technical change in order to recover their competitiveness. At the same time new market opportunities in the U.S., some of them created by the Caribbean Basin Initiative, are inducing a substitution toward production of fruit, vegetables, flowers and spices for exports; it is also deriving a latent demand for transfer of bio-technologies at the farm level, and for packaging, storage, transportation, and marketing technologies, in the post harvesting stage.

2.9 In order to represent within the typology this **ongoing substitution process** within exportables and among exportables and importables, producers in the exportable sector are classified into three major groups: producers of traditional commodities which maintain their competitiveness in international markets, here called producers of traditional export crops not in crisis; producers of traditional commodities whose competitiveness in the export market has been reduced, here called producers of traditional export crops in crisis; and producers of commodities like fruit, vegetables, flowers, ornamental plants, and spices for new export markets, here called producers of non-traditional exportables. This classification is most needed in order to identify technological imperatives induced by changes in external demand.

Agricultural Producers at the end of the 1980's

2.10 Table II.1 shows the distribution of farmers and land according to the above typology. The typology includes farmers of the Centro-America Common Market countries and Panama, for the period 1988/89. These are provisional estimates based on secondary information and a survey conducted by the Program of Technology Development and Transfers of IICA. These surveys were conducted among well informed policy makers and professionals of the agricultural sectors of the region. The dis-aggregation by countries is presented in the Appendix.

2.11 When all farmers, ranchers, and squatters are pooled together in Central America, a 20% of them operate within the exportable sector, a 63% in the importable sector, and the rest are ranchers and frontier farmers. The average farm size in Central America in about 9 Hectares, but there exists a wide distribution of farm sizes around this average (see table II). While cattle ranchers use extensive methods of animal production, marginal peasants, who represent a 44% of all producers, cultivated tinny plots of land averaging out around one Hectare. Some, but not all of these marginal peasants are isolated from changes in international prices and in the real exchange rate through wide bands between their selling and buying price of grains; therefore they belong to the non-tradable sector. This is also the case with some frontier farmers who do not have access to markets due to high transportation costs. Cattle ranches instead operate under the incentives of exportables.

Figure II.1

Table II.1
CENTRAL AMERICA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	9.4	100.0	100.0
EXPORTABLES	7.1	20.3	15.3
Traditional	7.6	17.2	14.0
Normal	6.6	12.6	8.8
In Crisis	10.4	4.6	5.1
Non Traditional	3.9	3.1	1.3
IMPORTABLES	3.2	63.4	21.4
Mechanical Intensive	18.1	3.3	6.3
Input Intensive	4.8	17.7	9.0
Marginal	1.3	44.0	6.1
OTHERS	36.6	16.3	63.3
Frontier Farming	24.2	6.6	17.0
Livestock and Milk	45.1	9.7	46.3

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures

2.12 Land productivity and gross farm income varies widely across those groups of producers. Average productivity of land, in terms of gross income per hectare, is about three times higher for producers of exportables than producers of importables, and near 20 times higher than it is for ranchers and frontier farmers (see table II.2). The higher productivity of exportables reflects larger capital investments per hectare, as in the case of coffee and bananas plants, investment in irrigation infrastructure, buildings, and other equipments. The law productivity of ranchers is a consequence of the extensive systems of animal production.

2.13 Differences in gross farm income are less marked than in land productivity because of the compensating effect of farm sizes. Marginal peasants, however, still have a meager income because both of low productivity and small plots. Their low land productivity is a consequence of the poor quality of the land which they control, of their costly access to inputs and credit, and of their limited know how. The poor quality of their land is a result of the location of their plots, for example on the hillsides, of their farming techniques which degrade soils, and of the absence of soil conservation practices. This is largely the case for peasants in la Sierra in the Dominican Republic, and for peasants in the hillsides of Honduras.

2.14 A large group of frontier farmers have precarious rights on their land or they can lease land only during short periods. As a consequence they use short run investment strategies like slash and burning agriculture, and they produce with extensive methods which require little investment in their land. Those who accumulate capital do it in animals. Many frontier farmers with precarious land rights, like some marginal peasants, won't be privately viable if they were not able to externalize some costs like deforestation, soil degradation, and downstream sedimentation.

2.15 **Commodity Mix Changes during the second part of the 80's**: During the last ten or more years, the typical exportables of Central America were coffee, bananas, sugar cane, cotton, tobacco, cocoa, African palm, cardomen, and beef. During the 1980's the international price and the export quotas of row sugar fell in a substantial amount. The same happen with the prices of cotton, tobacco, cordomen and beef. The lost in competitiveness in these commodities have induced a crop and factor substitution in the region. In the short and medium run, some growers of these exportables in crisis, for example cotton producers, have reallocated their land, mechanical equipments, and irrigation infrastructure to produce importables like sorghum, rice, corn, and beans. Mechanical-intensive producers of importables, and producers of exportables in crisis have a similar land productivity, operate medium and large size farms, and use high-inputs and mechanical techniques (see table II.1).

2.16 With a long run criterion, a new group of producers have joined the exportable sector. During the last five years, for example a 3% of the producers of Central America, who control only a 1.3% of agricultural land, have been producing and exporting fruits, vegetables, flowers, ornamental plants, and spices. Fruits exported by the region are mango, oranges, pineapple, strawberries, melons, and

Figure II.2

Table II.2
CENTRAL AMERICA: FARM GROSS INCOME AND LAND PRODUCTIVITY
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS %	FARM GROSS INCOME US$ per year	LAND PRODUCTIVITY* US$/HA
TOTAL	100.0	4562	484
EXPORTABLES	20.3	13422	1890
Traditional	17.2	13550	1773
Normal	12.6	15725	2374
In Crisis	4.6	7689	740
Non Traditional	3.1	12415	3158
IMPORTABLES	63.4	2016	633
Mechanical Intensive	3.3	10308	570
Input Intensive	17.7	4549	955
Marginal	44.0	304	231
OTHERS	16.3	3473	95
Frontier Farming	6.6	3250	134
Livestock and Milk	9.7	3632	80

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

watermelons; among vegetables are broccoli, cucumbers, avocado; and other commodities like sesame, and macedonia. The gradual development of these markets has been induced partially by the Caribbean Trade Initiative of the U.S., and the technical assistance of U.S.A.I.D.. Central American countries have some comparative advantages in the production of these commodities because both of their proximity to the U.S. markets and because they can produce during off-season with respect to California and other U.S. Western states. However they have to compete with Mexico, a well established supplier in the North-American markets.

2.17 Producers of non-traditional exportables tend to operate small and medium size farms, with high-input and high-labor using techniques, including both unskilled and skill labor; they also supply to domestic markets. These farmers have the highest land productivity in the region, almost twice that of traditional exporters (see table II.2).

2.18 Producers of importables supply part of the region requirements for rice, corn, sorghum, and beans. Central America, supply the rest of the requirement with imports from other regions. However, there exist an intra-regional trade of grains as well of vegetables, fruits, and beef. Marginal peasants produce corn and beans mainly for family consumption; some of them generate a marketable surplus producing sorghum, cassaba, and rice; but in all cases they produce under rainfall conditions, with low-input techniques, and therefore with low yields.

2.19 In general the effective rate of protection for these farmers is positive because of overvalued currencies, subsidized credits for commercial farmers, and price supports. The rate of protection has been particular high for the production of rice.

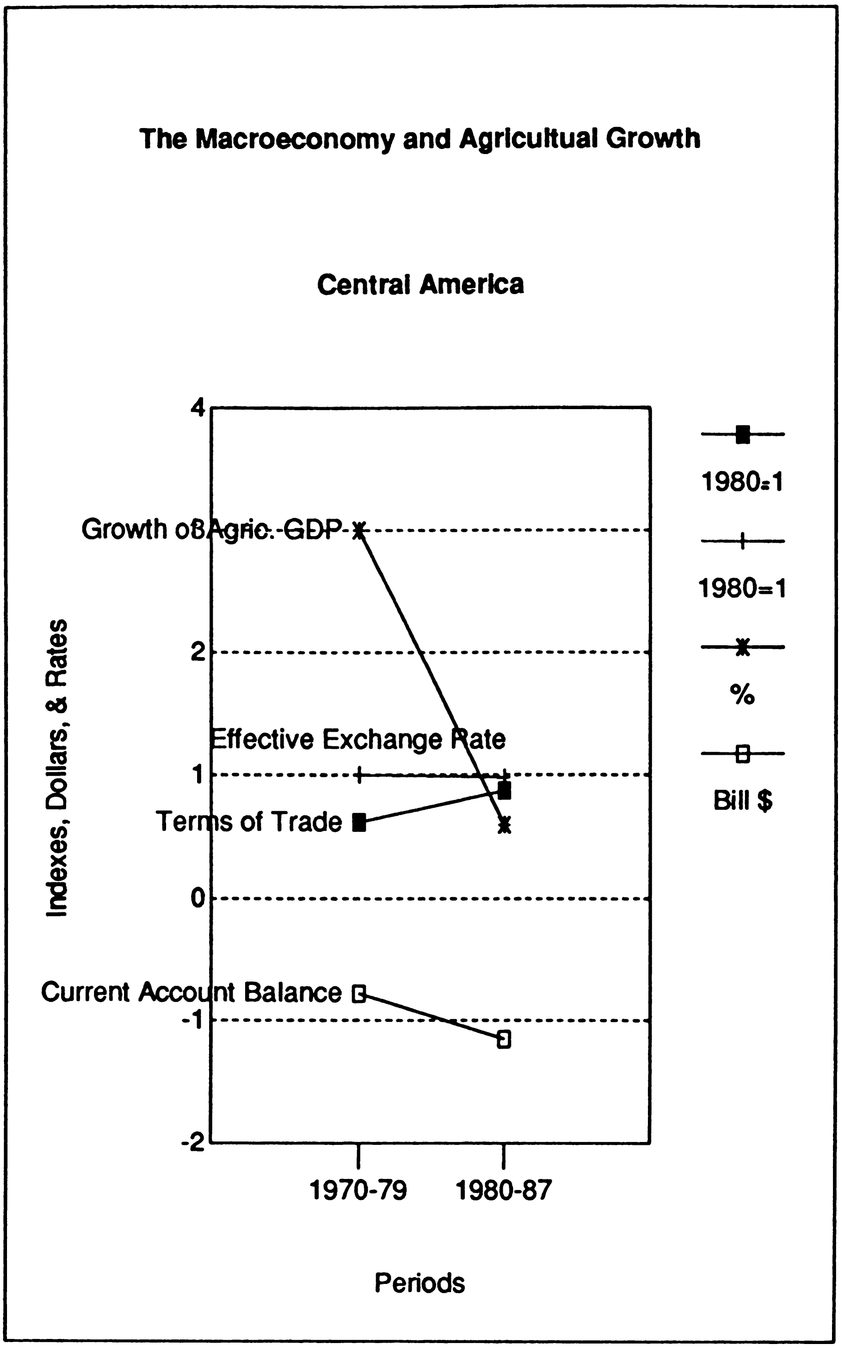
2.20 **Changes in Techniques during the 1980's**: Agricultural adjustments in response to changing international demands have been low in Central America. Decreasing competitiveness for a major groups of traditional exports did not induce a significant adjustment in macro-economic policies, in food and agricultural policies, and even less institutional adjustments in the technical research and transfers system. In addition the overall crisis of the region did not allow for significant investments in physical and human capital necessary to increase competitiveness in the traditional markets, and to position in the non-traditional markets.

2.21 Overall the real exchange rate did not increase in the region (see Table II.3), except for Guatemala, Costa Rica, and the Dominican Republic. The real interest rate has also be maintained low. This slowing adjustment was made possible by significant changes in international financing. Net foreign private transfers into the region, mainly workers remittances, increased during the 1980's. The same happened with official capital grants to the region (Kaimowitz, 1990). These private and official transfers financed a significant proportion of the increasing deficits in the balance

Table II.3
CENTRAL AMERICA: MACROECONOMIC DETERMINANTS OF AGRICULTURE
Distribution by Countries - 1970/1987

		GUATE-MALA	EL SAL-VADOR	HONDURAS	NICA-RAGUA	COSTA RICA	PANAMA	DOMINICAN REPUBLIC	CENTRAL AMERICA
MACROECONOMIC FACTORS									
Terms of Trade	1970-79	64	65	61	63	63	59	52	61
(1980=100)	1980-87	89	91	92	87	92	91	64	87
Effective Exchange Rate	1970-79	107	115	98	89	118	110	73	101
(1980=100)	1980-87	114	92	88	40	132	102	122	98
Current Account Balance	1970-79	-81	-44	-93	-64	-223	-159	-126	-790
Mill US$ per year	1980-87	10	-28	-185	-521	-277	178	-336	-1159
External Debt	1970	106	88	90	147	134	194	212	971
Mill US$ at year:	1980	549	524	760	1662	1692	2271	1220	8678
	1987	2345	1597	2681	6150	3629	3722	2936	23062
PERFORMANCE OF AGRICULTURE									
Growth of Agric. GDP	1970-80	4.7	3	3	0	2.6	1.5	3.4	3.0
	1980-87	0.3	-1.9	1.8	-2.0	1.2	2.5	2.2	0.6

Source: Own estimations with data from World Bank, World Tables 1988/89 Edition and ECLA (for Agric. Growth)


The Macroeconomy and Agricultual Growth
Central America
4
Growth of Agric. GDP
2
Effective Exchange Rate
1
Terms of Trade
0
Current Account Balance
-1
-2
1970-79
1980-87
Periods
Indexes, Dollars, & Rates
1980=1
1980=1
%
Bill $

of goods and services[1]. Official grants are coming mainly from the U.S.A., Canada, the European Economic Community, and from the Soviet Union in the case of Nicaragua. Furthermore, loans have continued to poor into the region in order to finance the still negative and increasing current account; thus, accelerating the accumulation of external debt. Countries like Honduras finance a significance proportion of their fiscal budgets with foreign capital grants.

Table II.4
CENTRAL AMERICA: FACTOR SUBSTITUTION

	1970-80	1980-87
Fertilizer/Land*	0.56%	0.35%
Land/Labor	-0.00%	-0.11%
Tractor/Labor	0.22%	0.35%
Fertilizer/Labor	-0.41%	-0.18%

Source: Own estimations.
* Growth of the factor ratio times the production elasticity of fertilizer.

2.22 Overvalued national currencies and low real interest rates did not developed incentives for a faster transfer of resources from the tradable to the non-tradable sector, nor for a faster growth of import substitution crops. That is, the real wage rate remained higher than necessary for a faster adjustment, which combined with subsidies to capital via low real interest rates, decreasing international prices of fertilizers, and increasing prices of land induced by a decreasing land/labor ratio, will prolong during the 1980's the same process of substitution of fertilizers for land, and of mechanical power for labor which took place during the 1970's.

2.23 During the 1980's, research and transfer of technology did not have noticeable effects on the mentioned changes in commodity mix and factor ratios within commodities. Those changes were mainly a consequence of changes in international demands and the listed policies. Substitution of fertilizers for land were not complemented with the adoption a new improved seeds or plants. Most of the benefits of the green revolution have been appropriated during the 1970's.

2.24 The faster use of mechanization, fertilizers, and other chemicals as a way to maintain the short run competitiveness of producers, is having a long run effect on land productivity: increasing compactation of soils and increasing pest resistances to chemicals is reducing land returns and impairing long run competitiveness.

----

1. Goods and Services Balance = Exports of Goods and Services - Imports of Goods and Services.

Current Account Balance = Goods and Services Balance + Net Current (Private) Transfers + Net Official Capital Grants

Current Account Balance = Capital Account Balance + Change in Reserves

The increasing deficits in the Goods and Services Balances were financed with grants (private and official transfers), and loans. In all countries but Guatemala and Costa rica, the long-term loans have to be even larger in orther to compensate for capital flights or short-term capital outpayments.

III. ECONOMIC AND INSTITUTIONAL SCENARIOS FOR TECHNICAL CHANGE

3.1 The identification of the future direction in the generation and transfer of agricultural technologies shall consider the prospective changes in external demands, in the dynamic of population, and the likelihood of institutional and policy changes. This is a formidable challenge since, changes in institutions and policies on the other hand can be affected by the availability of new technical alternatives, out-migration, and the political economy of international financing.

Forecasting International Prices

3.2 The forecasts for international prices of exportables and importables used here are based on the projections of the International Commodity Division of the World Bank (World Bank, 1990). These projections are in terms of constant dollars of 1985, from the year 1990 to the year 2000 (see [illegible] III.1)

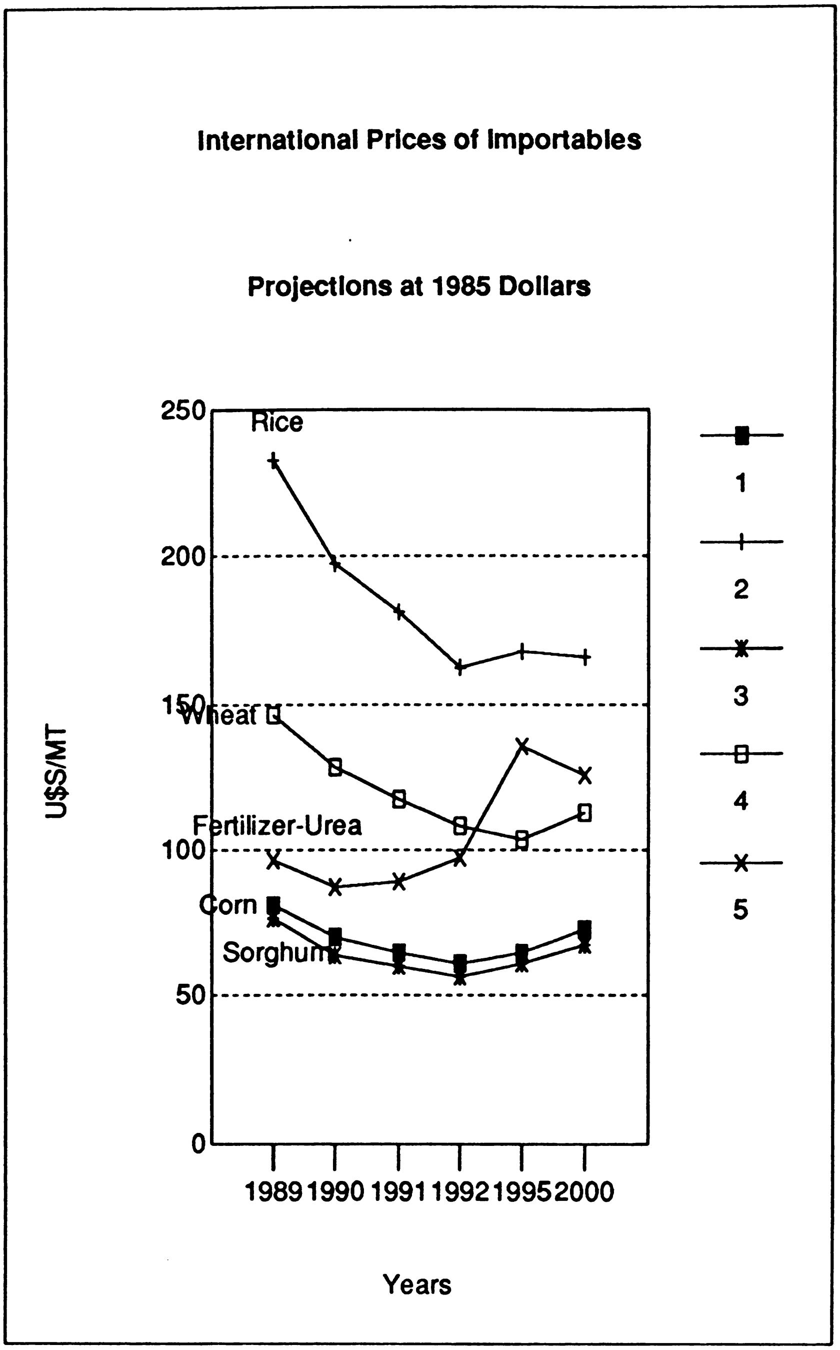
3.3 **Coffee.** The future prices of coffee will depend on whether the International Coffee Agreement is or not discontinued. Under both scenarios the price of coffee will continue its smooth decline until mid 1990's. From there on it will start growing until the year 2000, but without reaching the levels of the 1970's and mid 1980's. The average annual price will likely be lower in the 1990's than in the 1980's.

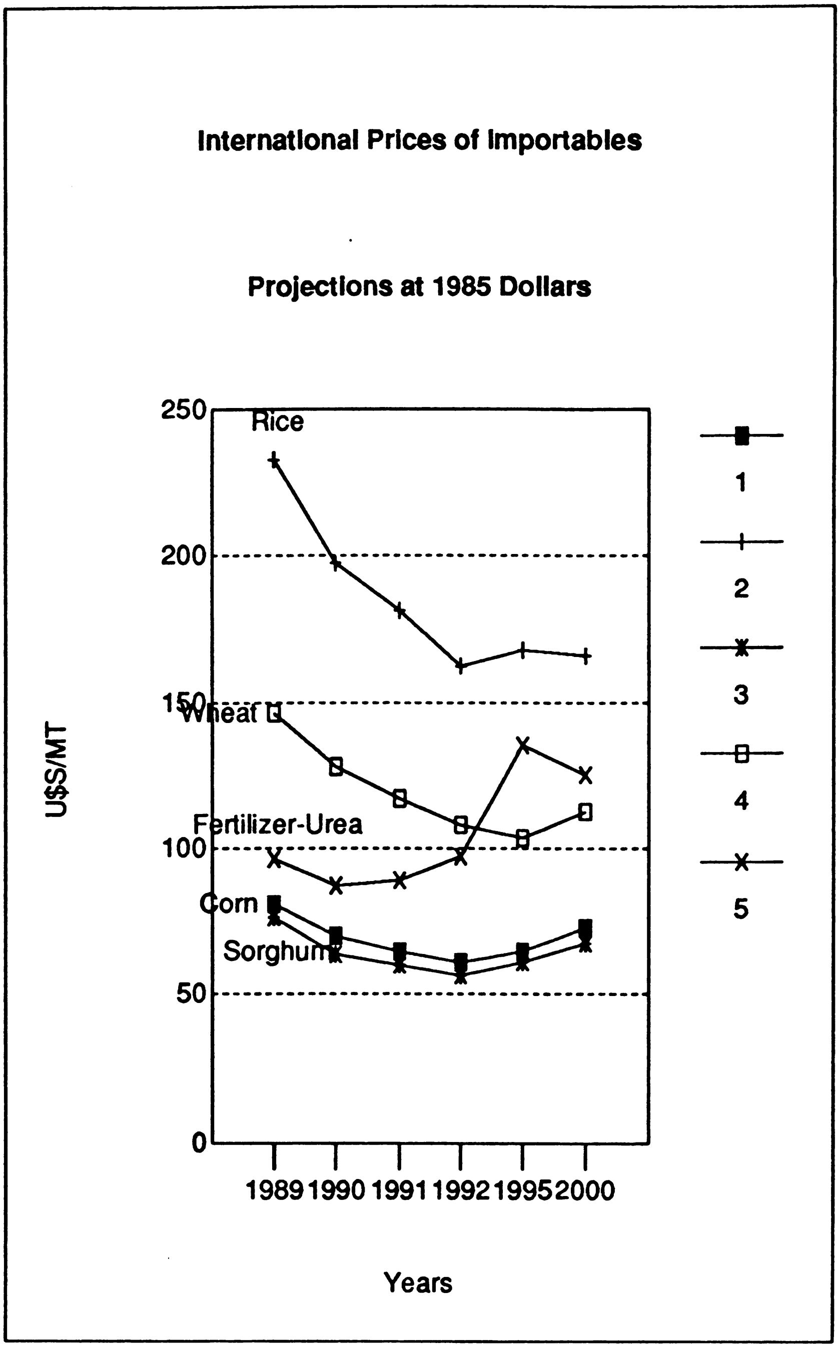
3.4 **Bananas and Oranges.** Bananas price would remain at the same levels of the late 1980's, but with a slight tendency to decline. That is the average price level of the 1990's will be smaller than in the 1980's. The price of oranges will continue their slight decline throughout the decade.

3.5 **Raw Sugar.** The price of sugar during the 1990's is expected to be higher than during the late 1980's, but without returning to the exceptional high levels of the 1970's. This forecast is based on the assumption the domestic agricultural support programs of the EEC and U.S. will continue, as well as the existing preferential trade arrangements. Therefore, free market sugar prices will remain below the long-run average cost of production. If we exclude the exceptional high price of 1980, it is expected that the average annual price of the 1990's will be slightly higher than in the 1980's.

3.6 **Cotton and Tobacco.** The prices of cotton and tobacco will remain under downward pressure until the end of the century. That is, the average annual price will be lower in the 1990's than in the 1980's.

3.7 **Beef.** Beef prices will maintain its downward trend but will recuperate during the late 1990's. The average annual price during the 1990's is expected to be lower than during the 1980's.


International Prices of Importables
Projections at 1985 Dollars
U$S/MT
250
200
150
100
50
0
Rice
Wheat
Fertilizer-Urea
Corn
Sorghum
1989
1990
1991
1992
1995
2000
Years
1
2
3
4
5


International Prices of Importables
Projections at 1985 Dollars
250
200
150
100
50
0
Rice
Wheat
Fertilizer-Urea
Corn
Sorghum
U$S/MT
1989
1990
1991
1992
1995
2000
Years
1
2
3
4
5

3.8 **Grains**. The prices of wheat and rice will remain rather constant during the 1990's but with a tendency to decline in relationship to the 1980's. Sorghum and corn, instead will have a slight trend to increase during the decade. But overall, prices of grain are expected to remain at low levels.

Forecasting the Direction of Structural Adjustment

3.9 The rate and direction of technical change for Central American agriculture during the 1980's has been determined by changes in external demand conditions and in factors scarcities. While changes in external demand conditions were exogenous to the region, changes in factors scarcities for the private sector were mediated by a system of economic institutions and policies on the one hand, and by population growth and migrations on the other hand. This system of economic institutions and policies translated itself into a structure of subsidies and taxes which modified market prices, and thereby conformed the incentives for changes within the traditional commodity mix and for changes in factor ratios within commodities.

3.10 **The Demand for Institutional Innovations in Central America.** Governments seek to maximize the support of the vested-interest groups of a country, all at the same time that these social groups exercises pressures for affecting price-distorting taxes and subsidies (Rausser and Foster, 1989, and Becker 1983))[1]. Thus while cultivators reallocate themselves among commodities and change factor ratios in response to prices; they also respond to prices by lobbying for different tax and subsidy structures. Depending of their power to generate distorting subsidies or taxes, they may demand technical changes aimed at increasing their competitiveness in a commodity, or they may settle for institutional rents.

3.11 The changes in external demand conditions, by affecting the competitiveness of traditional exports altered the economic-political equilibrium of Central America. The institutional and policy changes (structural adjustments) necessary for increasing the competitiveness of exportables and importables, had required a higher devaluation of national currencies in real terms, more trade liberalization, and increases in the real interest rate. These adjustments had implied higher reductions in the real wage rate and in the returns of capital invested in the non-tradable sector.

3.12 Given the distribution of physical and human wealth in Central America, a further reduction in wages had been experienced more by middle class occupations than rural workers who already were underpaid. In addition, in countries like El Salvador, Nicaragua, the Dominican Republic and Guatemala, a proportion of urban and rural workers endowed with international information networks, re-

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1. Gordon Rausser distinguish between political economic-seeking transfer policies (PEST) and political economic resource transaction policies (PERT). See Rausser and Foster (1989).

sponded to downward pressures in real wages and to increasing underemployment by migrating out of the region. Other skilled workers, white collar employees, professionals and technicians, instead establish a distributional coalition with private businessmen and public administrators of the non-tradable sector; they slowed down institutional adjustments, the reallocation of resources, and the adoption of new technologies both in agriculture and manufacturing.

3.13 Workers migration within and outside the region has began long ago and it already was important during the 1970's in response to structural poverty; this was for example the case in the Dominican Republic and El Salvador. However the crisis of the 1980's accelerated migratory flows toward "the North". These out-migrations will generate in a short period an increase in remittances into their home countries, thus deflating the pressure to devaluate national currencies. At the same time, governments in the region minimized the reduction in political support of domestic social groups, by finding financial support of foreign donors and gov ernments: an increase in official capital grants and official loans further reduced the need to adjust economic institutions, and therefore to change more the price-distorting tax and subsidy structure.

3.14 What is the probability of maintaining in-payments into the region through private transfers, official grants, and foreign loans, after two decades of deficits in the current account? And given alternative scenarios with regard to foreign transfers, what is the probability of adjustments in institutions and policies given the existing distribution the power? These are research questions which will demand further investigations. However, in a first approximation and for the purpose of informing research and transfer institutions we will consider two scenarios, based on the following matrix (see table III.3).

Table III.3
SCENARIOS FOR AGRICULTURAL GROWTH
Probability of Structural Adjustment for Given Foreign Transfers

	With Transfers	Without Transfers
Complete Adjustment	Very Low prob.	Low prob.
Partial Adjustment	Low prob.	High prob.
Without Adjustment	Low prob.	Very Low prob.

3.15 Whether or not Central America continues to be subsidized by private or official foreign donors, the most likely outcome in terms of adjustment is that the region will continue to muddle-through. That is, it will follow on the path of partial adjustment; it will reduce but not eliminate the price-distorting nature of the tax and subsidy structure. But still, partial adjustment with transfers would be very different than partial adjustment without transfers, and it would imply different set of incentives, and different directions for technical change.

3.16 The ultimate unknown then is what is the probability of maintaining the existing grant economy. In order to forecast these event we will need to consider the political economy of official international financing. The new developments in Eastern Europe will shift part of the official grants of U.S., Canada and the EEC toward the eastern block. The economic difficulties of the Soviet Union may reduce its grants for Nicaragua and Cuba. These new priorities will create incentives among international donors to push for negotiated solutions to the political and military conflicts in the region. Although the U.S. government may not reduce its grants in a significant proportion during the Bush administration, it will push for changes in the use of grants and loans, with the purpose of improving the economic efficiency and fairness of the region in the long run. That is the goal of improving the overall economy of these countries would override the goal of maintaining the existing distribution of taxes and subsidies within the region.

3.17 An additional exogenous factors on structural adjustment is the growing world awareness about deforestation and soil degradation in the rainfed areas of the planet. International demands for institutional and technical changes to maintain sustainability in the region will be matched by internal demands to invest in soil conservation as a means to increase long run productivity of the land.

3.18 That is, **the most likely scenario will be one of slightly declining prices for exportables and importables, with international adjustment financing, and continuous in-payments from workers remittances.**

3.19 **The Supply of Institutional Innovations in Central America.** The actual forthcoming of institutional and technical changes in Central America will depend on the supply of institutional changes (Feeny 1988). Resolving the conflicts which changes in prices, population growth, and soil degradation are generating among vested-interest groups implies additional costs for policy makers. They will be prepared to deliver changes in trade, exchange rate, and credit regimes, in organization of research, in the conservation of resources, and in access to human capital, if they were able to avoid a reduction in political support. The cultural endowments of the region, in particular political ideologies have made institutional change very costly so far (Hayami and Ruttan, 1985). **Advances in social sciences, education, and the cooperative contribution of international organizations will have to play an important role as exogenous factors shifting the supply of institutional innovations in the direction of new income streams, the encouragement of conflict resolution, and sustainability.**

IV. AGRICULTURAL TECHNOLOGICAL IMPERATIVES

4.1 Technological imperatives for the 1990's and the first decades of the 21st Century are here listed by users, with a a perspective of demand for technical change. The institutional innovations necessary to deliver these requirements are not investigated here, but they are the subject of different article by another author[1]. The generation and transfer of new techniques will also require complementary investments in land infrastructure, investments in processing equipments, investment in training and entrepreneurial abilities, and investments in marketing development (Johnson and Wittwer, 1984).

Imperatives for Exportables

4. **Traditional Exportables-Not in Crisis**. The shares of supply countries in the international market of bananas are very stable. For example, while Jamaica, Belize and other English speaking Caribbean countries exports mainly to the U.K., Central American countries and the Dominican Republic export mainly to the U.S. The most important imperative for Central America then is to maintain competitiveness by increasing land productivity, and in this case one of the first priorities is to control black sigatoca.

4. In the case of coffee, maintaining competitiveness will require both market development and increasing land productivity. The crisis in the International Coffee Agreement, point to the need to compete with other countries, and therefore the need to differentiate Central American coffee. On the other hand the potential sources for land productivity growth in Costa Rica and Guatemala, are intensification (plants per Hectare), more light, plant management, and control of coffee rust and coffee bean borer. Controlling these plant diseases may require a change in variety, since caturra coffee is very vulnerable to coffee rust.

4. An additional challenge to maintain competitiveness in coffee is to reduce the cost of labor in countries like Costa Rica. Plant intensification is complementary to labor intensification; under labor intensification and high wages there exist an incentives to substitute herbicides for labor in order to control weeds; and these substitution pose a problem to land sustainability in the supply side, and to the marketability of coffee because chemical residues are increased. Mechanization for harvesting, like in Brazil, isn't a sound alternative: it affects the quality of coffee and therefore the ability to retain market shares.

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1. Article by Eduardo Lindarte on Institutional Changes for Agricultural Research and Technology Transfer, IICA, 1990.

4. **Traditional Exportables in Crisis**. An efficient response to the disequilibrium in the markets of sugar cane, cotton, tobacco, and beef is to reallocate part of the land and capital into production of other commodities. Another complementary response is to increase competitiveness of those commodities. Cultivators of these traditional crops are already reallocating land and equipments toward the production of other crops like grains. Research institutions therefore shall reallocate part of their resources to other commodities, and refocus their programs in improving resource management and sustainability of the lands still cultivated with those commodities in crisis.

4. **Non-Traditional Exportables.** Increasing production and shipments of vegetables and fruits to international markets will require a continuous transfer of bio-technologies and post-harvesting technologies. Transferring these technologies will require exposing cultivators to training programs and important investments in packaging plants, freezers, and appropriate transportation systems. Producers and packers will require knowledge of marketing seasons, commodity specifications, sanitary controls, and grading practices in destination countries.

4. Production and trade of traditional exportables are based on massive production systems: production of standardized products by means of equipments and land infrastructures dedicated to one product, unskilled labor, and specialized farmers. However, the production and trade of vegetables, fruits, and even more of flowers, ornamental plants, and spices will require flexible production systems: production of different king of crops and processed commodities by means of land infrastructures and production lines which are easily adjustable, more skilled labor, and producers with the ability to learn different crop and processing systems (Benito, 1989). These are then technologies which are more intensive in physical and human capital.

4. The market of these non-traditional exportables are relatively small and changing: niche type of markets. Business opportunities in these markets depend on the ability of packers and producers to shift fast from one commodity to the next or to introduce changes in commodity characteristics. In the U.S., Canada and EEC there exist growing markets for high value added commodities, for example vegetables and fruits differentiated by their nutritional characteristics, by their chemical residues, and even by the social class condition of their growers. A higher access of Central American producers to these type of markets will require further development of entrepreneurial capacities, and development of research resources which are flexible enough as to take advantage and adapt the techniques already used in other countries, mainly in the U.S. and Mexico.

Imperatives for Importables

4. **Mechanical-Intensive Producers**. The technical imperatives for these producers in terms of factor ratios is similar to needs of producers of exportables in crisis. The major difference is their commodity mix. Mechanical-intensive growers, are producing rice, corn, sorghum and sesame. Were Central American countries to

move into conditions of trade liberalization in the import side and to eliminate subsidies to growers, it will take a large increase in the real exchange rate for producers of corn and sorghum to compete with international prices. The technological imperatives are then to increase yields -and the margin left is not to high--, and to reduce unitary costs of production.

4. **Input-Intensive Producers**. For those small and medium size producers growing grains, their economic imperatives are similar to those of mechanical-intensive producers, except that they use more labor intensive techniques. The technical imperatives for producers of vegetables and fruits for domestic markets, are to increase yields, to improve packaging systems, and to develop grades and quality control standards. These technical imperatives will need to be matched with development of wholesale and retail distribution systems. Under conditions of complete trade liberalization these producers will have to compete with Florida and Mexican growers, as well with growers from other countries in the region.

Imperatives for Marginal Peasants

4. As it was explained in section II, there exist at least two major two group of peasants from the perspective of trade, and as a consequence they have different imperatives. For peasants constrained by wide selling and buying bands of prices, the fundamental imperative is to increase trade; for example credits for marketing coops and brokers will reduce the monopoloid power of intermediaries. For peasants constrained by access to credit and input markets the imperatives are of technical nature. Giving the high transaction of costs for having access to credit, a second best solution is to develop technical packages tailored to their particular conditions, for example developing more labor efficient techniques for poor farmers; another is to change their production mix to meet their home consumption requirements, as with the case of vegetable gardens, poultry and fish production, and even milk production[1].

4. An additional imperative is to develop and transfer low-input techniques for marginal peasants farming in sloping hillsides and other fragile soils. It is necessary to diffuse minimum tillage practices and soil conservation practices like small terraces, and green barriers. Plan Sierra in the Dominican Republic and Granja Loma Linda in Honduras are good examples of the technical viability of low-input practices which besides improving peasant efficiency allow for resource sustainability (Benito, 1989).

4. The development of sustainable farming among marginal peasants will require that the mentioned technical imperatives be complemented with development of new institutions for externalizing the costs of deforestation, soil degrada-

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1. Plan Sierra in the Dominican Republic, has an experimental program called *la vaca atada*. Peasants produce milk for family consumption and even a market surplus, but the cow doesn't grass in open fields but is kept tied and fed with hay and other forrages.

tion, and downstream silting. Plan Sierra in the Dominican Republic is based on the principle of transferring income from downstream commercial farmers toward upstream peasants; aside from peasants themselves, farmers in the valleys are major beneficiaries of the reduction of silting in dams.

4. A faster transfer of low-input techniques and more diversified commodity mix among peasants will also require appropriate delivery institutions. It will be necessary to consider international programs like CATIE and CIMMYT-PECYC, non-governmental approaches like Granja Loma Linda, in Santa Lucia, Honduras, and joint ventures of official and non-governmental institutions like Plan Sierra, in the Dominican Republic.

4. No technical fix by itself will be able to reduce in a substantial amount the structural poverty of marginal peasants, although development and transfer of alternative practices will alleviate it. For a majority of these peasants the long run solution is to increase the earning power of their younger generations, and the ultimate answer is a massive program of investment in human capital. This approach will take a significant change in the tax and subsidy structure of the region. Subsidizing investment in human capital is a transfer approach which does not distort prices--it is both efficient and fair in the long run [1].

Imperatives for Beef and Milk Producers

4. With the fall in the international price of sugar, the domestic prices of sugar cane by-products have decreased, opening a possibility for the reduction in the costs of animal feeds. If in addition credit subsidies are reduced, and real exchange rates increases, an efficient alternative for Central America is to build its livestock programs on the improvement of the dual-purpose system. There exist technical and economic considerations for this approach. Under dual purpose systems growers produce both for the milk and beef markets with herds integrated with cows of mixed breeding, mostly crossbreeds of Criollo and Zebu with Holstein and Brown Swiss. A crossbred based on Criollo is very resilient within the conditions of subtropical or tropical regions. Depending on the relation between milk and beef prices, growers reorient their business toward milk or beef, by changing the crossbred and the age/sex structure of the herd. While average yields of dual purpose systems are smaller than in specialized systems, their costs are also lower and the production system is more flexible[2] (Carlos Benito 1987).

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1. The bias of international lending institutions toward infrastructure projects and equipments during the 1960's and 1970's was consistent with the distribution of power of vested-interest groups in the region. The consequence was a price-distorting tax and subsidy structure. Changing in a less price-distorting structure will require a strong change in the conditions of international lending and donations, as well as an educational effort for introducing new political ideologies in the region. The preference for price-distorting subsidies and taxes run deep in Central America and other Latin American countries both among the left and the right.

2. The short run elasticity of supply of milk and beef is higher in a tropical country than in a temperate region (Carlos Benito, 1987).

4. An increase in the real exchange rate will induce an expansion both of beef production, an exportable, and milk production, an importable. Major technical imperatives for increasing their competitiveness are applied research in forage production and utilization, management production using records, reproductive management, reducing calfhood mortality, and producing and handling of clean milk. These imperatives are specially relevant for Honduras, Nicaragua, and the Dominican Republic. It will be necessary to prepare specialists in dairy production, nutrition, breeding, pasture and range management, biometrics, ecology and production systems.

Imperatives for Frontier Farmers

4. The most important imperatives for frontier farmers are institutional in nature. Among the major challenges are the transformation of migratory farming into permanent farming systems, to reduce overgrazing, and to prevent irrational deforestation. It will be necessary to investigate institutions for assignment of property rights and land leasing contracts which induce a sustainable type of agriculture. However, some of the technical imperatives for marginal peasants will apply to frontier farmers, as with the case of low-input farming and soil conservation techniques for hillsides and other fragile environments.

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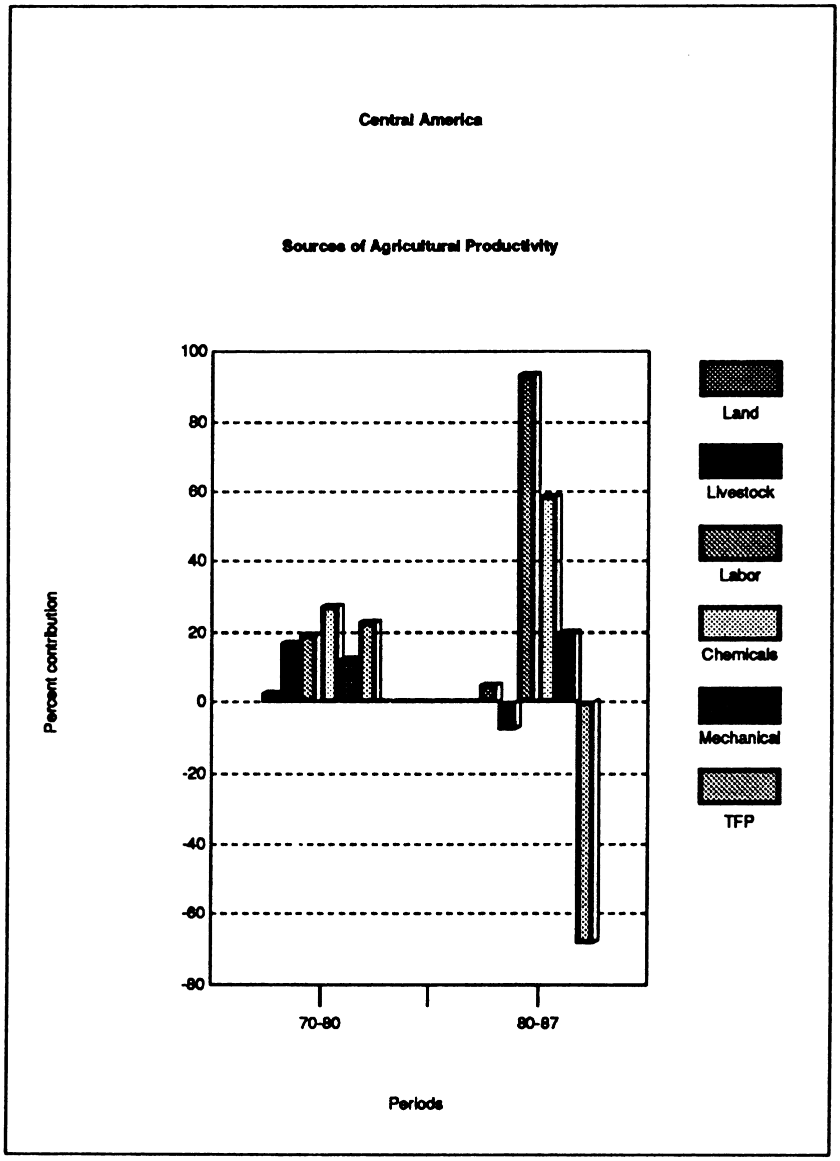
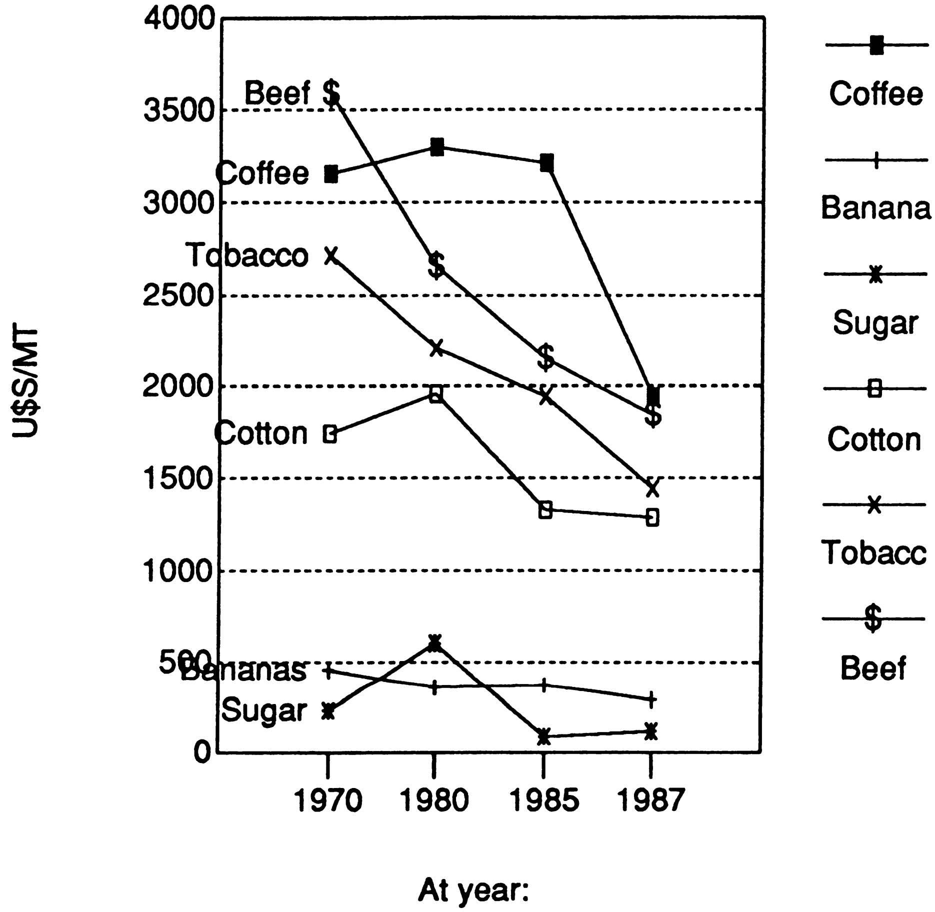
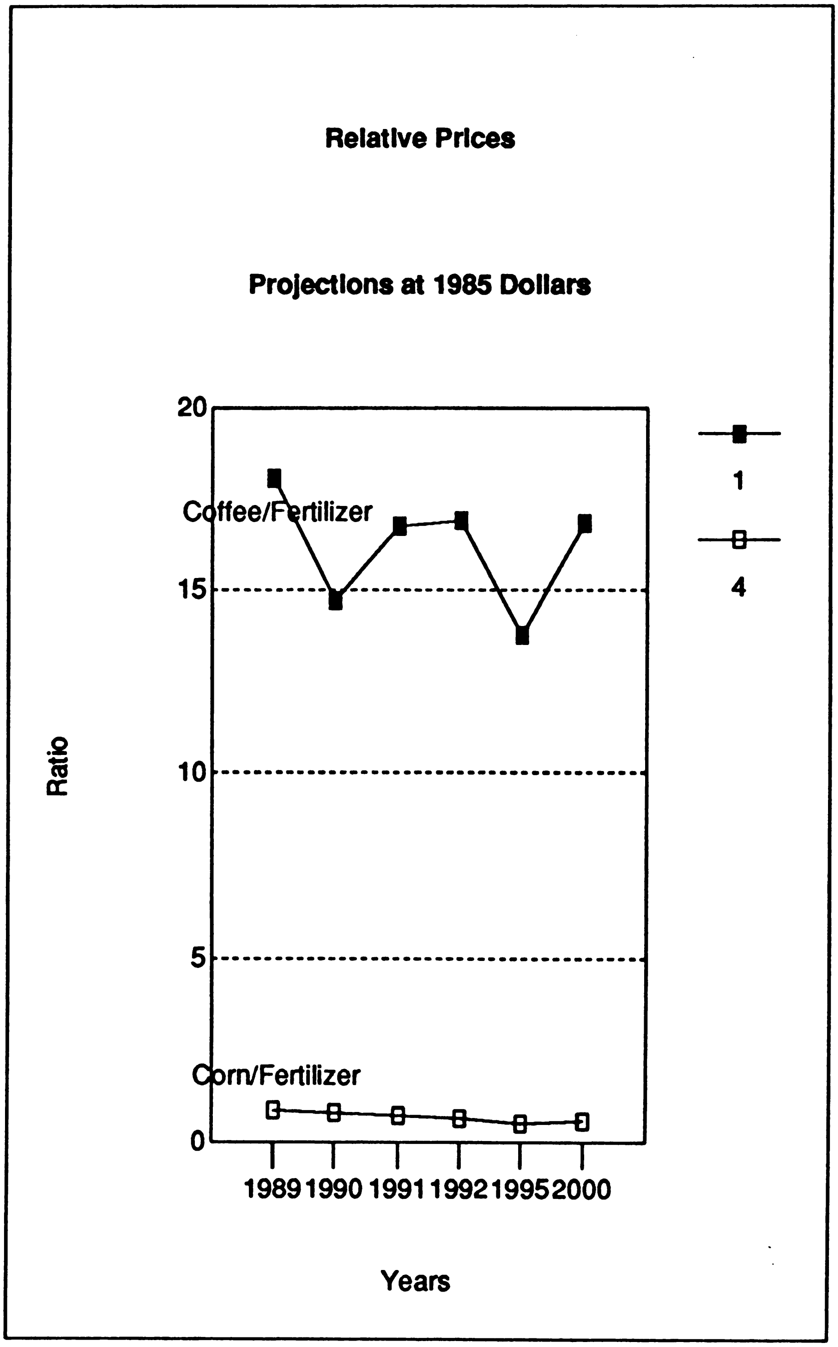
Graphical Annex


Central America
Sources of Agricultural Productivity
100
80
60
40
20
0
-20
-40
-60
-80
Percent contribution
70-80
80-87
Periods
Land
Livestock
Labor
Chemicals
Mechanical
TFP

Exportables: Price History

Intern. Market-In 1985 Constant Dollars





Relative Prices
Projections at 1985 Dollars
Ratio
20
15
10
5
0
Coffee/Fertilizer
Corn/Fertilizer
1
4
1989
1990
1991
1992
1995
2000
Years

Statistical Appendix

Table A.1
CENTRAL AMERICA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	1944	18309	9.4	100.0	100.0
EXPORTABLES	394	2796	7.1	20.3	15.3
Traditional	334	2555	7.6	17.2	14.0
Normal	244	1617	6.6	12.6	8.8
In Crisis	90	938	10.4	4.6	5.1
Non Traditional	61	240	3.9	3.1	1.3
IMPORTABLES	1233	3925	3.2	63.4	21.4
Mechanical Intensive	64	1158	18.1	3.3	6.3
Input Intensive	345	1642	4.8	17.7	9.0
Marginal	855	1125	1.3	44.0	6.1
OTHERS	317	11588	36.6	16.3	63.3
Frontier Farming	129	3115	24.2	6.6	17.0
Livestock and Milk	188	8473	45.1	9.7	46.3

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures

Table A.2
GUATEMALA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	848	3235	3.8	100.0	100.0
EXPORTABLES	179	718	4.0	21.1	27.3
Traditional	145	653	4.5	17.1	24.9
Normal	124	388	3.1	14.7	14.8
In Crisis	20	265	13.0	2.4	10.1
Non Traditional	34	65	1.9	4.0	2.5
IMPORTABLES	612	1126	1.8	72.2	19.7
Mechanical Intensive	5	97	19.4	0.6	3.7
Input Intensive	133	608	4.6	15.7	23.1
Marginal	474	421	0.9	55.9	16.0
OTHERS	57	1391	24.4	6.7	53.0
Frontier Farming	51	873	17.1	6.0	33.3
Livestock and Milk	6	518	86.3	0.7	19.7

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.3
EL SALVADOR: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	197	1801	9.2	100.0	100.0
EXPORTABLES	17	456	27.6	8.4	25.3
Traditional	16	439	27.4	8.2	24.4
Normal	8	335	40.5	4.2	18.6
In Crisis	8	104	13.4	3.9	5.8
Non Traditional	1	17	33.0	0.3	1.0
IMPORTABLES	165	810	4.9	84.0	45.0
Mechanical Intensive	3	114	38.1	1.5	6.4
Input Intensive	82	600	7.3	41.7	33.3
Marginal	80	95	1.2	40.7	5.3
OTHERS	15	535	35.7	7.6	29.7
Frontier Farming					
Livestock and Milk	15	535	35.7	7.6	29.7

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures. Land estimates used here are higher than FAO reports.

Table A.4
HONDURAS: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	340	4315	13.4	100.0	100.0
EXPORTABLES	84	920	11.0	24.7	21.3
Traditional	68	828	12.2	20.0	19.2
Normal	42	552	13.1	12.3	12.8
In Crisis	26	276	10.6	7.6	6.4
Non Traditional	16	92	5.8	4.7	2.1
IMPORTABLES	182	865	5.3	53.6	20.0
Mechanical Intensive	36	567	15.6	10.7	13.1
Input Intensive	27	120	4.5	7.9	2.8
Marginal	119	178	1.5	35.0	4.1
OTHERS	74	2530	34.2	21.7	58.6
Frontier Farming	47	1180	25.1	13.8	27.3
Livestock and Milk	27	1350	50.0	7.9	31.3

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures

Table A.5
NICARAGUA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	205	4237	20.7	100.0	100.0
EXPORTABLES	15	236	16.2	7.1	5.6
Traditional	15	228	15.6	7.1	5.4
Normal	5	79	17.0	2.3	1.9
In Crisis	10	149	15.0	4.9	3.5
Non Traditional	2	8	4.3	0.9	0.2
IMPORTABLES	124	501	4.0	60.8	11.8
Mechanical Intensive	4	99	25.1	1.9	2.3
Input Intensive	27	120	4.5	13.0	2.8
Marginal	94	282	3.0	45.8	6.6
OTHERS	66	3500	53.3	32.1	82.6
Frontier Farming	28	1050	37.5	13.7	24.8
Livestock and Milk	38	2450	65.0	18.4	57.8

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures. Land estimates used here are higher than FAO reports.

Table A.6
COSTA RICA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	191	2826	14.8	100.0	100.0
EXPORTABLES	71	295	4.2	37.1	10.4
Traditional	64	242	3.8	33.5	8.6
Normal	50	177	3.6	26.1	6.3
In Crisis	14	65	4.6	7.4	2.3
Non Traditional	7	53	7.8	3.5	1.9
IMPORTABLES	69	231	3.3	36.2	8.2
Mechanical Intensive	14	140	10.0	7.3	5.0
Input Intensive	52	86	1.7	27.2	3.0
Marginal	4	7	2.0	1.8	0.2
OTHERS	51	2300	45.1	26.7	81.4
Frontier Farming		n.s.			
Livestock and Milk	51	2300	45.1	26.7	81.4

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures

Table A.7
PANAMA: TYPOLOGY OF AGRICULTURAL PRODUCERS
Distribution by Number of Farms and Farm Size-1989

TYPE OF PRODUCERS	FARMS (1000)	LAND 1000 HA	FARM SIZE HA	PERCENT OF FARMS	PERCENT OF LAND
TOTAL	163	1895	11.6	100.0	100.0
EXPORTABLES	29	171	5.9	17.8	9.0
Traditional	27	165	6.1	16.6	8.7
Normal	15	86	5.7	9.2	4.5
In Crisis	12	79	6.6	7.4	4.2
Non Traditional	2	6	3.0	1.2	0.3
IMPORTABLES	80	392	4.9	49.1	20.7
Mechanical Intensive	2	141	78.3	1.1	7.4
Input Intensive	24	108	4.5	14.7	5.7
Marginal	84	143	1.7	51.5	7.5
OTHERS	54	1332	24.7	33.1	70.3
Frontier Farming	3	12	4.4	1.6	0.6
Livestock and Milk	51	1320	25.9	31.3	69.7

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989
Cultivated Land and Pastures

Table A.8
GUATEMALA: FARM GROSS INCOME AND LAND PRODUCTIVITY
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS %	FARM GROSS INCOME US$ per year	LAND PRODUC-TIVITY*
TOTAL	100.0	3530	926
EXPORTABLES	21.1	8099	2016
Traditional	17.1	8572	1899
Normal	14.7	8010	2565
In Crisis	2.4	11995	924
Non Traditional	4.0	6085	3203
IMPORTABLES	72.2	1954	1063
Mechanical Intensive	0.6	14880	767
Input Intensive	15.7	7429	1625
Marginal	55.9	283	319
OTHERS	6.7	6126	251
Frontier Farming	6.0	4847	283
Livestock and Milk	0.7	16995	197

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.9

EL SALVADOR: FARM GROSS INCOME AND LAND PRODUCTIVITY

Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS	FARM GROSS INCOME	LAND PRODUC-TIVITY*
	%	US$ per year	
TOTAL	100.0	9216	1006
EXPORTABLES	8.4	64985	2358
Traditional	8.2	65669	2398
Normal	4.2	109975	2718
In Crisis	3.9	18389	1369
Non Traditional	0.3	43923	1331
IMPORTABLES	84.0	3912	797
Mechanical Instensive	1.5	91139	2390
Input Intensive	41.7	4327	591
Marginal	40.7	216	181
OTHERS	7.6	6066	170
Frontier Farming			
Livestock and Milk	7.6	6066	170

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.10

HONDURAS: FARM GROSS INCOME AND LAND PRODUCTIVITY

Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS	FARM GROSS INCOME	LAND PRODUC-TIVITY*
	%	US$ per year	
TOTAL	100.0	11368	897
EXPORTABLES	24.7	29895	2730
Traditional	20.0	29402	2415
Normal	12.3	42399	3226
In Crisis	7.6	8407	792
Non Traditional	4.7	31967	5563
IMPORTABLES	53.6	6145	1295
Mechanical Intensive	10.7	24529	1571
Input Intensive	7.9	7022	1580
Marginal	35.0	337	225
OTHERS	21.7	3204	94
Frontier Farming	13.8	3264	130
Livestock and Milk	7.9	3100	62

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.11
NICARAGUA: FARM GROSS INCOME AND LAND PRODUCTIVITY
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS	FARM GROSS INCOME	LAND PRODUC-TIVITY*
	%	U$S per year	
TOTAL	100.0	3348	162
EXPORTABLES	7.1	18840	1164
Traditional	7.1	17945	1148
Normal	2.3	19176	1128
In Crisis	4.9	17370	1158
Non Traditional	0.9	7018	1632
IMPORTABLES	60.8	1510	375
Mechanical Intensive	1.9	8609	343
Input Intensive	13.0	2597	577
Marginal	45.8	903	301
OTHERS	32.1	3389	64
Frontier Farming	13.7	5850	156
Livestock and Milk	18.4	1560	24

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.12
COSTA RICA: FARM GROSS INCOME AND LAND PRODUCTIVITY
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS	FARM GROSS INCOME	LAND PRODUC-TIVITY*
	%	US$ per year	
TOTAL	100.0	11396	770
EXPORTABLES	37.1	22850	5489
Traditional	33.5	17416	4608
Normal	26.1	20936	5894
In Crisis	7.4	5026	1097
Non Traditional	3.5	74428	9542
IMPORTABLES	36.2	3257	973
Mechanical Intensive	7.3	10970	1097
Input Intensive	27.2	1340	810
Marginal	1.8	555	280
OTHERS	26.7	6539	145
Frontier Farming			
Livestock and Milk	26.7	6539	145

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.13
PANAMA: FARM INCOME AND LAND PRODUCTIVITY
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF FARMS	FARM GROSS INCOME	LAND PRODUC-TIVITY*
	%	US$ per year	
TOTAL	100.0	7335	631
EXPORTABLES	17.6	29855	5071
Traditional	16.6	31777	5200
Normal	9.2	53091	9260
In Crisis	7.4	5135	780
Non Traditional	1.2	4080	1360
IMPORTABLES	49.1	2860	584
Mechanical Intensive	1.1	68226	871
Input Intensive	14.7	3519	782
Marginal	51.5	257	151
OTHERS	33.1	1869	76
Frontier Farming	1.6	2210	508
Livestock and Milk	31.3	1864	72

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

* Land productivity: Farm gross income/Land. Notice that in other tables productivity is given in value added units.

Table A.14
GUATEMALA: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADINGLEADING COMMODITIES: FOR EXPORTS Ten Years or More	Last Five Years	Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	27.3				
Traditional	24.9				
Normal	14.8	Coffee, Bananas			
In Crisis	10.1	Cotton, Sugar Cane, Cardomen			
Non Traditional	2.5		Broccoli, Melons Flowers, Vegetables		
IMPORTABLES	19.7				
Mechanical Intensive	3.7				Rice, Sorghum
Input Intensive	23.1				Corn, Rice Potatoes
Marginal	16.0				Corn, Sorghum
OTHERS	53.0				
Frontier Farming	33.3				Beef, Corn
Livestock and Milk	19.7	Beef			Beef Milk

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.15
EL SALVADOR: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADING COMMODITIES: FOR EXPORTS Ten Years or More	FOR EXPORTS Last Five Years	FOR EXPORTS Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	25.3				
Traditional	24.4				
Normal	18.6	Coffee			
In Crisis	5.8	Sugar Cane Cotton			
Non Traditional	1.0		Cucumber, Watermelons Melons	Citrus, Broccoli	
IMPORTABLES	45.0				
Mechanical Intensive	6.4				Beans, Corn
Input Intensive	33.3				Rice, Mango Fruits, Vegetables
Marginal	5.3				Corn, Beans Sorghum
OTHERS	29.7				
Frontier Farming	n.s.				
Livestock	29.7				Beef, Milk

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.16
HONDURAS: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADING COMMODITIES: FOR EXPORTS Ten Years or More	Last Five Years	Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	21.3				
Traditional	19.2				
Normal	12.8	Bananas Coffee			
In Crisis	6.4	Sugar Cane Tabacco, Afr. Palm			
Non Traditional	2.1		Pineapple, Orange Melons		
IMPORTABLES	20.0				
Mechanical Intensive	13.1				Rice, Vegetables
Input Intensive	2.8				
Marginal	4.1				Corn, Beans
OTHERS	58.6				
Frontier Farming	27.3				Corn, Beans Beef
Livestock	31.3	Beef			Beef Milk

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A. 17
NICARAGUA: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADING COMMODITIES: FOR EXPORTS Ten Years or More	FOR EXPORTS Last Five Years	FOR EXPORTS Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	5.6				
Traditional	5.4				
Normal	1.9	Coffee Bananas			
In Crisis	3.5	Sugar Cane Cotton, Tabacco			
Non Traditional	0.2		Sesame Sorghum	Avocado, Mango Melons, Watermelons	
IMPORTABLES	11.8				
Mechanical Intensive	2.3				Rice, Corn Sorghum, Beans
Input Intensive	2.8				Rice, Corn, Sorghum Beans, Vegetables
Marginal	6.6				Corn, Beans Yuca
OTHERS	82.6				
Frontier Farming	24.8				Corn, Beans, Yuca
Livestock	57.8	Beef			Beef, Milk

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.18
COSTA RICA: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADING COMMODITIES: FOR EXPORTS Ten Years or More	Last Five Years	Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	10.4				
Traditional	8.6				
Normal	6.3	Coffee Bananas Yuca			
In Crisis	2.3	Cocoa Sugar Cane			
Non Traditional	1.9		Flowers Ornamentals	Pineapple Macedonia	
IMPORTABLES	8.2				
Mechanical Intensive	5.0				Rice Sorghum
Input Intensive	3.0				Corn, Rice Potatoes
Marginal	0.2				Corn, Beans
OTHERS	81.4				
Frontier Farming	n.s.				Apple, Avocados
Livestock	81.4		Beef		Beef

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.19
PANAMA: AGRICULTURAL COMMODITIES
Distribution by types of producers - 1989

TYPE OF PRODUCERS	PERCENT OF LAND %	LEADING COMMODITIES: FOR EXPORTS Ten Years or More	Last Five Years	Begining	FOR DOMESTIC MARKET
TOTAL	100.0				
EXPORTABLES	9.0				
Traditional	8.7				
Normal	4.5	Coffee Bananas			
In Crisis	4.2	Sugar Cane			Sugar
Non Traditional	0.3		Melons	Watermelons	
IMPORTABLES	20.7				
Mechanical Intensive	7.4				Rice Sorghum
Input Intensive	5.7				Corn, Beans Potato, Tomato
Marginal	7.5				Corn, Beans Rice, Yuca
OTHERS	70.3				
Frontier Farming	0.6				Corn, Beans Rice, Plantain
Livestock	69.7	Beef			Beef, milk

Source: Own Estimations based on data from IICA, Programa de Generacion y Transferencia de Tecnologia, 1989

Table A.20
INTERNATIONAL PRICES FOR CENTRAL AMERICAN COMMODITIES
In 1985 Constant Dollars

		1970	1980	1985	1987
PRICES OF EXPORTABLES	(1985 Doll)				
Coffee	US$/MT	3160	3300	3210	1950
Bananas	US$/MT	455	363	378	293
Sugar	US$/MT	223	606	90	116
Cotton	US$/MT	1740	1960	1320	1280
Tobacco	US$/MT	2717	2205	1950	1437
Oranges	US$/MT	462	374	398	354
Beef	US$/MT	3590	2650	2150	1850
PRICES OF IMPORTABLES	(1985 Doll)				
Corn	US$/MT	161	120	112	59
Rice	US$/MT	396	416	216	179
Sorghum	US$/MT	143	124	103	57
Wheat	US$/MT	173	183	173	104
Fertilizer-Urea	US$/MT	133	213	136	91
RELATIVE PRICES					
Coffee/Fertilizer	Ratio	24	15	24	21
Bananas/Fertilizer	Ratio	3	2	3	3
Sugar/Fertilizer	Ratio	2	3	1	1
Cotton/Fertilizer	Ratio	13	9	10	14
Tobacco/Fertilizer	Ratio	20	10	14	16
Coffee/Corn	Ratio	20	28	29	33
Corn/Wheat	Ratio	0.9	0.7	0.6	0.6
Corn/Fertilizer	Ratio	1.2	0.6	0.8	0.6

Source: World Bank, International Econ. Depart., International Commodity Division. Relative prices:own estimations.

Table A.21
PROJECTIONS OF INTERNATIONAL COMMODITY PRICES
In 1985 Constant Dollars

		1989	1990	1991	1992	1995	2000
PRICES OF EXPORTABLES	(1985 Doll)						
Coffee	US$/MT	1730	1280	1490	1640	1860	2100
Bananas	US$/MT	352	319	297	296	291	281
Sugar	US$/MT	2050	2710	3400	3140	2160	2160
Cotton	US$/MT	1220	1250	1190	1190	1160	1090
Tobacco	US$/MT	1551	1608	1562	1516	1377	1318
Oranges	US$/MT	324	320	311	311	310	300
Beef	US$/MT	1870	1800	1700	1610	1890	2000
PRICES OF IMPORTABLES	(1985 Doll)						
Corn	US$/MT	81	70	65	61	65	73
Rice	US$/MT	233	197	181	162	168	166
Sorghum	US$/MT	77	64	60	57	61	68
Wheat	US$/MT	146	128	117	108	104	113
Fertilizer-Urea	US$/MT	96	87	89	97	135	125
RELATIVE PRICES							
Coffee/Fertilizer	Ratio	18	15	17	17	14	17
Bananas/Fertilizer	Ratio	4	4	3	3	2	2
Sugar/Fertilizer	Ratio	21	31	38	32	16	17
Cotton/Fertilizer	Ratio	13	14	13	12	9	9
Tobacco/Fertilizer	Ratio	16	18	18	16	10	11
Coffee/Corn	Ratio	18	15	17	17	14	17
Corn/Wheat	Ratio	1	1	1	1	1	1
Corn/Fertilizer	Ratio	1	1	1	1	0.5	1

Source: World Bank, International Econ. Depart., International Commodity Division. Relative prices: own estimations

Table A.22
CENTRAL AMERICA: FACTOR ALLOCATION AND FACTOR PRICES
Centro-America and Panama - 1988/89

	Units	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama
FERTILIZER/LAND	MT/1000HA	62	90	22	54	162	61
FACTOR PRICE RATIOS							
Fertilizer/Land Rent	HA/10 MT	20	21	80	110	10	40
Wage/Land Rent	HA/1000 D	11	40	53	40	24	67
Tractor/Land Rent	HA/100 PR	16	16	23	49	7	17
LAND/LABOR	HA ARABLE	1.4	1.2	2.1	2.8	2.1	2.7
TRACTOR/LABOR	TRAC/1000	3	6	4	5	25	30
FACTOR PRICE RATIOS							
Land Rent/Wage	DAYS	88	25	19	25	42	15
Tractor Rent/Wage	DAYS	8.7	4.2	10	67	2	4

Source: Own estimations, based on IICA, Generacion y Transferencia de Technologia.

Table A-23
CENTRAL AMERICA: AGRICULTURAL PRODUCTION AND TRADE
Distribution by Countries - 1987

		Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Dominican Republic	Central America
GNP per caput	Dollars	903	661	587	617	1412	1828	1162	1024
Population	Millones	8.4	4.9	4.7	3.5	2.8	2.3	6.7	33
Gross National Product	Mill Doll.	7615	2361	2744	2160	3939	4156	7803	4397
Agriculture in GDP	%	28	36	26	23	19	9	19	23
Agric. Exportables/ Agric. Importables	Proportion	4.5	2.7	5.6	2.2	4.9	1.3		4
Agricultural Exports	Mill Doll	745	409	677	195	779	267		3072
Agricultual Imports	Mill Doll	167	149	120	89	160	204		889
EXPORTS: TEN LEADING PRODUCTS-1985	% on Total								
Traditional-Normal		39.5%	56.1%	65.6%	37.5%	57.2%	31.9%		46.0%
Traditional-In Crisis		10.7%	4.2%	1.0%	34.8%	1.5%	9.1%		10.2%
Non Traditional		14.0%		3.1%					2.9%
Livestock				1.9%	4.6%	5.8%			3.1%
Lumber				4.5%					4.5%
Fishing			3.8%	6.4%	3.4%	2.1%	21.2%		7.4%
Unclassified		35.8%	35.9%	17.5%	19.7%	33.4%	37.8%		30.0%

Sources: ECLA

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Meet Central American Challenges"

TECHNOLOGICAL INSTITUTIONS IN THE REGION: EVOLUTION AND CURRENT STATE

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I. INTRODUCTION

Over the past four decades Central America has experienced substantial agricultural growth. Yet this growth relied primarily on increasing the use of traditional land and labor inputs. The prospects for continuing such trends seem unfavorable with a rural labor force that will soon be decreasing, with most of the best and easily accessible lands already in use or requiring heavy investment for such a purpose, with mounting evidence of ecological decline, and with increasingly difficult and demanding external as well as internal markets. Already many crops show either declining or stationary yields in the eighties.

A steady supply of innovations is clearly needed to allow agricultural production to intensify and diversify on existing lands and to develop safely on new ones while counteracting ecological problems. A yet substantial population increase in coming decades, the competitive requirements of international markets and the difficulties of growth in other economic sectors further enhance the need for improved agricultural technology. Failure to invigorate agricultural growth--for which technology delivery capabilities will be essential--could undermine the region's economic foundations. Institutions and institutional change in the technology system remain the most directly accessible point of leverage for action here. This makes it essential to understand clearly their potential and problems.

The purpose of this paper is to review the major technology institutions in Central America (CA), their origins, development and evolution. The aim has been to offer a coherent interpretation of the role, potential and problems of these institutions. The paper relies primarily on existing secondary materials. It seeks to bring together the information and experience on the subject that exists within IICA's Program II. In addition to the above, a primary search for data was conducted in all countries of Central America and more intensively in those covered by the USAID-ROCAP grant, i.e., Costa Rica, Honduras, Guatemala and El Salvador.

The rest of this chapter introduces the concepts used in the paper, namely a systems perspective, differentiation, integration and institutionalization, and a learning approach stressing continuities and discontinuities. Chapter 2 presents an extended review of technology institutions in the region, looking at their background and origin, and at major patterns and trends in their development. Chapter 3 addresses a number of complexities in technical change and adoption, from an institutional standpoint and concludes by outlining the major learning processes involved. In finalizing, Chapter 4 sums up the argument stressing the various discontinuities in institutional learning processes and goes on to advocate a more differentiated approach to technology delivery. Building on this, we propose an adjusted role for the public sector in agricultural technology activities and outline potential implications in relation to major kinds of technology users. In concluding, we suggest and discuss recommendations.

A. AGRICULTURAL TECHNOLOGY AND KNOWLEDGE SYSTEMS

Technology and related knowledge generation and transfer are not isolated phenomena. Rather they take place within the context of what may be called an agricultural technology system (ATS) (Roling, 1990). An ATS is a structured arrangement of dynamically interconnected parts--organizations and/or persons--generating, transforming, delivering and using agricultural technology and related knowledge. An ATS involves more than just organizations. It also comprises other related elements such as resources, norms, and legal frameworks, and it may be viewed as a subsystem within broader knowledge systems or, even more generally, as part of larger agricultural and economic systems. An ATS approach allows for both global and partial analyses of complex phenomena and for considering synergy resulting from the emergent properties of interacting parts.

As a "social" system, an ATS has particular features. If it is simply a set of reacting interconnected parts without further elaboration, then it must be viewed as governed by environmental stimuli. However, another possibility exists for both human and non human systems--that one or more of the components play the role of a control mechanism so that the system can function cybernetically. This implies a monitoring of the environment through feedback and the use of this to direct the actions of the system through feedforward processes (Manderscheid, 1986:44). As we shall emphasize, successful ATS require that part of control responsibilities be widely distributed among system components.

An important characteristic of ATS as social systems is that they are symbol forming and symbol mediated arrangements. Knowledge and understandings play key roles, not only in system relations to their environments but also in their internal operations and capabilities1. In actuality, capabilities are knowledge-governed and, consequently, affected by the learning and agreement processes influencing this knowledge.

From an evolutionary perspective, organizations and systems may be evaluated in terms of their cybernetic capabilities to manage environmental challenges and demands. We introduce the concept of adaptive capacity to designate the "intelligent" steering competences that organizations and systems develop. Systems can engage in learning processes that lead to raising their internal capabilities for dealing with environmental challenges. What this means is that systems can learn to behave like intelligent individuals, taking in information from their environments, processing it, and generating a response that combines both the implications of the data and internal tendencies or goals.

Within the Central American context, a number of categories of institutions are relevant to an analysis of technological and technical change. The most important include the following: a.public agricultural research and extension agencies, b. private and non governmental organizations directly engaged in research and technology delivery, c. universities and schools likewise involved, d.international, regional and foreign research centers and universities, e.credit and banking institutions for agriculture, f.private sector providers of inputs and production services, g. public and quasi public agencies involved in agrarian reform, rural development, land improvement, or agricultural promotion, and h. commodity associations and producer organizations.

In addition to organizations that directly supply or demand technology there are others relevant to the workings of an ATS. These include the educational system as a provider of human capital, central governments and agriculture ministries as policymakers and providers of funding, and international lending agencies and donors such as USAID, USAID/ROCAP, IDB and the World Bank. While the emphasis of the paper will be focused on the first and second categories, the others should be kept in mind.

B. DIFFERENTIATION AND INTEGRATION

Many institutional changes assume the form of differentiation (or integration) initiatives.2 Examples of the former are the creation of new programs within complex organizations (such as new research units or areas) as well as the creation of new and different organizations for special purposes.

Differentiation processes can raise the adaptive capacity of an ATS through increasing its internal complexity which in turn may potentially enhance its capabilities for responding to more heterogeneous environments and mandates. If so, it raises a higher balance of reciprocities between itself and its environments. However, whether this happens in given cases is an empirical question. Specific differentiations may prove inappropriate, overload the system, or lead to evolutionary dead ends. On the other hand, differentiation, by creating a relative autonomy for specialized activities and actors can raise problems of integration.

The latter may be taken to mean two things. One, is simply to designate the linkage of system activities or functions. For instance, the solution of practical technical problems in agriculture requires bringing together the specialized knowledge of researchers and extension agents with the understanding and views of those bearing the problem, i.e., farmers. In some cases such functional integration is performed through mediating automatic mechanisms such as the market; in other cases specific integrating or articulating mechanisms need to be created.

Two, integration may be understood as social integration, i.e., the creation of common views by way of shared understandings, norms and values. By virtue of its breaking up activities into specialized and different niches, differentiation creates a structural condition favoring the emergence of differential views. This heterogeneity ultimately can lead to difficulties even when mechanisms of functional integration are operative and in place. Consequently, although this paper addresses mostly issues of functional articulation, the significance of social integration should be kept in mind.

Much of what has taken place in Central American ATS can be viewed in terms of differentiation processes of new technology delivery organizations and of new research and extension programs within them. Likewise, many of the existing problems derive from inadequate (i.e., non adaptive) forms of differentiation, from institutional discontinuities and from unintegrated activities, structures and functions. These various processes can be reviewed in terms of their contribution (positive or negative) to raising the system's adaptive capacity.

C. SYSTEM INSTITUTIONALIZATION AND EVOLUTION

The institutionalization of systems and organizations involves a twofold set of balances. On the one hand, it means that a steady3 set of exchanges have been worked out among its parts. Research and transfer organizations provide technology to farmers in return for their political and, in some cases, financial support. Likewise, mandators supply funding and guidelines in return for benefits deriving from the consequences of technology provision. Second, vis-a-vis the broader society, the ATS offers technology in return for acceptance, support and mandate. Achieving a suitable balance of exchanges or reciprocities both among parts of a system and between the system or subsystems and their environments, will, therefore, constitute a primary condition for institutionalization. Expressed differently, this simply means that the organizations making up an ATS as a whole, if they are to persist over time and make a contribution, will have to work out a suitable--i.e.,widely accepted as satisfactory--balance between what they take and what they give to society. The same basic consideration applies to relations among the organizations making up the ATS.

Exchange patterns tend to crystallize into shared understandings and beliefs about reciprocities which become a guide in themselves. These "normative" patterns can usually take over the guiding function of direct exchanges. If, over time, however, in a dynamic situation, the basic reciprocities underlying a normative settlement become unbalanced this can make the system lose institutionalization. In sum, system building involves working out reciprocities and developing steering or adaptive capacity to adjust performance in the face of changing mandates and environments. Such, of course, is easier said than done. Social systems are multifaceted constructions which, in addition to patterned work activities, involve political (authority, power, status), economic, motivational and cultural arrangements. Imbalances in any of these can feed backward or forward into work and performance spheres. This gives deliberate system building and institutionalization efforts a particular complexity, since work structuring in itself represents only one dimension. Successful efforts will also need to consider motivational, normative, political and economic dimensions.

Deliberate innovations in systems--those not generated by drift or other processes--imply at least three kinds of conditions. One concerns basic knowledge about the innovation: its conceptual and methodological nature and implications. Here the focus will be on the learning processes taking place and the conditions for their advancement. A second aspect involves institutional knowledge which implies appropriate arenas for the free discussion of innovations and the development of shared understandings regarding their validity and implementation. A third aspect comprises the issues of impetus and sources of change and adoption--the question of prime movers. (Roling, 1990). Stated summarily in more simple terms this simply means having the innovation, knowing how to implement it, and having a source of impetus for making the change.

D. CONTINUITIES AND DISCONTINUITIES IN SYSTEM EVOLUTION

Any discussion of system evolution should avoid a gratuitous assumption of linear progress and stick to the empirical record. Evolutionary dead ends as well as discontinuity are at least equally possible. An important part of the discussion in this paper will focus on continuities and discontinuities in the building of ATS in the region. Discontinuities, both across and within institutions, can have the effect of reducing the system to a set of interrelated parts largely governed by short term environmental stimuli which hinders potential transformation into an integrated whole with a steering capacity oriented toward institutionalization. Precisely the thesis of the paper argues that despite important learning processes taking place in the region, this has tended to occur. While external conditions--namely the expansion of the international economy and the development of technology in it--as well as the evolution of regional socioeconomic conditions contribute to heighten the priority of technical change, the effects of fiscal crisis and other variables upon the state are largely responsible for persisting discontinuities.

II. PREMISES, ORIGINS AND EVOLUTION OF CENTRAL AMERICAN AGRICULTURAL TECHNOLOGY INSTITUTIONS

A-THE CONTEXT OF EMERGING INSTITUTIONS

A number of external conditions favored the emergence and growth of Central American interest in agricultural technology institutions.

1. The Postwar Context

The end of the Second World War brought with it a heightened interest in economic development and a new faith in the possibilities of science and technology. For agriculture, a large pool of modern technology was believed to be ready and available to be transferred (Evenson, 1981). Within this perspective, the United States promoted modernization and channeled aid to developing countries seeking to encourage the market development of their agriculture (Flora and Flora, 1989).

2. Population Growth and Urbanization

Toward the middle of the century, the population of the six Central American countries began to grow quickly 4. Between 1950 and 1988, it more than tripled from 9.1 to 34.2 million, and the urban percentage rose from 34% in 1960 to 48% in 1988 (BID,1989:484). On the other hand, the labor force in agriculture increased only by 67.4%, from 2.63 to 4.51 million between 1950 and 1988 (ILO,1986;FAO,1989). Since 1950, this has implied a more than doubling of the productive burden on each member of the agricultural labor force, from slightly under 3.5 to over 7.5 persons. Projections based on these trends suggest the agricultural labor force will reach a peak of around 4.45 million in 1997 and then decline from there to 4.42 million by the year 2000. ILO projections estimates the total population of the region for that year at around 48 million which would imply an average load of almost 11 persons per agricultural worker.

Population and urbanization growth have placed an increasing food and raw materials burden on the agricultural sector which has drawn attention to technological and technical considerations.

3. Economic Diversification

A substantial diversification of activities outside of agriculture has taken place. Whereas in 1950 more than 67 percent of the economically active population (EAP) worked in agriculture, by 1988 only 41.9 percent did so (ILO,1986). The degree varied, with Costa Rica and Panama retaining around a quarter of their labor force in agriculture at one end while Guatemala still maintains over 56%. The share of agriculture within the gross domestic product fell from 28.7% in 1960 to 20.35 % in 1987 (BID, 1989:489,493). Although this growth was not as concentrated in the industrial sector as in other Latin American countries, but rather spread out through a number of non agricultural activities, it has still implied the emergence of food and raw material processing industries.

Central American agriculture has undergone a substantial diversification of agricultural efforts into a number of new or previously marginal commodities such as vegetables, fruits, beef and non traditional exports over the past decades. This diversification of regional agricultural production has drawn attention to technical variables. The challenge of engaging in commercial production of a variety of products has made clear the need for a steady and adequate flow of innovations not only to maintain production but to ensure competitiveness and profitability vis-a-vis increasingly demanding markets.

4. International Markets

The expansion and development of international markets for a number of agricultural commodities in the postwar era stimulated their production. Favorable prices for many also helped to induce technical modernization efforts, as was the case with cotton.

5. Availability of New Inputs

By the end of the War, the production and provision of modern inputs for agriculture was rapidly becoming a large industry in DCs, particularly the US. In the region this was reflected through a growing availability and promotion of fertilizers, commercial seeds, implements, machinery and other products. Much of early technical modernization reflected direct adoption processes of such new inputs, and difficulties with the use of these probably stimulated eventually a demand for farming advisory services.

6. Supervised Credit

As part of deliberate efforts to induce both modernization in agriculture and protect financial investments, credit programs for agriculture in the region, first through agrarian banks and later generalized to other banks, were linked to special technical requirements also included in the funding. These normally covered agronomic and management practices, and the use of improved seed, fertilizers and implements. Although its requirements were often honored more in the breach than in practice, it is widely believed that supervised credit has had a substantial impact on the technical modernization of a number of crops.

7. Internal Economic and Social Policy

In general most explicit agricultural policy in the area has sought to promote agricultural modernization, of which the very creation of technology delivery institutions themselves were part. An important stimulus for selective technical modernization has derived from preferential exchange rates favoring the importation of modern inputs and capital goods for agriculture. At a later point in time, and touching upon other social groups, agrarian reform and rural development programs have both involved technical modernization components.

8. Growth of the International Technology System

A huge expansion in the pool of available agricultural technology developed outside of the region has proved important to internal efforts. Critical aspects have included those of the CGIAR centers--particularly CIAT, CIMMYT, CIP and IRRI--as well as those of research centers, universities and multinationals in the DCs. These centers actively speed-up the transfer to national institutions of new developments and seek to involve them in their adjustment and improvement. Additionally, they provide methodological and technical assistance to national efforts, and, often, financial assistance.

9. Development Assistance

Over the past decades, Central American countries have become recipients of much economic aid and development assistance which in part has reflected strategic Cold War considerations. A plethora of foreign governments and international agencies have channeled aid, loans and technical assistance to the modernization of various sectors, and among them, outstandingly, agriculture. Research and extension institutions have not been left out of the process. Over the past decades the World Bank, the International Development Bank (IDB), USAID and USAID/ROCAP, among others, have played a key role in funding agricultural institutions and activities. External funding has increased resources available for knowledge and technology activities in the region although it often appears to have substituted in part for national efforts.

B. INSTITUTIONAL EMERGENCE AND EVOLUTION

1. Origins

Comprehensive research and extension institutions in Central America date back to the forties and early fifties, and display certain specific characteristics. One, in virtually all cases they were the product of joint efforts between local governments and the US government, through the USDA (Table 1). In some instances, such as in Guatemala, earlier institutions predated these, but even here they usually involved joint efforts.

Two, some of the early US efforts in the region, such as those in Nicaragua and Costa Rica, appear related to strategic concerns such as the search for sources of key materials or supplying troops in the Panama Canal Zone (Campos-Sardi,1988:1). More generally, however, U.S. involvement here may be seen as part of a larger overseas assistance effort that began to develop in the forties (Flora and Flora, 1989). Three, the building of technology institutions was part of a broader concerted effort, involving the restructuring or creation of agriculture ministries and related state organizations, with the objective of promoting growth and modernization.

Joint US-national institutions in any case represented a first and temporary phase of institutional development that in most cases extended between 5-10 years. As one of their main contributions, they awakened interest in technology institutions and provided initial funding and staffing for these, although not always in terms of developing and institutionalizing truly indigenous capabilities.5 Perhaps because of this, but also because they were short-lived, major contributions from this early period seem to be rather meager, especially in the case of research.

Another main contribution of joint institutions was to provide an institutional. This model derived from the land grant university-centered system in the US, although necessarily in a modified form. As part of the adjustment, Ministry-based organizations assumed responsibilities which in the US public system were far more decentralized (land grant colleges). In this transfer process, however, a number of direct and indirect links among actors relevant to making the system workable in the US, were left out inadvertently 6. In the absence of these key features, subsequent institutional development lacked important checks and balances, as well as conditions for maintaining or developing necessary linkages and responsiveness.

After the phase of joint sponsorship, development of national institutions proceeded. In the case of research this took either one of two forms. They became units within the line structure of the Agriculture Ministries (Costa Rica, Dominican Republic, Honduras, El Salvador). Livestock research was housed in separate units from crop research in Costa Rica, Honduras, the Dominican Republic and El Salvador, and together with crop research in Panama (IDIAP) and Guatemala (ICTA). Alternatively, in some cases this led eventually to establishing decentralized institutes (INTA in Nicaragua, ICTA in Guatemala, IDIAP in Panama). Extension services on the other hand assumed and retained the form of central units within ministries of agriculture although later they were subject to regional decentralization. Once adopted, these basic organizational forms were retained although subject to periodic and frequent reorganization and change.

2. Expansion and Growth of Research and Extension

The evolution of research organization in the region has been characterized since its beginnings by a rapid increase in a number of institutional dimensions.

a. Organizations

Research and extension in the region began in public organizations. This was a process involving a particular role of the state as a catalyst for modernization and change and reflecting the absence of alternative structures and resources for such functions. Public agricultural technology organizations were of two kinds: the direct research and extension agencies in each country, and other public organizations with some degree of direct research or delivery responsibilities such as the coffee institutes, a few universities, and agrarian reform institutes.

Gradually, a still broader diversification process of institutional structures took place. Key actors here included specific institutional mechanisms for dealing with agricultural credit, post harvest and marketing, regulatory services and supervised credit.

In addition and more recently in most cases, a third category of institutional diversity comprises private and non governmental actors with research and & or transfer of technology responsibilities. This includes such organizations as FHIA in Honduras, FUSADES in El Salvador or ASBANA in Costa Rica. Table 2, while not exhaustive, shows a listing of main actors in this process. Not listed in the table are multinationals, such as United Fruit and United Brands engaging in research on banana, nor does it include the growth and diversification of providers of seeds and agricultural inputs.

Last but not least, a host of foreign, international and regional organizations have emerged in the area. Some play a direct technology performing role while others concentrate on a funding role; and a third group does both. Organizations with a direct technology role have included non governmental organizations as well as foreign universities. CGIAR centers--particularly, CIMMYT, CIAT, CIP, IRRI and ISNAR--have played an active role in the region's technology development. IDB, BIRF, USAID offices and USAID/ROCAP have played a key role in funding many of the activities in the region. In addition the EEC, national European agencies and even the Japanese International Cooperation Agency, have been increasing their projection in the region.

CATIE and IICA are two important technology institutions with a regional spanning capabilities. CATIE is an essentially Central American regional center for education and research. IICA, a broader LAC organization, plays a key role through its network generating, managing and sponsoring capabilities in addition to the support it provides directly to public agricultural research institutions.

b. Interorganizational Structures

A second dimension of diversity in technology delivery institutions in the region over the period is somewhat more recent, and it refers to interorganizational structures and arrangements. Here it is possible to distinguish two major kinds. One consists of joint programs and agreements involving two or more organizations in a common technology effort. An example of this sort of arrangement is PROGETTAPS, a joint project among ICTA, DIGESA and DIGESEPE in Guatemala (Ortiz, Ruano and Juarez, 1989). In this case, although not always, the project gives rise to a separate coordinating structure of its own.

Networks, joining together a number of organizations, comprise the second kind of interorganizational effort. Although not always limited to the region. Their significance is twofold. First, they create ways of pooling efforts and resources for a function that transcends the mandate and possibilities of any single country organization. Second, and particularly in the case of networking, they offer ways of capitalizing on and sharing knowledge created elsewhere--both outside as well as inside the region. In this sense, they raise the potential overall benefits deriving from a given investment in knowledge generation. They also introduce new research goals and technology and engage governments in research commitments.

A number of research networks operating in the region extend beyond Central America (PRECODEPA, rice, beans, corn, wheat, tropical grasses) and are sponsored by CGIAR member organizations--CIAT, CIMMYT and CIP. PCCMCA is a unique Central American network not based on any single sponsoring organization. Its activities are centered around yearly meetings which provide a scientific forum for research papers and reports in the region. PROMECAFE, and PROCACAO are USAID/ROCAP and IICA sponsored initiatives mostly restricted to Central American countries and having a fixed duration. Also sponsored by IICA, RISPAL brings together efforts in animal production systems. FAO, additionally, sponsors other networks.

c.Intraorganizational Diversity

A third dimension of institutional diversification covers programs, projects and resources within technology delivery institutions in the region. Virtually all public research organizations began operating with a restricted mandate, emphasizing basic grains, agricultural diversification and export crops and with activities limited to a small number of commodities--usually not more than five or six. Over time, these efforts tended to branch out along a number of lines.

One, the number of commodities covered expanded quickly. By the second half of the eighties, Costa Rica reported research activities in over 80 commodities. An analysis of the 1987-1991 Midterm Plan for ICTA in Guatemala suggests activities planned for a similar number of areas. Although a more recent reaction in favor of priority setting has taken place, similar trends appeared in Panama in the early eighties, as well as in Honduras, El Salvador and the Dominican Republic.

Two, in addition to commodity diversification, geographic coverage has similarly expanded. From initial operations at a few experiment stations, coverage has tended to spread to all major ecological zones. This appears reflected in the growth of infrastructure in terms of experiment stations and farms. Although most of the increase occurred at an early point of institutional history, it has continued. Table 3 shows the numbers of experiment stations and farms for major institutions in several countries at three points in time--at an early period right after the organization was established, then in 1978, and as of 1989.

Three, in addition to new commodities and geographic areas, other forms of institutional diversification have taken place. An expanded disciplinary spectrum is one. Initial efforts were mostly confined to agronomists and veterinarians. Current disciplinary representation includes phytopathology, plant breeding, genetics, social sciences, engineering, etc. Finally, over recent decades the differentiation between on-station and on-farm activities--often with a farming systems approach--has emerged in all countries.

d. Staff and Funding Trends

Alongside with diversity and to an extent because of it, the size of technology delivery efforts in the region have grown steadily since the fifties. Contrary to common belief, institutional growth has proceeded in most countries even throughout the eighties. Nowhere is this more evident than in the evolution of staff figures. Table 4 and 5 present country and institutional estimates of the number of researchers and extension agents, for 1978 and for 1988-89.

Before proceeding, a note of caution is in order with respect to institutional data. The latter should be seen as illustrative of general patterns and trends rather than providing rigorous measurements. Institutional data in Central America is often problematic because of vagaries and variability in both institutions and data collecting efforts. Consequently, problems of precision, reliability and validity remain unavoidable.

The tables provide an underestimate rather than an overestimate of staff, since data on some organizations, particularly in Costa Rica, was lacking at the time this paper was written. Not counted also are some purely private sector and non-governmental efforts. The effect of these omissions, however, probably minimizes growth between the two years. What emerges is that research staff has more than doubled over the period while extension staff has expanded in over two thirds. The growth trend is common, to a variable degree, to both extension and research--except the latter in El Salvador--at the country level. Expansion was most notorious in Guatemala and Honduras, as well as in Panama and Nicaragua although the latter case is harder to assess. Finally, absolute numbers of university graduates and graduate degree holders in both research and extension have increased in most organizations.

While staff growth is quite evident despite data limitations, funding is another story. Tables 6 presents 1978 and 1988/9 budgets in current "local currency units" (LCU) for major public research and extension organizations. Table 7 shows country level research and extension expenditures in constant 1985 LCU in both absolute as well as per researcher and per extensionist terms. Table 8 examines the sources of funding for a number of the public research and extension agencies. Table 9 and 10 show relationships among Ministry budgets, overall national budgets, agricultural GDP and overall GDP.

In reviewing the full set of information on research, a number of developments become evident. First, while current budgets have risen everywhere over the period, in constant terms this has only occurred in Honduras, Guatemala and Panama. When the data is viewed in per researcher or per extensionist terms, however, real funding has declined substantially everywhere with the apparent, although perhaps not real, exception of extension in Guatemala 1. When sources of funding for public institutions are taken into account (Table 8), the picture looks worse. In almost all cases, loans and donations have become either a sizeable or the largest source of spending. If government commitment to agricultural research and transfer were to be measured by via of its direct and real financial contributions to these activities we would be forced to conclude that the commitment has been declining. Stated this flatly, however, such a conclusion would involve an oversimplification since trends for research and extension partake of and are affected by broader trends. Evidence of this appears in Table 10. With few exceptions (i.e., research and extension in El Salvador and research in Guatemala), R & E expenditures have tended to rise as a proportion of their Ministry of Agriculture expenditures suggesting that no decline of priority has taken place at the Ministry level. This is still too coarse a measure since country totals in some cases include expenditures by private organizations. When excluding the latter, however, the conclusion does not alter in any fundamental way.

When the relationship between MOA budgets and central government budgets is taken into account, it appears that the former have declined in relation to the latter everywhere. Because of this, MOA budgets have also declined as a share of the gross domestic product of agriculture (GDPA) everywhere except for Guatemala. In other words, what has weakened is the priority of spending on agriculture and this in turn has affected real spending on R & E. The emergent implication here is that the roots of the funding problem of public agricultural research and delivery transcend the Ministries of Agriculture and c considerations. Finally, in relative terms, however, the larger shares of R & E in MOA spending have been substantial enough in most cases (except El Salvador) to translate into rises of the former in relation to the agricultural domestic product of agriculture (GDPA). Although the latter proportions are currently between 1-1.7% for R & E expenditures taken jointly, they still remain low in relation to the standard norm of at least 1% for research alone.

3. Discontinuities

A number of discontinuities in public research and extension efforts emerge from the overall data and the country reports. These may be grouped roughly into two categories or groups: those bearing on interinstitutional issues and those bearing on intrainstitutional ones.

a. Interinstitutional discontinuities

Central American ATS are disarticulated systems. The various functions of the system--such as policy setting, research, extension, credit provision for adoption, input supply, etc.--and the actors involved--farmers and their organizations, the various research and extension agencies, banks, suppliers, policymakers, etc.--tend to operate each on their own with at most a weak coupling. Consequently, the reciprocal flow of information, feedback and coordination among components tends to be either feeble or nonexistent. All evidence converges in showing this aspect as a fundamental problem for ATS performance in the region and a number of proposals seeking to ensure coordination have been advanced8. In such a light, the well-known difficulties of making the research and extension link (Kaimowitz, 1990) amount only to a part of what actually constitutes a larger systemic problem.

The roots of the above are complex and derive from problems or gaps at various levels. From an overall institutional and organizational perspective, most of the public research and extension organizations in the region are Ministry-based ones and as such governed internally without explicit connections to other participating actors in the system. In the case of more decentralized organizations, such as IDIAP and ICTA, these have governing and advisory boards which provide some, although not comprehensive, formal linkage to other actors. The actual effect of the latter, however, tends to be reduced, in part due to the absence of matching links at other organizations.

In relation to the above, major difficulties arise from the fact that general links while useful do not provide a substitute for the concrete articulation of more specific actors and functions. For instance, the articulation of research, extension and farmers does not take simply take place in a single overall organizational way. Effective articulation occurs within differentiated settings involving particular farmers, researchers and extensionists in given regions or communities and specific crops and commodities. Consequently, effective links need to be specific in time and space in relation to given actors (suborganizational units and people) and to given activities. This in turn poses problems of identifying, constructing, activating and sustaining relevant subsystems. And behind them lies the issue of sources of impetus for changes along such a direction.

One contributing factor to the above is the weakness of policymaking in relation to agriculture. While the countries over time have sought to develop and implement agricultural policies, these attempts have often proved feeble and only partially effective due to the disruptive influence of other macroeconomic variables and conditions. Furthermore, no systematic and effective science and technology policies exist in relation to agriculture.

b. Intrainstitutional discontinuities

A number of intraorganizational discontinuities in public research efforts emerge from the overall data and the country reports. The first one was already noted: an obvious discontinuity arises from the increase of staff and efforts versus the decline of resources. This translates into falling real salaries and operating expenses which in turn gives rise to a number of consequences. One, lack of funding for operating expenditures effectively constrains research possibilities and not only limits the total amount of work done but also weakens staff motivation and interest. Two, under conditions of internal financial scarcity scarce internal funding, the influence of foreign funding becomes paramount and tends to draw to it both staff in and internal resources as counterpart funds. Specially when project funding is the dominant mode, this reduces possibilities of setting internal priorities and tends to disperse efforts which become linked to project life cycles. Third, the decline of real salaries has stimulated a high turnover among the most dynamic and capable members of research staffs. That it has not been even larger, is probably attributable to limitations in the availability of other attractive jobs.

In addition to the above, political instability has aggravated the problem of turnover. Political changes have generated a considerable turnover of research heads and major directors and in some instances have also affected part of the research staff.

The combination of high turnover and discontinuous funding in the light of evident performance gaps, has in turn produced a number of consequences. One is a frequent process of restructuring of programs and organizations. Another is a frequent process of change in activities and real priorities. A third involves major discontinuities in learning processes relating to the management and organization of research institutions and, more generally, of ATS.

4. Planning

Planning raises a rationalizing claim in terms of a systematically ordered of ends for institutional action. Because of this it is strategic for our subject although only a few summary points are made here.

--In principle planning may be of a strategic and/or operational nature and ranging from only broad strategic guidelines to including priorities and targets to comprehensive plans to detailed operational planning and programming. According to level it may originate as an institutional endeavor or as part of broader or national planning efforts either for agriculture or for science and technology. According to its temporal horizon it may address short, medium or long-term concerns.

--Most public R & E organizations in the region are direct Ministry units. As such they partake of sectorial planning efforts. Over the past years these have tended to become increasingly weak and ineffective due to disruption from and instability in macroeconomic variables. In practice, planning has tended to concentrate on preparing an annual operating plan (AOP).

--The 2 decentralized technology institutes in the region, ICTA and IDIAP, have their own internal planning units and have made attempts during the eighties at setting priorities and drafting five-year plans (i.e., IDIAP, 1986; ICTA, n.d.). These plans, however, were not implemented. With Panama, the political evolution in recent years and, with ICTA, financial difficulties appear to be responsible. IDIAP, since the middle of the eighties, has also engaged in several priority-setting exercises but the internal effects remain unclear.

--Therefore, the AOP, as an adjunct to budgeting, remains the major planning effort of regional R & E organizations. This effort is in practice mostly an internal exercise where, for instance, researchers begin by planning for their experiments in the coming years. The AOP, depending on the internal process, amounts to a reviewed aggregation of these plans. Practically no effort is expended on directly involving external users in the planning process. Neither is much effort placed on monitoring and evaluating results. Resources for this are scarce and planners, whether at the Ministries or at the institutes, are mostly absorbed by budget management responsibilities.

--In conclusion, while planning has represented an important mechanism for an internal ordering of activities and for legal accountability, its overall effectiveness so far appears to have been rather limited. Internally, even AOPs tend to be disrupted by vagaries in the disbursement of resources. Additionally, their predominantly intraorganizational nature has done little to bring in feedback from external users or to bridge interorganizational discontinuities.

5. Performance

Institutional performance may be evaluated at two levels: effects and impacts on the one hand and output at the other.

Effects and impacts. These refer to the changes institutional output has on agriculture. It is not the role of this paper to assess them here for CA agriculture so we limit remarks to a couple of very general and basic points. the evidence shows some more or less clear cases of gain and improvement--e.g., coffee in Costa Rica, rice in general, modern corn, cotton for a time, and probably in terms of sustainability of the banana industry. Also evident, however, and without seeking to attribute blame for a complex evolution, is the fact that technology institutions have proved unable to stem the declining and stationary trends in many regional average yields in the eighties.

Outputs. An effort was made through the country consultants to generate a rating of efforts, results and impacts of technological institutions. Table 11 presents the available results in some cases given in terms of crops or commodities and in others in terms of kind of technology (agronomic, biological, chemical, or mechanical). The table registers a concentration of efforts and outputs mostly in basic grains. In terms of kinds of technology generated, most efforts and results have involved agronomic or cultural practices on the one hand, and biological products--plant breeding on the other. Neither chemical or mechanical technologies have received major attention; what appears reported under chemical technology refers mostly to the testing, dosage, and usage of such products. Interestingly enough, the area of technical and farm management has not constituted a focus of attention. Technological institutions in CA have been primarily biophysical in their focus with limited attention to socioeconomic dimensions. In this they reflect the disciplinary composition of their staff--predominantly from biophysical areas.

A key variable linking technological output and actual technical change in agriculture is the delivery capability of responsible institutions. This may be gauged in part through the degree to which institutions cover their target populations. Our country-based consultants attempted to generate estimates of the degree of coverage by technology institutions of the various commodity producers. The results appear in Table 12. As may be observed, in most cases this entails only a very small proportion of target populations. In practice, real significant coverage is in all likelihood far more reduced since what such coverage stands for--in some case perhaps a single visit by an extension agent--is far from clear. Additionally, the decline, discussed earlier, in operating funds over the past years has reduced the level of fieldwork by extension agents.

The institutional significance of the above arises from its highlighting a structural problem of technological institutions in the region. Even were a supply of relevant technology and solutions to the problems of farmers an actual fact (which is not the case) the current relation of existing delivery capabilities vis-a-vis target populations would still remain a major obstacle to system performance. This poses a challenge to institutions in terms of seeking viable alternatives to individualized delivery, a topic to be taken up again later.

III. PROBLEMS, LEARNING AND CHALLENGES

After reviewing the major patterns of institutional evolution in the last chapter we turn next to a more specific discussion of extension services. The argument stresses that lack of appropriate linkage to research facilities has undermined their performance and institutionalization and also disarticulated them from farmers. But what about countervailing efforts seeking to address the problem and the wider disarticulation it entails? For these we turn to a discussion of learning processes which are taking place mostly at research organizations although heavily influenced by extra regional actors. Finally, although ongoing learning processes improve on the bases for solving the problems of ATS, additional considerations relating to the small country problem, the structuring of research responsibilities, and future challenges also need to be brought into the relevant framework for action. These are taken up in the last two sections.

A. PROBLEMS IN THE EVOLUTION OF EXTENSION SERVICES

Throughout Central America, as noted earlier, extension services were created or developed through bilateral agreements with the United States. These new services had a number of characteristics 6. As special ad hoc units, they enjoyed, considerable administrative autonomy and flexibility. Their early heads and leaders tended to be highly competent and motivated individuals, able to transmit their enthusiasm to subordinates. Funding was abundant enough to cover operating expenditures and training needs--the latter helped unify views and approaches. The activity was innovative in the countries at the time and opened new roles and prospects for graduates emerging from incipient agricultural vocational schools and university programs.

Most of the joint programs also included a research component intended to support farmer advisory services. In practice, however, it is highly unlikely that results from these ever affected the efforts of extension services to any significant degree . In part this was due to the short duration of joint programs in relation to the time required to develop research and produce results. But also because the early postwar era saw the problem of agricultural change largely as one of testing available technology and delivering it to the farmer. This view also regarded the peasant as a potentially progressive rational manager willing to innovate.

The view failed to take sufficiently into account the extent that agroclimatic and socioeconomic differences condition technology performance. In addition, the early bilateral extension programs did not seek to restrict their mandate in a defined way and worked instead with a variety of crops in a wide range of settings. As a result, they could hardly avoid running into problems of adequate technology supply which, however, was not entirely recognized as such at first.

A systematic evaluation of the early days of extension in Latin America found little evidence of a a large impact (Rice, 1971). Yet these programs coincided with the beginnings of technical change in Central American agriculture. In some cases lack of impact appeared related to the absence of conditions--e.g., credit or input supply--for adoption. Nevertheless, it is hard to rule out the potential indirect sensitizing effect to modern technology that extension services may have induced.

In any given population, innovativeness over time will tend to follow a normal bell-shaped distribution (Rogers, 1983:242-45). Extension agents in Central America, as their counterparts virtually everywhere, tended to work with the more receptive segments of their target population--i.e, the larger, literate, socially mobile and commercially oriented 9. Also, the beginnings of the joint extension programs coincided with ample postwar facilities for importing production inputs--fertilizers, implements, machinery, and seeds.

The fifties and early sixties in Central America were a time when a great deal of adoption of locally untested modern technology took place, specially with commercial crops. As a comparative study of technical change in cotton growing in El Salvador and Nicaragua stresses, from the end of the war up to the mid sixties, growers adopted an increasing number of innovations, beginning with new metal implements, planting procedures, commercial varieties, and expanding later into an intensive utilization of agrochemicals and machinery (OAS-IDRC,1985). In both countries, cotton growing was a large landholder activity, involving mostly farm units of over 50 hectares and drawing heavily on private suppliers, but in which the extension service nevertheless played an important promotional role. As the report makes clear, adoption continued, although the changes involved were not particularly cost efficient or appropriate, until the excessive use of machinery and agrochemicals began to have strong negative consequences on the sustainability of the crop (ibid:64-65,117). This stimulated research efforts and led to a partial change in technical patterns. It also appears, that in other crops a cross section of the most innovative farmers also engaged in adopting untested technologies, involving such things as new implements, chemical fertilizers and cultural practices.

Over time the bilateral programs became national extension units within the Ministries of Agriculture. The move shifted them to a bureaucratic and politicized setting characterized by reduced flexibility and operational funding. It also further cut off extension services from research facilities although top-down and largely ineffective attempts were made periodically to connect them. As the general political thrust of the time shifted from an undifferentiated emphasis on growth and modernization to agrarian reform in the sixties, and then to integrated rural development programs in the seventies, the mandate of extension services focused more explicitly on serving small farmers. For these, restrictions other than technology were critical and technical change under such conditions involved complexities that were not fully recognized until the early seventies. It meant that extension services faced an increasing problem of adequate technology supply.

Given the early paradigm assumption of technical change as a largely top-down process induced by enlightened change agents, reactions to these difficulties tended to emphasize the need for suitable diffusion and communication strategies. As this proved insufficient, the stress shifted to emphasize a more active role by the change agent who should provide technical assistance in addition to information as a way of facilitating adoption. This shift of perspective already began to recognize some difficulties in reaching the farmer but still assumed his receptiveness to the technical change being promoted. As such it proved more successful with the larger farmers, and with those more educated and inclined to be modern, but less so with the core of smallholders. A further step involved bringing in an educational concept--stressing the responsibility of the change agent in educating what was already being viewed as a change-resisting, traditional peasantry. Additionally, supervised credit, requiring adoption of modern inputs and practices, spread in recognition of the constraints of resource poor farmers. All these views, despite important advances, continued to retain a top-down approach with insufficient attention to local conditions and restraints.

Following the early phase of technology adoption, three developments hindered the further impact of the extension services. One, the negative consequences of adopting untested technology started to become evident. In the case of cotton, for example, the excessive use of heavy machinery and of agrochemicals led to soil compaction and pest infestation problems. This brought into focus the need for different technologies and local research. Two, declines in external prices for a number of products restricted the continuing use of inefficient "modern" technology. The economic difficulties of the region, starting with the oil crisis of the seventies, by raising inputs prices and restricting their importation, discouraged capital intensive approaches. Third, the shift of extension services, from an earlier and largely general mandate to a specific focus on small and medium scale farmers, additionally brought into focus the problems of technology supply.

Within the Ministries, once the period of early adoption was over, and especially with the mandated focus on smallholders, it became evident that technology delivery was far more complex than initially considered. This had several consequences. Given conspicuous performance gaps and lacking a positive valuation because of this, extension roles in general either experienced a decline of prestige or failed to gained satisfactory institutionalization. In the bureaucratic setting of the Ministries this stimulated many of the more capable early extension agents to move to other activities and led to an overall weakening of work motivation.

General trends in the evolution of extension have not been very different from those of research. Their responsibilities expanded not only in terms of new commodities and areas but also in terms of taking over new functions. Staff numbers grew, with a larger proportion of college graduates in the total number, but also with a high turnover and a heterogeneous composition that included many personnel not fitting elsewhere. Real overall funding and, with it real salaries and operating expenditures, tended to decline in a similar way to research.

Extension services have, perhaps even more than research ones, been subjected to frequent reshuffling and reorganization. As part of the line operation of Ministries, the incidence of politics in their operation has clearly been greater than with research. Their activities also tended in practice to move away from farmer advisory responsibilities to other functions including a broad field representation of the Ministries. Because of this, staff numbers do not tell the whole story since extensionists tend to be involved only part time in actual technology transfer activities.

From the formal perspective of the Ministries, improving extension work posed the problem of how to supervise effectively a large number of disperse fieldwork activities in rural areas. This gave rise to a search for uniform and controlling methodologies, suitable for a personnel core with low and variable levels of education and training. It explains, for example, part of the attractiveness of methodologies such as the Training and Visit approach, also sponsored by the World Bank and other lending agencies, and adopted at the national level during the early eighties in Costa Rica and the Dominican Republic, and more partially in El Salvador and Panama. The T and V approach provides for a highly disciplined, centralized and standardized technology delivery arrangement 10.

Extension programs, however, continued to face a structural obstacle: that of ensuring a steady supply of technology suitable to their clientele. As Hage and Finsterbusch put it:

> T and V is a standardized process for communicating relatively standardized technical information to farmers; high variation in local conditions, however, calls for non standardized information. (1987:113).

Under conditions of high agroclimatic and farmer variability, the basic problem of ensuring technology supply became critical. Not only was the extension service largely disconnected to the research one. Responding to local needs would have required a different kind of research effort, one bringing closely together researcher and farmers in a joint and often interdisciplinary attempt, seeking to identify key local restrictions and solve them in ways suitable to the various conditions and limitations of potential users. Even in the unlikely case that the T and V approach had sought to deal with the problem of providing locally adapted technologies, its centralized and rigid hierarchic nature would have conspired against the participatory climate and kinds of efforts required.

Another conditioning factor in the evolution of extension has involved the broader decentralization and regionalization of the Ministries of Agriculture throughout the region. Costa Rica, for example began decentralizing extension in the late sixties with the original creation of 5 regional agricultural centers (Ureña, 1989:6). Over the next two decades, the number of regions and extension agencies expanded and several shifts took place back and forth in terms of the degree of control and authority retained at the Ministry's headquarters. Decentralization of research, however, only began effectively in 1987 with the creation of the Regional Research Teams (ERI) under a single head (Palmieri, 1989, 13-14).

Throughout the countries, extension has been regionalized in the Ministries yet research only partially so and then usually on a different administrative basis. This is true even for Nicaragua where both research and extension are located within the MIDINRA in different units. Research there is based essentially at experimental centers and stations while delivery is organized around farmer development centers, state production units and private enterprises. Throughout the countries, emerging on-farm efforts at research organizations facilitate linkages between research and extension, but many problems remain unresolved even in Costa Rica where perhaps the regionalization of both services has advanced most.

When also taking into account the points raised in Chapter 2 regarding coverage, an additional and major bottleneck for the ATS performance becomes evident. Even were technology supply not a problem, the size of delivery services in Central America is very small in relation to target populations. Given the high costs of individualized delivery and the existing fiscal crunch, this would appear to represent an almost unsurmountable obstacle within present arrangements.

B. SOURCES OF INSTITUTIONAL LEARNING

Behind changes in Central American institutions, an important learning process, arising from both internal and external sources, is taking place despite many discontinuities. External sources include the diffusion of an increasing literature on agricultural technology systems as well as pressures arising from donors and international lenders. Internally to the region, the learning process has been stimulated by four kinds of efforts or developments.

1. Development of Service Components

Since the sixties and in part due to agrarian reform efforts, innovative Latin American leaders, and personnel involved in what would come to be known as integrated rural development, were facing a clear lack of reliable and suitable technology for the smallholder. Through a number of experiences--such as Puebla and Caqueza (e.g., Whyte, 1983:164-93)--they came to frame the question in terms of how to ensure context--initially agroclimatic but not social--sensitive research results. Doing this was seen originally as posing a problem of how to motivate and involve the "self centered and disciplinary bound" traditional researcher in processes of <u>in situ</u> practical research and, second, how to develop a suitable and legitimate scientific methodology for dealing with an essentially uncontrolled research process, affected by multiple variables, and quite different in nature from standard experiments conducted at stations.

Out of such efforts, on-farm strategies, as a distinct approach, were born. An early way social variables, in addition to agroclimatic ones, were incorporated into the analysis was through farming system approaches which emphasized interactions among crops and resource uses. These developments contributed important conceptual and operational advances in what would eventually represent a new paradigm for research generation and transfer. In these developments, institutions in the region played a key role, specially ICTA in Guatemala and CATIE as a regional center (Whyte, 1983:164-93; Ruano and Fumagalli, 1988). The Programa Nacional de Investigaciones Agropecuarias in Honduras also sought to improve on the experiences of ICTA (Whyte, 1988:177). In addition, CIMMYT in Mexico has played a key and strategic role in advancing these developments both in conceptual as well as institutional terms . In 1978, Panama began to plan for an on-farm program which started in 1980 (Cuellar, 1987).

At present all of the Central American countries have some form of on-farm research program or activities. Their development should be seen as a joint product of three categories of institutions. First, international and regional centers--particularly, CIMMYT and CATIE--played a key conceptual and methodological role in helping to develop the knowledge basis for such programs. Additionally, they served as a linkage for incorporating pertinent and related results and knowledge developing outside the region. Second, funding agencies, particularly, USAID, ROCAP, IDB and the World Bank provided essential funding which allowed the new programs to have an institutional embodiment. Last but not least, research organizations in the region adopted and helped develop the approach--ICTA's role in Guatemala has been particularly important and has continued evolving (Ortiz et al,1989; Ruano and Fumagalli, 1988).

The fact that a number of the region's research organizations or programs are quite recent, only dating back to the seventies (ICTA, CENTA,PNIA and IDIAP) helps account for their flexibility and innovativemess in this regard. They were established already with a clear awareness of the need for an on-farm component which they sought to develop.11 This has been a part of their strength. However, doing so is a complex matter involving not only the methodological and operational issues of conducting such research. It also requires institutionalizing the program within the research institute. This implies attempting to establish a balance of rewards, status and motivation among existing and new programs or activities and in which the latter find a suitable niche while minimizing resistance from the former. Accounts are full of references to the difficulties of making on-station and on-farm researchers work together, to the differential status and authority claims put forth by staff coming from different agencies, to the mutual distrust and misunderstanding displayed by members of multi agency teams, and so forth. However, as the experience of the dairy cattle project in Nueva Concepción, Guatemala shows, for example, an open communication setting can promote a learning and adjustment process within which many of these difficulties may be gradually minimized.

2. The Regionalization of Agricultural Ministries

In the late sixties, a process of regionalization of Agriculture Ministries began to take place. In Costa Rica this involved, for instance, the establishment of 8 agricultural regional centers between 1967-1977 (Ureña-Brenes,1988:7). Regionalization began with extension services, primarily from a technical standpoint, while administrative arrangements and practices remained centralized. Over time other aspects of the Ministry including research services and budget execution and control were decentralized (ibid). In Honduras, regionalization began in 1975 and involved both research and extension. In El Salvador it began in the eighties and involves extension more than research.

The idea behind regionalization was greater responsiveness to regional and local conditions. In practice this has not always been achieved. Although potentially representing a step toward increased operating flexibility, decentralization processes initially tended to raise problems of activity integration and articulation. Because of this they have been affected by recurring power conflicts and by swings between attempts to centralize control over resources and the search for greater local operating flexibility. Throughout time and despite recurring discontinuities and setbacks, a gradual learning process has been taking place, as the gradual removal of obstacles to regionalization shows.

3. Research Extension Linkages

Throughout the region, particularly since the late seventies and early eighties, a number of efforts have sought to integrate research and extension efforts. References to, or descriptions of these processes appear in a number of reports12. For instance, in Guatemala, between 1974 and 1985 authorities carried out at least seven attempts to improve links between ICTA and DIGESA (Ortiz et at, 1989:9). Similar efforts took place in Panama. In Costa Rica, research and extension were brought together in 1985; research was regionalized in 1987--extension already was decentralized. Despite all the restructuring, Palmieri (1989) in her analysis of maize research and extension found little evidence of real change in the working of either service. An interesting linkage experience has been that of the PROGETTAPs project in Guatemala which connects ICTA, specially its on-farm component, with both DIGESA--crop extension--and DIGESEPE--livestock extension. In addition, the project involves a large number of rural leaders and farmers through consultative groups, stresses the research-extension interface, and establishes coordination at various levels. All this has involved a steady increase of feedback mechanisms and processes.

potentially ground one. In some cases this will not be available and producing a solution may require a full research effort. On the other hand, the service researcher also has the responsibility for pulling down, testing, adjusting and drawing attention to new technological developments that may raise existing ceilings to ongoing productive efforts.

The second major function or responsibility of an agricultural research system is to develop new technological solutions or technologies of a general nature. "General" here only intends to mean they are potentially suitable or adaptable to more than one specific ecological or functional niche but for which further development (in the sense this term is used in industrial research) efforts would be necessary. The actual performance of such adaptive work would be a responsibility of the service level. Examples here might include the development of new varieties or of a specific package for soil, water or pest management. In relation to industrial research it is analogous to the development of general prototypes for a new technology.

Finally, a third function remains--that of advancing knowledge potentially useful for later and more specific applications. This includes fundamental and basic oriented forms of inquiry.

A related matter here is that while all three functions are important to any ongoing ATS this does not necessarily imply that all three need to be performed endogenously. In some instances, this will happen even within a single (large) research organization. In other cases, such as those of very small countries, only the first function may be performed endogenously. The second function may be performed through a regional multicountry effort or regional center. The third function may be covered through participation in a network providing access to results generated in other countries.

These distinctions seek to draw attention to the contention that the three kinds of effort are characterized by different thrusts, goals and work, methodologies, skills, interests and motivations, kinds of researchers, clienteles and reference groups. The problem lies in that most research organizations have in practice treated research instead as if it were of a single nature and this has tended tends to affect their performance negatively.

The distinction of research types is also relevant in terms of posing an institutional response to the small country problem. Briefly, it is that almost any production initiative will require a service and delivery capability, the burden of which will almost unavoidably have to be assumed locally since the benefits of these activities are mostly local in nature. For the two remaining research modes, possibilities are broader, given their externalities, and would allow for the two strategies mentioned above--joint efforts and networking.

E. LONG TERM CHALLENGES FOR REGIONAL ATS

We shift now to a prospective mode in considering three major challenges that ATS in the region will face in coming years.

1. Changes in Agricultural Science and Technology

The underlying bases of agricultural science and technology are rapidly changing with the likelihood of revolutionizing the nature of agriculture in coming decades. Biotechnology here constitutes the main development although contributions from other areas will also interact with its effects.

In knowledge terms, biotechnology has the effect of linking agricultural technology development potential to the forefront of that of basic science in fields such as industrial microbiology, biochemical engineering and molecular biology. One difficulty this poses is an abrupt discontinuity in the requirements for human capital and research capabilities. In the region, the disciplinary composition of public agricultural research institutions, like that of many other Latin American countries, appears sorely lacking in terms of the new abilities. A recent survey and review of existing facilities and requirements (i.e., Jaffe,1989) in the region found a number of problems. Qualified staff in the new areas, particularly with graduate training, are few, mostly at universities --- other than at agricultural research organizations, concentrated in only two countries, and overextended in too many activities with insufficient funding (ibid:55-56).

For research organizations in the region, the biotechnological revolution will pose the challenge of increasing their qualified staff in pertinent areas which may require developing graduate training capabilities on a joint regional basis and perhaps also involving local universities. It will also require a closer integration with local universities and other organizations and laboratories in order to make better use of existing facilities and staff. It will also demand an increased networking effort in working together with other organizations.

Another aspect related to the above will involve developing coherent and appropriate priorities in the new fields for making the best use possible of the few resources available. This will require communication and joint agreements with organizations from other sectors.

Biotechnology and related developments will pose a challenge to extension organizations in terms of training their staff to ensure their basic understanding of the new technologies and allow them a linkage function between potential users and laboratories (Trigo and Runsten,79-80).

2. Sustainability and Natural Resource Conservation

Latin America and the Caribbean enjoy one of the richest endowments of the world in terms of genetic and natural resources. Central America is in turn one of the most endowed regions of the continent. Several developments are taking place here. One, the extension of agriculture to hillsides, watersheds, forests and marginal areas is generating pressure on fragile ecological systems, deteriorating soils through erosion, and threatening species with extinction. Two, in more established agricultural areas, similar effects are deriving from the overuse of machinery and agrochemicals. Three, most of the basic crops of the region have a rather narrow genetic base which raises their vulnerability to pests and diseases.

Although the roots of these problems go beyond technological issues, nevertheless technology institutions have an important role to play in countering their development. One necessary action encompasses developing technologies that allows a sustainable productive exploitation of fragile environments, such as the plains (cerrados) and of tropical forest areas. Another comprises special efforts to develop regenerative options and alternatives to destructive practices taking place in existing areas under production. Related to this will be the need for incorporating sustainability and natural resource considerations into most research aimed at raising productivity. Finally, networks for germplasm collection and banking will be needed to assure the survival of genetic diversity.

3. Achieving Equitability: Managing the Socioeconomic Consequences of Technology

As the process of technological intensification in agriculture proceeds its broader effects and externalities become more important. For instance, the constant application of capital and knowledge to raising the productivity of land, labor and capital, and through this of the agricultural production achieved, inevitably entail at some point a conflict with an essentially inelastic demand for food as a whole, the latter in turn reflecting a natural ceiling on the eating capacity of human beings. Increasing total and factor productivity entail at some point a limit on the amount of factors allocated to agricultural production, beyond which surpluses translate into declining prices and losses to farmers. While, from a single country perspective, the possibility of exports offers a way out, from a global perspective this is not the case.

As an issue, the topic has usually been confounded by other considerations. One has been the fact that in many countries, such as those of the region, production is still behind the growth level of effective demand and consumption. Even were effective demand covered, this might not be considered a satisfactory ceiling given that unequal income distribution still constrains satisfying the "latent" needs of a large majority of the population which is either undernourished or would eat more given other income levels. Finally, there is the question of the role that cost-reducing, versus production-increasing, technologies play in ameliorating this difficulty.

Such considerations, while true, do not invalidate the structural implications of a steady rise in the capacity to produce versus a growing--although still limited by natural ceilings--capacity for using the additional product. They only postpone the relevance and visibility of its consequences. The management of surpluses, rather than of deficits, has become an increasing problem outside of the region and even in it at particular times and places. When surpluses accumulate, unavoidably part of the factors allocated to production must be withdrawn from it. While this hardly applies at present to the region, it is likely that toward the future the whole consideration of the effects of technology as an issue will become an increasingly relevant one.

For technology institutions this will imply the challenge of a more careful scrutiny of all of the economic and social consequences, favorable and adverse, on different sectors accompanying the release of technologies. It will imply, next, in association with representatives from broader contexts what to do about adverse effects. A standard argument in this regard has been to hold that many of the adverse consequences resulting from technological change are best (more efficiently) handled through policy means other than imposing constraints on the nature of the technology generated. For instance, it might be argued that unemployment resulting from fewer farmers might be dealt with best through an appropriate resettlement program. While the point may be valid, however, it should not be taken as a generalized prescription in lieu of the detailed examination and weighing of alternatives in specific instances.

To restate the institutional implications of this challenge more clearly, it will require a greater capability by institutions to evaluate and assess a broad spectrum of technology impacts which in turn will imply strengthening their economic and social analytic capabilities for doing so. In addition it will imply helping to build the arenas and networking for more inclusive assessments of the relevant cases, causes, and issues with the aim of developing guidelines and strategies that may be considered legitimate by broader constituencies.

IV. TARGETING INSTITUTIONAL CHANGE

In this chapter we move toward the subject of change in the ATS of the countries and the region. This begins in Section A with a review of major problems emerging from the discussion and their implications. The section provides the groundwork and the most general elements for a strategy of action. Section B outlines bases for redefining and rescaling the role of the public sector in agricultural technology as well as the consequences of this for major user groups. Finally, Section C sketches some preliminary suggestions for getting the change process off the ground.

A. SUMMING UP THE ARGUMENT

The agricultural technology systems of the countries and of the region as a whole are disarticulated ones. This entails that individual organizations, despite notable and perhaps increasing exceptions, lack the appropriate linkages to ensure functional and social integration. Rather, they tend to operate separately without the reciprocal feedback and exchanges that, as mentioned in Chapter 1, bring them together as a system with steering capacity vis-a-vis its external environment. This translates into a practical difficulty or incapability to articulate a suitable technological response (supply) in response to demand. The fact that technology demand for certain kinds of users tends to remain implicit making necessary its reconstruction via such strategies as on farm or service research only compounds this difficulty.

While a substantial growth and diversification both of and within agricultural technology organizations has taken place since the fifties, the institutional model behind them has been premised largely on expanding public sector responsibilities. The outcome has been an overgrown and overburdened, relative to resources, public sector effort. Consequently, the differentiations involved have tended to be non adaptive to the increasingly complex agricultural environment, favoring discontinuity and isolating rather than bringing together relevant technological actors.

Over time, a number of leaders and other persons have engaged in a learning process concerning what is required to make technology institutions work successfully. The impetus for this comes largely from the international environment, originating from the diffusion of the results of experience outside the region as well as from pressures by donors and lenders. Nevertheless, another part of this learning process derives from experience with institutions in the region and the effort to improve them. This has improved the understanding of agricultural technology systems, especially concerning the importance and difficulties of systematically linking technology efforts and actors and of incorporating a bottom-up approach.

Despite the above, this learning has remained limited. To a great extent this is due to the many discontinuities within technology organizations. Frequent reorganization efforts, staff turnover, resource limitations and instability have placed their toll on the continuity of efforts. Two limitations appear obvious. One is that conceptual understanding of the problems has advanced more quickly than the know-how for solving them. This, for example, is reflected in the persisting difficulties of getting researchers, extensionists and farmers to actually work together. The other limitation is that further progress is still required at the conceptual level. For instance, much of the current discussion about integrating technology efforts is still conceived in terms of a general coordination of organizations. We would argue instead that the really crucial articulations emerge at a subsystem level involving very specific actors--marketing structures, processors, exporters, credit and input suppliers, researchers and extensionists, etc., involved with specific kinds of farmers and commodities in given regions and having a very specific institutional configuration. Furthermore, these tasks need to be undertaken with an eye on other conditioning factors and challenges such as the small country problem, the need to rationalize efforts in the different kinds of research and the imperative of responding to future challenges.

As a consequence of all the above, conspicuous performance gaps characterize technology institutions. This means that, notwithstanding their well recognized importance, their legitimacy remains questionable to an extent. Since individual organizational efforts are insufficient for getting around this quandary, improvements will require moving from the ATS as a conceptual and theoretical construct to actually developing it as a concrete interorganizational actor (or set of actors) able to demonstrate adaptive capacity vis-a-vis its environment. If this conclusion is correct the most fundamental question concerns the prime mover for changes in existing conditions.

We propose that the only actor with the capability to sponsor the required changes is the government or public sector in each of the countries. In advocating a government leadership role, however, we actually propose two different things. One of these these involves a rescaling of current government efforts and of the institutional model behind present arrangements. The bases for this are discussed in the following section. The second aspect involves actual leadership by the governments in promoting necessary changes. This topic is sketched briefly in the last section.

B. THE ROLE OF THE STATE

1. Structural Funding Problem

The development of the present public research and extension system dates back to a time when the role of the state was considered an alternative to market absence or failure. Under this mantle, public agricultural generation and delivery efforts expanded to cover a wide range of responsibilities. Since its beginnings, however, important changes have modified the conditions giving rise to the initial assumptions. At least four considerations become pertinent.

a. Over the period, agricultural and industrial growth have proceeded as has the expansion of a market economy. This presents a more favorable situation for potential sharing by non governmental sectors of technology generation and delivery expenditures .

b. The very diversification of agriculture involved, as well as the competitive demands of an increasingly market dominated economy, imply a corresponding multiplication of technological requirements over a great number of crops, regions and specific groups of technology users.

c. Responsiveness to the great diversity entailed by the preceding entails that the corresponding ATS enjoy sufficient operating flexibility. Precisely this flexibility is lacking and operational rigidity has rather increased as a way of responding to raising demands over limited resources.

d. The general economic crisis affecting the region has implied a fiscal one of a structural nature that is unlikely to improve over the foreseeable future. Along with trends in the evolution of the international economy, this will limit the extent to which governments can provide subsidies and will increasingly bring under close scrutiny those given to sectors and groups that might be able to pay for themselves.

2. Policy Considerations

We propose here that toward the future a fundamental policy principle should involve the elimination of technology subsidies for all groups in condition of absorbing this burden. Accordingly, subsidies would remain only for two categories of users:

a. Research, and the delivery of its results, for those unable to pay for technology but otherwise making an important economic contribution and/or otherwise raising a justifiable claim for preferential treatment on grounds of equitability.

b. Research and technology generation of a broader nature, i.e not aimed at immediate practical problems of narrowly defined groups and involving the possibility of externalities. This would include basic, basic-oriented research and much of technology development. It would also include research clearly of a strategic nature and not considered elsewhere (e.g., some research on sustainability and frontier areas).

An operational structuring of the preceding would require taking into account a number of points:

a. Resources of user groups. Those able to pay should absorb the burden of their technology costs and institutional organization.

b. Nature of specific research, e.g.,basic, general technology development, service research, other strategic research. Non resource-poor user groups would pay directly for their service research and for technology delivery. These groups would also assume in part the costs of other kinds of research, taking into account the consideration following below.

c. Small country problem. The population and economic bases of even strong user groups in small countries, as discussed earlier, raises the per capita costs of technology provision. This enhances the priority of structuring all research--other than service research and the delivery of its results--that is, basic forms of inquiry and general technology development, through cost sharing strategies such as joint efforts with other countries and communities facing similar conditions and an intensive reliance on networking.

3. Strategic Public Responses

We propose that public sector agricultural technology activities be structured around the three following modes of response:

a. Facilitating role. For agricultural strata and commodities in condition of paying for their technology services, the role of the state or public sector would be directed to facilitating this strategy. This would involve sponsoring, in agreement with affected groups, the establishment of mechanisms--taxes, levies, special funds, etc.--for the funding of research and delivery. In a more general sense, public institutions would retain a broader facilitating function in relation to other concerns--for instance, acting upon the biases of research and delivery--in terms of promoting their discussion, necessary linkages and corrective actions.

b. Technology provision role. Here it would be desirable to distinguish between funding and delivery responsibilities. Funding in our proposal, along with actual delivery would be restricted to those agricultural clienteles and problems falling within the principles outlined above: importance, strategic nature, or lack of ability to pay. However, public technology institutions might retain a broader delivery function. Some clienteles able to pay for their research may not actually find it advantageous to establish in-house facilities for doing so, on the basis of specific considerations. These users would still retain the option of contracting with public research and delivery institutions for their technology requirements.

c. Joint efforts and networking. The above refers primarily to service research and the delivery of its results. For other modalities--i.e., more general technological development efforts, basic research, and research in such areas as biotechnology and sustainability--given the small country restriction, the approach to follow would emphasize, to the extent feasible, working together with other countries and the intensive use of networking for making the best use possible of work done elsewhere.

3. Specific Consequences According to Technology User Groups.

In this section we attempt to elaborate briefly on the preceding with reference to the specific groups in the typology of technology users.

a. Traditional Exports. In general the role of the state here would primarily involve a facilitating stance in terms of generating revenues for research and delivery and in terms of sponsoring joint efforts and networking for more costly and broader kinds of activities. For export crops in crisis, the facilitating stance would extend to include the consideration of production alternatives.

b. Non Traditional Exports. A facilitating role here would be crucial not only for generating revenues from growers in exchange for technology services but also for attracting other funding--such as loans, special funds, and donations for this purpose. Most likely, public institutions and NGOs would need to supply, on the basis of payment or joint ventures, the actual provision of technology because of the high level of fixed costs involved in setting up operations for highly uncertain crops in terms of markets or the viability of local production. Whether public funds should be committed to this on strategic investment grounds--the infant industry argument--is an issue for which we do not have an answer or position at present. Even were the state not to provide funding for technology services in this case, it is highly likely that some support for these activities would come by way of public investment in infrastructure and other services.

c. Large Intensive Growers. The public sector role here would primarily involve a facilitating stance in terms of generating revenues for research and delivery efforts as well as in terms of sponsoring networking and joint efforts for broader concerns. Organization for the former would most likely tend to follow a crop or commodity pattern, via grower associations or the creation of special funds, based upon levies or taxes. Research and delivery performance might take place through commodity or regional centers.

d. Small and Medium Intensive Farmers. This category would constitute the main target group for delivery and funding by public technology institutions. Where possible, however, regional or geographically based organizations (e.g., such as the Patronato de Sonora) or NGOs might be sponsored for the purposes of helping articulate technology demand and paying for farmer advisory services. Research performance, even of the service type, however, would likely require some degree of subsidy or backstopping by public technology institutions.

e. Marginal and Frontier Area Groups. Integrated rural development programs and NGOs would assume most of the funding of research and technology delivery for these group . Much of the actual performance of research and technology delivery and some of its funding, however, would take place through public research and extension institutions. Networking and joint efforts with other countries would also have a place here, particularly in relation to the strategic concerns of frontier area groups. In addition, foreign donations might play a potentially important role here given the rising interest and concern over ecology issues in DCs.

f. Traditional Non Intensive Large Landholders. Since this category is a non adopter one, no particular strategy is envisaged for them. The problem here would seem to transcend a technology supply focused solution and to involve other components and actors.

4. Institutional Implications

Institutional implications of the approach suggested here would follow along a number of different lines.

a. Public Research and Extension

The preceding has suggested a modified yet major role for public research and delivery organizations. Although it would restrict public funding for a number of areas, government agencies would retain substantial responsibilities as research and delivery performers for a number of user groups paying for these either in part or entirely. The call here would be for responsiveness to a highly diversified context, for operating flexibility, and for effectiveness and efficiency in doing so. This in turn would require new organizational arrangements for public sector institutions. We suggest the three following guidelines should orient the nature of these new arrangements:

i. Public technology institutions will need to keep enough of a public sector identity to maintain full political support of governments and capabilities for linking with other public efforts and institutions.

ii. Public technology institutions at the same time, and this is a crucial aspect, need enough operating flexibility and administrative agility to work closely together with both private commercial and non governmental organizations.

iii. These institutions at the same time require a sufficiently independent status to be fully attractive to donors and lenders--both national and international.

The above, in our judgement, calls for new organizational alternatives of a quasi public nature which need further exploration. Examples might include such modalities as autonomous public corporations, executive organizations built around a national fund, or public companies. While the foundation model may, perhaps, as some recent experiences suggest, prove unattractive because of its purely non governmental status, mixed or public-owned foundations are also possible here.

2. The Promotion of NGOs and Private Organizations

As visualized here, both NGOs and private organizations would play a larger role in technology efforts than before. This would imply the eventual emergence and diversification of a number of such organizations which might assume a variety of forms. One would be centers attached to commodity associations or funds. Another alternative might comprise organizations with a geographic mandate and encompassing a cross section of farmers and commodities. Still another mode might take the form of foundations and other kinds of related non government organizations. Finally, university-based centers and efforts might also find a place here. The advantages of such structures would include a specific focus on insuring responsiveness to a given set of users and the ability for linking both research and delivery with users as well as with other institutions and concerns. Still other advantages would include operating flexibility and a manageable size and scope of activities, thus favoring their effectiveness and efficiency.

C. MOVING TOWARD CHANGE:PRELIMINARY THOUGHTS AND SUGGESTIONS

1. Focuses of Change

The results of this paper target the following overlapping areas for change.

a. Institutional articulation. The call here is for bringing together all relevant institutional actors and participants in technology processes. As noted before, however, although a general articulation of major actors is desirable this cannot by itself substitute effectively for specific subsystem integration around groups of technology users.

b. Identifying meaningful categories of technology users. Defined as users characterized by common problems, challenges and technology institutions, these constitute the pivot for an alternative strategy. The user groups proposed in these papers, as validated initially by the workshop, would offer a convenient starting point.

c. Redesigning institutional and organizational models. The suggestions advanced in Section B of this chapter would entail a major thrust in this direction in terms of redefining funding and technology performing responsibilities of public agencies.

d. Developing coherent science and technology policies for agriculture. While this would be a a strategic development supportive of the above we do not view national policy formulation as a required prior step but rather as a product also emerging from the broader process of institutional change suggested here.

e. Emphasis on regional cooperation. A-go-it-alone approach would prove unduly expensive for Central American countries given their relatively small size in production and population terms. Therefore, sharing tasks and pooling resources and information would constitute an integral part of the proposed strategy.

f. Incorporating user control. One way of increasing institutional responsiveness to user needs is through incorporating elements of external user control or influence over pertinent decision-making areas as part of the linkage process.

g. Insuring key movers. This is crucial for activating, implementing and sustaining change. We propose that the public sector take the leadership role in this process. Section 2 outlines specific suggestions for getting started.

2. Moving Toward Change

We suggest that the workshop recommend that each country move toward establishing an institutional mechanism for the reform of agricultural technology institutions. This mechanism might take the form of a special ad hoc task force with the mandate to work on three things:

a. Defining relevant agricultural subsystems. This would entail identifying and validating a relevant typology of users and identifying and bringing together relevant actors and institutions.

b. Generating studies and information to backstop the above.

c. Proposing policy and legal instruments in relation to the above.

d. Networking with matching task forces in other CA countries.

The task force should be constituted at a high and non sectorial level, other than within the Ministry of Agriculture, for it to secure a ready institutional access and mandate in relation to relevant organizations outside of the agricultural sector such as universities and industrial centers and enterprises.

The overall task force in each country would be divided into workgroups around user categories once these were tentatively validated. Each specific workgroup would then act as a prime mover for institutional reform and integration.

IICA would play a supportive role in this process specially in relation to promoting and backstopping the necessary networking activities.

TABLE 1
BEGINNINGS OF TECHNOLOGY INSTITUTIONS IN CENTRAL AMERICA

COUNTRY/INSTITUTION	YEAR ESTAB. ISHED	U.S. INVOL VEMENT	FUNCTION
COSTA RICA			
National School of Agriculture	1929	N	R,FA
Institute for Interamerican Affairs (IAI)	1942	Y	FA
Interamerican Technical Service for Agricultural Cooperation (STICA)	1948-56	Y	R, FA
GUATEMALA			
National Institute for Chemistry and Agriculture	1930	N	R
National Agricultural Institute (IAN)	1944	Y	R
El Servicio	1945	Y	R, FA
Interamerican Agricultural Cooperative Service (SCIDA)	1954-9	Y	R, FA
HONDURAS			
Interamerican Technical Service for Agricultural Cooperation (STICA)	1951-63	Y	R, FA
EL SALVADOR			
Technical Service Unit of National Coffee Groners Association	1937	N	FA
National Agronomy Center	1943	Y	R, FA
Salvadoran Coffee Research Institute	1950	N	R
Salvadoran-American Cooperative Agricultural Service (SCASA)	1955-60	Y	R, FA
NICARAGUA			
Technical Agricultural Service	1942	Y	R
of Nicaragua (STAN)	1950-56	Y	FA
PANAMA			
Reorganization (Law 55) of Department of Agriculture in Secretariat of Education and Agriculture	1938	N	R
Department of Agricultural Diffusion	1952	N	FA
Panamarian Service for Agricultural Information and Cooperation (SICAP)	1954	Y	R, FA

NOTES: R = Research, FA = Farmer advisory services

TABLE 2

CENTRAL AMERICA: MAJOR ORGANIZATIONS INVOLVED IN AGRICULTURAL RESEARCH AND DELIVERY

ORGANIZATIONS	YEAR	STATUS	TECH FUNC.
PANAMA			
Instituto de Investigación Agropecuaria de Panamá (IDIAP)	1975	PD	R
Universidad de Panamá (FACA)			
Facultad de Ciencia Agronómicas		PD	ET, R
Ministerio de Desarrollo Agropecuario (MIDA)		PC	FA
COSTA RICA			
Dirección General de Investig. y Extensión Agrícolas (DGIEA)	1985	PC	R, FA
Direcciones Superiores de Operaciones Regionales	1986	PC	FA
Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)	1942	IO	R,FA,ET
Asociación Bananera Nacional (ASBANA)	1971	PA	R, FA
Universidad de Costa Rica		PrU	
Facultad de Agronomía	1940		R
Centro de Investigaciones Agronómicas (CIA)	1955		
Centro de Investigaciones en Biología Celular y Molecular (CIBM)	1979		R
Centro de Investigaciones en Granos y Semillas (CIGRAS)	1971		R
Instituto del Café de Costa Rica (ICAFE)	1941		R, FA
Universidad Nacional			
Escuela de Ciencias Agrícolas			
Escuela de Ciencias Biológicas			
Escuela de Medicina Veterinaria			R
Instituto de Desarrollo Agrario (IDA)	1961/1982		FA,ET
Escuela Centroamericana de Ganadería	1969		R, ET
Dirección General de Ganadería			
Departamento de Investigación Pecuaria			R
Direcciones Regionales			FA

TABLE 2--Continued

ORGANIZATIONS	YEAR	STATUS	TECH FUNC.
EL SALVADOR			
Instituto Salvadoreño de Investigaciones del Café (ISIC)	1955	PD	R, FA
Instituto Nacional de Azúcar (INAZUCAR)	1982		R, FA
Centro Nacional de Tecnologia Agricola (CENTA)	1973	PC	R
Ministerio de Agricultura y Ganaderia		PC	FA
Centro de Desarrollo Ganadero (CEGA)	1972	PC	R, FA
Cooperativa Algodonera (COPAL)	1964	P	R, FA
Fundación Salvadoreña para el Desarrollo Económico y Social	1985	P	R, FA,ET
GUATEMALA			
Instituto de Ciencias y Tecnologia Agricola (ICTA)	1973	PD	R
Dirección General de Servicios Agricolas (DIGESA)	1970	PC	FA
Dirección General de Servicios Pecuarios (DIGESEPE)	1978	PC	FA
Dirección General de Bosques y Vida Silvestre (DIGEBOS)	1974	PC	FA
Universidad de San Carlos		Pu	R, FA,ET
Universidad del Valle	1966	PrU	R, ET
Universidad Rafael Landivar	1984	PrU	R, ET
Asociación Nacional del Café (ANACAFE)	1969	NGO	R, FA
Asociación de Azucareros de Guatemala (AZAGUA)		NGO	R, FA
Compañia Bananera de Guatemala (BANDEGUA)		P	R
Gremial Nacional de Trigueros	1961	P (through ICTA),FA	R
Asociación de Productores de Cardomomo			R, FA

TABLE 2--Continued

ORGANIZATIONS	YEAR	STATUS	TECH FUNC.
HONDURAS			
Secretaria de Recursos Humanos			
Dirección General de Agricultura			
Escuela Agricola Panamericana (EAP)	1941	Pr	ET, R
Instituto Hondureño del Café	1970	PD	R, FA
Fundación Hondureña de Investigación Agricola (FHIA)	1984	MGO	R, FA
Universidad Nacional Autónoma de Honduras			
Centro Universitario Regional del Litoral Atlántico (CURLA)		PuU	ET, R,FA
Ministerio de Desarrollo Agropecuario y Reforma Agraria (MIDINRA)	1983	PC	
Dirección General de Tecnologia Agropecuario	1988	PC	R, FA
Instituto Superior de Ciencias Agropecuarias	1986	PC	ET, R,FA

NOTE: 1) STATUS PD = Public decentralized organization, PC = Public centralized organization, PrU = Private university, PuU = Public university, NGO = Non Government Organization.
2) TECH FUNCT R = research, FA = Farmer advisory services, ET = Education and training.

TABLE 3

NUMBERS OF EXPERIMENT STATIONS, CENTERS AND FARMS ONE YEAR AFTER ORGANIZATION WAS ESTABLISHED, IN 1978 AND IN 1988

COUNTRY/ORGANIZATION	NUMBER OF STATIONS, FIRST YEAR AFTER	FARMS AND 1978	CENTERS 1988
GUATEMALA			
ICTA	13	17	24
HONDURAS			
SERN	5	9	10
PANAMA			
IDIAP	-	15	23
EL SALVADOR			
CENTA	1	6	6
GANADERIA	1	4	4
FUSADES	3	-	3
COPAL	1	1	1
INAZUCAR	2	2	2
ISIC	1	1	1
COSTA RICA			
DGIEA		3	4

SOURCE: Country-based consultants

TABLE 4

RESEARCH STAFF

	1968	(1)	1978 ALL	1978 UG	1978 MS	1978 Ph.D	1988/89 ALL	1988/89 UG	1988/89 MS	1988/89 Ph.D
COSTA RICA	54		91	91			115	85	22	8
MAG		(2)	91	91			101	71	22	8
ASBANA							14	14		
EL SALVADOR	49		181	177	3	1	131	124	6	1
CENTA			123	120	2	1	84	82	2	
INAZUCAR			–	–	–	–	1	1		
GANADERIA			32	31	1		8	6	2	
FUSADES							6	3	2	1
ISIC			21	21			31	31		
COPAL			5	5			1	1		
GUATEMALA	22		49	37	11	1	144	113	30	1
ICTA			49	37	11	1	144	113	30	1
HONDURAS	56		32	25	3	4	208	159	35	14
S.R.N.			32	25	3	4	148	129	16	3
IHCAFE			–	–	–	–	18	13	5	
FHIA			–	–	–	–	42	17	14	11
PANAMA	7		78	51	17	10	156	72	65	19
IDIAP			38	21	14	3	112	58	41	13
FACA	24	(3)	40	30	3	7	44	14	24	6
NICARAGUA			44	44			320	280	32	8
DIR.CIEN.TECN. MIDINRA		(4)	44	44						
DIR.GEN.							78	77	1	
EXP.CENTERS							151	134	16	1

TABLE 4--Continued

	1968 (1)	1978				1988/89			
		ALL	UG	MS	Ph.D	ALL	UG	MS	Ph.D
EMP.ESTATALES						87	65	15	7
PRIVATE SECTOR						4	4		
REGION	*212*	*495*	*425*	*34*	*16*	*1074*	*833*	*190*	*51*

SOURCE: Country Reports: Tripartite Study Team (1978: data collected by G.Villanueva on Panama; ISNAR series.

NOTES: (1) All data for 1968 from ISNAR series, i.e., Figures corresponding to 1965/69 for Guatemala, El Salvador, Costa Rica and Nicaragua; figures corresponding to 1972 for Honduras and to 1960/64 for Panama.
(2) 1981 data
(3) 1976 data
(4) 1986 data

TABLE 5

EXTENSION STAFF

	1969 TOT.	1969 UG.	1978 TOT.	1978 UG	1988 TOT.	1988 UG
GUATEMALA	*45*	*8*	*626*	*69*	*1067*	*274*
DIGESEPE			(1)200	69	411	132
DIGESA			426		(2)656	142
EL SALVADOR	*99*	*30*	*449*	*41*	*471*	*83*
CENTA			315	15	-	-
GANADERIA			86	26	-	-
FUSADES			-	-	1	1
ISIC			48	-	35	11
MAG			-	-	435	71
HONDURAS	*49*	*0*	*165*	*39*	*582*	*166*
SRN-CROPS			165	39	255	103
SRN-LIVESTOCK			-	-	68	29
IHCAFE			-	-	156	23
INFOP			-	-	103	11
COSTA RICA	*76*	*43*	*217*	*94*	*467*	*ND*
MAG			(3)370	151	467	
MAG			(4)217	94		
NICARAGUA	*52*	*2*	*633*	*97*	*694*	*ND*
DIRECT.OF EXT.			191	25		
INVIERNO			232	12		
C.A.C					694	
B.N.N.			210	60		

TABLE 5--Continued

	1969 TOT.	1969 UG.	1978 TOT.	1978 UG	1988 TOT.	1988 UG
PANAMA	*124*	*43*	*214*	*33*	*414*	*261*
MIDA			118		(2)414	261
BANCO NACIONAL			44	21		
MINISTRY OF HEALTH			18	-		
INST.DEL SEGURO			13	6		
B.D.A.			21	6		
REGION	*445*	*126*	*2304*	*373*	*3925*	*784*

SOURCE: Country reports; Tripartite Study Team (1978); Rice (1971:91); Cuellar (1989:58)

NOTES: (1) 1980 figures. Includes administrative, laboratory and other operational personnel.
(2) 1987 figures
(3) 1981 figures
(4) 1980 figures

TABLE 6

RESEARCH AND EXTENSION BUDGETS
(in thousands of current LCU)

	RESEARCH		EXTENSION		
	1978	1988	1968	1978	1988
PANAMA	*3291*	*5597*	*341(1)*		
IDIAP(2)	3291	5597			
PERS	1277	3126			
OPER	253	370			
MANAG.AND GER.SERVICES	196	231			
INVESTMENT	1565	1871			
HONDURAS	*1612*	*11522*	*510*	*5463*	*16804*
SRN-CROPS	1612	2925		5463	7034
PERS.	1358	2711		3522	5963
OPER.	165	214		831	1072
INV.	89	-		15	-
OTHER	-	-		1096	-
SRN-LIVESTOCK		200			4829
PERS.		151			4485
OPER.		39			344
INV.		10			-
IHCAFE		926			3433
PERS.		736			2577
OPER.		114			282
INV.		4			20
OTHER		72			553
FHIA		7501			
PERS.		5900			
OPER. EXC.		1050			
OTHER		551			
INFOP					1508
PER.					930
OPER.					171
INV.					82
OTHER					325

TABLE 6--Continued

	EXTENSION 1967	RESEARCH AND 1978	EXTENSION 1988
EL SALVADOR	*854*	*37495*	*57273*
CENTA		32000	24600
Management		3000	3000
Tech. Salaries		3000	2000
Oper.Expend.		2500	2900
Other Current.Exp.		2000	2700
Investment		21500	14000
ISIC		3800	7200
Management		400	600
Tech.Salaries		2200	3300
Oper.Expend.		400	1700
Other Current.Exp.		800	1200
Investment		-	400
COPAL		355	69
Management		5	1
Tech.Salaries		250	50
Oper.Expend		75	10
Other Current.Exp.		25	8
Investment		-	-
INAZUCAR			174
Management			1
Tech.Salaries			18
Oper.Expend			125
Other Current.Exp.			25
Investment			5
FUSADES			10300
Management			1000
Tech.Salaries			2000
Oper.Expend.			600
Other Current.Exp.			500
Investment			6200
GANADERIA		1340	7430
Management		80	1000
Tech.Salaries		1100	2900
Oper.Expend.		80	1700
Other Current.Exp.		80	700
Investment		-	1130
MAG			7500
Management			2000
Tech.Salaries			3000
Oper.Expend.			1500
Investment			1000

TABLE 6--Continued

	RESEARCH 1978	RESEARCH 1988/89	EXTENSION 1968	EXTENSION 1978	EXTENSION 1988/89
GUATEMALA	*3830*	*12401*	*233*	*6219*	*50547*
ICTA	3830	12401			
Per.	2759	7739			
Oper.	841	2123			
Inv.	230	2529			
DIGESA				3134	15499
Per.				1954	6118
Oper.				1015	3600
Inv.				165	5781
DIGESEPE				3085(3)	35048
Per.				1316	7348
Oper.				1164	11410
Inv.				605	16290
NICARAGUA	*10502*	*152943*	*2363*		
INTA	10502				
Per.	7800				
Oper.	1183				
Inv.	1512				
MIDINRA (4)		152943			
Per.		52248			
Oper.(1985)		100695			
COSTA RICA	*15350*	*85233*		*28786*	
MAG	15350	85233		28786	
PERS.	10460	74000		21885	
OPER.	2754	11233		5865	
INV.	2136	-		1036	

SOURCE: Country reports: Tripartite study team (1978): data collected on Panama, by G. Villanueva: rICE (1971:100).

NOTES: (1) Data for 1963
(2) Data for 1980 and 1986
(3) Data for 1980
(4) Data for MIDINRA includes both research at experimental stations and extension.

TABLE 7
ABSOLUTE AND PERCAPITA RESEARCH AND EXTENSION
EXPENDITURES BY COUNTRY AND YEAR IN THOUSANDS OF 1985 LCU

	1978			1988		
	STAFF	EXPENDIT	E/S	STAFF	EXPENDIT	E/S
COSTA RICA						
Research	91	111732	1228	115	54219	471
EL SALVADOR						
Research/Extension	630	85605	136	602	31434	52
HONDURAS						
Research	32	2613	82	208	10296	49
Extension	165	8854	54	582	14977	26
GUATEMALA						
Research	49	6876	140	144	7273	51
Extension	626	11165	18	1067	29646	28
PANAMA						
Research	78	3941	50	156	5787	37

SOURCE: Tables 4-6,9

NOTES: LCU estimates were generated using GDP deflators from IMF (19892; 19896). Deflators for El Salvador and Honduras in 1988 were projections.

TABLE 8

SOURCES OF FUNDING FOR PUBLIC RESEARCH AND EXTENSION

COUNTRY/ INSTITUTION	YEAR	GOVERN. BUDGET	INTERNAL REVENUES & CAPITAL	LOANS	DONATIONS	TOTAL
GUATEMALA						
ICTA	(1978)	78.6	12.5	8.9	-	100
ICTA	(1988)	49.9	6.4	42.3	1.4	100
DIGESEPE	(1980)	100.0	-	-	-	100
DIGESEPE	(1988)	22.8	.7	73.1	3.4	100
DIGESA	(1978)	94.9	1.8	3.3	-	100
DIGESA	(1988)	25.8	-	51.7	22.5	100
HONDURAS						
SRN (Global)	1988	40.3	-	36.6	23.1	100
SRN (Crop.Res)	1978	100.0	-	-	-	100
SRN (Crop.Res)	1988	48.9	-	51.1	-	-
SRN (Livestock Res)	1988	-	-	-	100.0	100
SRN (Crop.Ext)	1978	90.9	-	9.1	-	100
SRN (Crop.Ext)	1988	74.7		25.3		100
SRN (Livestock Ext.)	1988	100.0				100
IHCAFE	1988		100.0			100
EL SALVADOR						
CENTA	1978	25.3		68.4	6.3	100
CENTA	1988	25.2		68.7	6.1	100
GANADERIA	1978	99.1		-	.9	100
GANADERIA	1988	17.9		82.1		100
ISIC	1978	100.0				100
ISIC	1988	93.1			6.9	100
PANAMA						
IDIAP	1977	83.4	16.6	-	-	100
IDIAP	1986	61.9	2.4	30.8	4.9	100
IDIAP	1987(1)	47.8	2.7	47.3	2.2	100
IDIAP	1987(2)	69.2	5.6	25.2	-	100

SOURCE: Country reports.

TABLE 9
COMPARATIVE EXPENDITURE DATA
(current LUC--local currency units)

COSTA RICA (COLONES)	**1979**	**1988**
1. Research Expenditures (RE)	20.000.000	85.233.000
2. Extension Expenditures (EE)	29.000.000	
3. Ministry Agriculture Exp.(MOAE)	240.000.000	585.522.150
4. Central Goverment Exp.(CGE)	7.036.000.000	49.611.000.000
5. Ag GDP (GDPA)	6.398.600.000	65.383.800.000
6. GDP	34.584.400.000	356.325.400.000
EL SALVADOR (COLONES)	**1978**	
1. Research Expenditures (RE)	37.495.000	57.273.000
2. Extension Expenditures (EE)		
3. Ministry Agriculture Exp.(MOAE)	102.572.920	172.565.430
4. Central Goverment Exp.(CGE)	1.184.200.000	3.427.200.000
5. Ag. GDP. (GDPA)	2.048.896.000	3.571.600.000
6. GDP	7.692.157.000	27.200.000.000
HONDURAS (EMPRESAS)		
1. Research Expenditures (RE)	1.612.000	11.552.000
2. Extension Expenditures (EE)	5.463.000	16.804.000
3. Ministry Agriculture Exp.(MOAE)	102.923.376	101.654.677
4. Central Goverment Exp. (CGE)	831.914.872	2.015.605.765
5. Ag. GDP. (GDPA)	945.000.000	1.683.000.000
6. GDP	3.372.000.000	7.766.000.000
GUATEMALA (QUETZALES)		
1. Research Expenditures (RE)	3.830.000	12.401.000
2. Extension Expenditures (EE)	6.219.000	50.547.000
3. Ministry Agriculture Exp.(MOAE)	39.847.700	138.418.000
4. Central Goverment Exp. (CGE)	798.866.700	2.875.304.400
5. Ag. GDP. (GDPA)	1.203.886.400	3.817.038.300
6. GDP	5.440.451.900	16.448.946.700
PANAMA (BALBOAS or DOLLARS)	**(1980)**	**(1987)**
1. Research Expenditures (RE)	3.291.000	5.931.253
2. Extension Expenditures (EE)		
3. Ministry Agriculture Exp. (MOAE)	20.000.000	21.500.000
4. Central Goverment Exp. (CGE)	1.163.400.000	1.787.709.880
5. Ag. GDP. (GDPA)	320.400.000	508.600.000
6. GDP	3.558.800.000	5.317.400.000
NICARAGUA (CORDOBAS)		**(1989)**
1. Research Expenditures (RE)	10.502.000	78.670.000
2. Extension Expenditures (EE)		
3. Ministry Agricultures Exp.(MOAE)		
4. Central Goverment Exp. (CGE)	2.526.000.000	
5. Ag. GDP. (GDPA)	3.703.500.000	
6. GDP	14.266.600.000	

TABLE 10
SELECTED INDICATORS
(Percentages)

	1979	1988
COSTA RICA		
(1) RE/MOAE	8.3	14.6
(2) EE/MOAE	12.1	-
(3) RETEE/MOAE	20.4	-
(4) RE/GDPA	.3	.1
(5) EE/GDPA	.5	-
(6) RETEE/GDPA	.8	-
(7) MODAE/CGE	3.4	1.2
(8) MOAE/GDPA	3.8	.9
(9) CGE/GDP	20.3	13.9
(10)GDPA/GAP	18.5	18.3
EL SALVADOR		
(3) RE+EE/MOAE	36.6	33.2
(6) RE+EE/GDPA	1.8	1.6
(7) MOAG/CGE	8.7	4.8
(8) MOAE/GDPA	5.0	4.8
(9) CGE/GDP	15.4	12.6
(10)GDPA/GDP	26.6	12.6
HONDURAS		
(1) RE/MOAE	1.6	11.4
(2) RE/MOAE	5.3	16.5
(3) RETEE/MOAE	6.9	27.9
(4) RE/GDPA	.2	.7
(5) RE/GDPA	.6	1.0
(6) RETEE/GDPA	.8	1.7
(7) MOAG/CGE	12.4	5.0
(8) MOAE/GDPA	10.9	6.0
(9) CGE/GDP	24.7	26.0
(10)GDPA/GDP	28.0	21.7

TABLE 10--Continued

	1980	1987
GUATEMALA		
(1) RE/MOAE	9.6	9.0
(2) EE/MOAE	15.6	36.5
(3) RETEE/MOAE	25.2	45.5
(4) RE/GDPA	.3	.3
(5) EE/GDPA	.5	1.3
(6) RETEE/GDPA	.8	1.6
(7) MOAE/CGE	.5	4.8
(8) MOAE/GDPA	3.3	3.6
(9) CGE/GDP	14.7	17.5
(10)GDPA/GDP	22.1	23.2
PANAMA		
(1) RE/MOAE	16.5	27.6
(4) RE/GDPA	1.0	1.2
(7) MOAE/CGE	1.7	1.2
(8) MOAE/GDPA	6.2	4.2
(9) CGE/GDP	32.7	33.6
(10)GDPA/GDP	9.0	9.6

SOURCE: TABLE 5

NOTES: Re= research expenditures, EE= extension expenditures, MOAE= Ministry of Agriculture Expenditure, CGE= Central government expenditures, GDPA= Gross Domestic Product of Agriculture, GDP= Domestic Product.

TABLE 11
MAJOR AREAS OF CONCENTRATION OF EFFORTS, OUTPUTS AND IMPACTS

PAIS	MAGNITUD DE ESFUERZOS	TECNOLOGIAS GENERADAS	IMPACTO ECONOMICO
PANAMA			
MIDA	1.ARROZ MECANIZ,2.MAIZ,3.ASIST.SANIT.Y FOMENTO DEL CAFE,3.SORGO,4.MELON Y SANDIA DE EXPORT.,5.HORTALIZAS.		1.ARROZ,2.MAIZ,3.CAFE,4.SORGO,5.MELON, 6.SANDIA,7.HORTALIZAS.
COSTA RICA			
DIECA	INVEST: 1.MEJ.GENETICO(CAFE,ARROZ,ALGODON) 2.ENTOMOLOGIA(HORTALIZAS). 3.PRODUCC DE SEMILLAS.(G.BASICOS, RAICES Y TUBERCULOS.) EXTENS:1.FERTILIZ.(CAFE,CACAO,G.BAS,HORT.) 2.CONTROL FITOSANIT.(HORT,FRUTALES) 3.INTRODUCC. DE SEMILLAS MEJORADAS.	1.VARIEDADES MEJORADAS(ARROZ,CANA,CAFE, GRANOS BASICOS.) 2.CONTROL BIOLOGICO (HONGOS ENTOMOFAGOS,FEROMONAS.) 3.SEMILLAS MEJORADAS(G.BASICOS,RAICES Y TUBERCULOS)	1.CAFE,2.ARROZ,3.ALGODON.4.PAPA,5.NAME. 6.HORTALIZAS.
NICARAGUA			
MIDINRA-DGTA	1.FRIJOL,2.CAFE,3.MAIZ,4.SORGO,5.ALGODON, 6.TABACO,7.HORTALIZAS,8.SOYA,9.AJONJOLI, 10.FRUTALES,11.ARROZ.	1.MEJORAMIENTO GENETICO,2.PROTECCION DE CULTIVOS,3.MANEJO DE CULTIVOS.	
HONDURAS			
SEC.REC.NAT.	1.MAIZ,2.FRIJOL,3.ARROZ,4.SORGO,5.SOYA, 6.PAPA,7.HORTALIZAS,8.AJONJOLI,9.YUCA.	1.MAIZ,2.FRIJOL,3.ARROZ,4.HORTALIZAS, 5.SORGO,6.PAPA,7.SOYA,8.AJONJOLI,9.YUCA.	1.ARROZ,2.HORTALIZAS,3.PAPA,4.SOYA, 5.MAIZ,6.FRIJOL,7.AJONJOLI,8.SORGO,9.YUCA.
INCAFE	1.CAFE 2.CACAO 3.CARDAMOMO	ICAFE. 2.CACAO 3.CARDAMOMO.	1.CAFE. 2.CACAO. 3.CARDAMOMO
GUATEMALA			
DIGESA	1.TRANSF.DE TECNOLOGIA EN GRANOS BASICOS. 2.TRANSF. DE TECNOLOGIA EN HORTALIZAS (PAPA,TOMATE).3.TRANSF. EN TEC.MECANICA.	1.TRANSF. DE TECNOLOG. EN G.BASICOS 2.TRANSF.EN MINIRIEGOS Y CONSERVAC. DE SUELOS.3.TRANSF.EN CULT.DIVERSIFICADOS	1.TRANSF.EN MINIRIEGOS Y CONSERVAC. DE SUELOS.2.TRANSFERENCIA EN HORTALIZAS. 3.TRANSFERENCIA EN GRANOS BASICOS.
DIGESEPE	1.SANIDAD ANIMAL.2.TRANSF. DE TECNOLOGIA.	1.VACUNAC.2.DESPARASIT.3.INSEM.ARTIF.	1.MEJ. HATO BOVINO.2.MEJ. HATO SP MENORES.
ICTA	1.VARIEDADES EN HIBRIDOS DE MAIZ. 2.VARIEDADES DE FRIJOL. 3.VARIEDADES DE ARROZ.	1.VARIEDADES E HIBRIDOS DE MAIZ. 2.VARIEDADES DE TRIGO. 3.VARIEDADES DE ARROZ.	1.USO DE MATRIAL GENETICO EN MAIZ CON PEQUENOS Y MEDIANOS AGRICULTORES. 2.INCREMENTO PROD. DE ARROZ CON AGRICUL. GRANDES INTENSIVOS. 3.ASISTENCIA EN PROD.AGROIND.Y COMERCIALIZ.EN MELON.
EL SALVADOR			
CENTA	1.MAIZ,2.FRIJOL,3.TOMATE.	1.MAIZ,2.FRIJOL,3.SORGO.	1.MAIZ,2.SORGO,3.ARROZ.
INAZUCAR-ITALC	1.MANEJO AGRONOMICO,2.TRANSFERENCIA, 3.PROTECCION FITOSANITARIA.	1.MANEJO AGRONOMICO,2.VARIEDADES.	1.MANEJO AGRONOMICO, 2.PROTECCION FITOSANITARIA,3.VARIEDADES.
CGG	1.BOVINOS,2.CERDOS,3.AVES.	1.BOVINOS,2.CERDOS,3.AVES.	1.AVES,2.BOVINOS,3.CERDOS.
COPAL	1.VARIEDADES,2.MANEJO AGRONOMICO, 3.PROTECCION FITOSANITARIA.	1.PROTECCION FITOSANITARIA, 2.MANEJO AGRONOMICO,3.VARIEDADES.	1.VARIEDADES,2.MANEJO AGRONOMICO, 3.PROTECCION FITOSANITARIA.
FUSADES	1.MELON,2.PEPINO,3.CHILE DULCE.	1.MELON,2.PEPINO,3.CHILE DULCE.	1.MELON,2.PEPINO,3.CHILE DULCE.
ISIC	1.MANEJO AGRONOMICO,2.VARIEDADES, 3.TRANSFERENCIA.	1.VARIEDADES,2.MANEJO AGRONOMICO, 3.PROTECCION FITOSANITARIA.	1.VARIEDADES,2.MANEJO AGRONOMICO, 3.PROTECCION FITOSANITARIA.
MAG	1.MAIZ,2.FRIJOL,3.GANADO	1.MAIZ,2.FRIJOL,3.GANADO	1.MAIZ,2.AVES,3.TOMATE.

TABLE 12
COBERTURA DE PRODUCTORES POR PRODUCTOS, INSTITUCIONES Y PAISES

PAIS	COSTA RICA			
NSTITUCION	DGIEA (MAG)			
S	% HA.	TOTAL HA.	% PRODUCT	TOTAL PRODUCT
MAIZ	11.7	50.7		
FRIJOL	8.5	40.7		
ARROZ	3.7	86.4		
SORGO		13.7		
SOYA				
ORTALIZAS				
PAPA	12.3	2.7		
AJONJOLI				
YUCA				
PIÑA		2.4		
CACAO	24.5	19.7		
CAÑA	13.9	47.3		
FRUTALES				
ALGODON		1.1		
CITRICOS				
PLATANO				
NADO BOVINO	0.6	2190.0		
MANGO				
BANANO		32.3		
CAFE	13.0	89.9		
ANOS BASICOS				
LMA ACEITERA		16.0		
PEPINO				
MELON				
SANDIA				
TOMATE				
CHILE				
PAPAYA				
FORRAJES				
CEBOLLA				
CARDAMOMO				
ZAPALLO				

PAIS	HONDURAS										EL SALVADOR					
INSTITUCION	SRN		FHIA		INFOP		IHCAFE		MAG		MAG-INAZUCAR		MAG-COPAL		MAG-FUSADES	
RUBRO	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT	% PRODUCT	TOTAL PRODUCT
MAIZ	10.5	171590							30.0							
FRIJOL	10.5	67857							25.0							
ARROZ	10.5	16093							30.0							
SORGO	10.5	30703							20.0							
SOYA	70.0	24	10.0	24												
HORTALIZAS	20.0	3650	5.0	3650	7.0	3650										
PAPA	25.0	913			5.0	913										
AJONJOLI	30.0	767														
YUCA	5.0	5750														
PIÑA	30.0	1669			0.3	11669										
CACAO	5.0	1220	20.0	1220	2.0	1220	63.0	1220								
CAÑA	10.0	17616									30.0					
FRUTALES	15.0	121			4.0	2192										
ALGODON	60.0	245											50.0			
CITRICOS	5.0	2071	30.0	2071					25.0							
PLATANO	10.0	6220	30.0	6200	2.0	6200			22.0							
GANADO BOVI	5.0	82610							20.0							
MANGO			10.0						10.0							
BANANO			15.2													
CAFE					1.0	66529	55.0	50300	50.0							
GRANOS BASI					3.0	314251										
PALMA ACEIT					0.5	20										
PEPINO															25.0	
MELON															53.0	
SANDIA															33.3	
TOMATE									27.0							
CHILE															33.3	
PAPAYA																
FORRAJES																
CEBOLLA																
CARDAMOMO							[illegible]	[illegible]								

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1Here we are distinguishing between information as the normal material (input) and output of an ATS and information and knowledge relating to its structure and operation.

2Differentiation here refers to the "splitting off" of a given activity into a separate organizational niche of its own. It should not be confused with "segmentation" which refers to the replication of functionally equivalent units--for instance the segmentation of a community, or a family, into a number of separate families all of which are equivalent. The organizational separation also implies a distinct identity of its own as well as normative regulation.
Differentiation processes take place both within complex or formal organizations--for example, the creation of a new program--as well as through the creation of new and different organizations.

3 Steady here does not necessarily imply constant; steady variation is also possible and more likely.

4 Between 1920 and 1950 the total population of the six Central American countries almost doubled, from 4.9 to 9.1 million, and 48% of that increase took place in the forties (Reyes-Pacheco,1986:143).

5 In some cases at least the bulk of technology efforts remained in foreign hands. For instance in the case of early US-Nicaraguan research efforts research results were analyzed abroad (Berrios, 1989). While this undoubtedly reflected absence of local top quality facilities and personnel it also reflected a rather limited attempt to systematically develop such local capabilities.

6 On the various conditions making for linkage among parts of the agricultural research system in the United States,see, for instance, Flora and Flora (1989) and Busch ;and Lacey (1983).

7 Extension budgets for Guatemala include the full cost of DIGESA and DIGESEPE which also engage in other activities in addition to extension.
8 In addition to country reports see, for example, ISNAR (1981;1987) for Costa Rica;FAO (1985) and Cuellar (1989) for Panama; ICTA (n.d.) on Guatemala; and Tripartite Study Team (1978) for all of the countries.
9 The very largest and better-off modernizing landholders, however, probably interacted less with the public extensionist since they had access to private sector technology which was becoming available in the postwar. Extensionists probably had their greatest impact on modernizing medium to large landholders plus a few innovative smallholders.
10 On the T and V methodology see Benor and Harrison (1977) and Hage and Finsterbusch (1987:106-13) for a critical appraisal.
11See, for example, Whyte, 1983 on this for ICTA and PNIA; the second instance actually involved a learning process with regard to the first.
12 eg., Ortiz et al (1989) and Itúrbide (1990) for Guatemala, Cuellar (1989) and Pereira (1989) for Panama, and Palmieri (1989) for Costa Rica.
13 The above refers primarily to research where the costs of results represent a kind of fixed cost or overhead that may be spread out over large or small productions and populations. This is not the case with extension which tends to represent more of a variable cost in relation to numbers of farmers and areas covered.

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SEMINAR "Mobilizing Agricultural Technology to

Meet Central American Challenges"

PRODUCCION Y DESARROLLO AGRICOLA SOSTENIBLE

Por: Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)

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INDICE

PRODUCCION Y DESARROLLO AGRICOLA SOSTENIBLE

A nivel mundial la producción de cereales en las últimas cuatro décadas ha aumentado a una tasa promedio anual de 2.7%, es decir, suficiente para responder a las demandas en aumento causadas por el crecimiento de la población, por un mejoramiento en la dieta alimenticia de los países en desarrollo, así como por las necesidades crecientes de alimentación que existen en el mundo desarrollado. Por otra parte podemos aseverar que la productividad agrícola ha aumentado en estos mismos años debido principalmente a las innovaciones tecnológicas, producto a su vez entre otros esfuerzos, al de la llamada "Revolución Verde" y de la orientación de la investigación agrícola, que se puede ilustrar en forma resumida mediante los siguientes aspectos:

1. Nuevas variedades de alto rendimiento

2. Mayor uso de agroquímicos

3. Una mayor área bajo irrigación

A pesar de los logros significativos, el crecimiento observado y el desarrollo de la agricultura no ha sido equilibrado en su impacto. Es decir, si bien la investigación ha propiciado el desarrollo de variedades de altos rendimientos, estas son exigentes en insumos que por lo general, son inaccesibles para los productores de escasos recursos, los que permanecen al margen del desarrollo. En términos absolutos, existe actualmente un mayor número de personas mal alimentadas en el mundo. Se estiman entre 700 y 800 millones las que tienen un nivel de desnutrición significativo.

El impacto de la nueva tecnología ha sido desigual; la brecha tecnológica se ha incrementado. Puede decirse que la llamada "Revolución Verde" ha tenido un efecto limitado en América Central y en Africa. Igualmente puede aseverarse que la agricultura hasta ahora tiene en el mundo el potencial para producir suficiente comida para toda la población humana, pero este alimento no siempre está disponible donde se necesita. Bajo estas premisas, debe promoverse la produccion eficiente y económica de alimentos en países que son deficitarios, pudiendo así mitigarse la distribución alimentaria desigual.

Sin embargo es necesario reconocer que el desarrollo agrícola no puede medirse únicamente por la disponibilidad de alimentos o incrementos de comida, sino también, por las diferentes formas o mecanismos que otorgan diversas oportunidades a las personas de ganar más dinero para satisfacer sus necesidades indispensables. Los subsidios a las exportaciones de alimentos en los países desarrollados, con las correspondientes importaciones por parte de los países en desarrollo que tienen recursos por explotar, puede conducir a un severo desempleo en el mediano plazo. Acciones de esta naturaleza tienden a marginalizar a la población más pobre, no dejándole a las comunidades rurales otra alternativa, que la de emigrar a áreas sometidas básicamente a la incertidumbre de las lluvias, con suelos frágiles difíciles de trabajar, como son las tierras de laderas, las tierras altas, las tierras xerófilas y los bosques naturales.

Todo lo anterior obliga a que estas poblaciones para sobrevivir utilicen alternativas de producción que afectan negativamente la base de recursos naturales existentes. Sin embargo, esta es sólo una dimensión del problema, debido a que la pobreza rural es un factor que afecta la sostenibilidad del desarrollo agrícola; pero también ésta es afectada por la explotación agrícola comercial moderna. Un ejemplo de ello lo tenemos en las plantaciones bananeras donde el uso excesivo de agroquímicos ha ocasionado serios daños ecológicos desde la época en que se usaba el Caldo Bordeles para el combate de enfermedades.

I. Usos predominantes del suelo en el Istmo Centroamericano

Los principales usos del suelo en la región son los cultivos múltiples xerófilos, el monocultivo anuales y perennes en tierras bajas, la producción ganadera de doble propósito, el pastoreo extensivo, la agricultura trashumante, los cultivos múltiples en tierras de elevación intermedias y altas, la producción de café, la ganadería lechera de altura, las actividades extractivas de bosque primario y de bosque secundario y la conservación de áreas silvestres. En el Cuadro 1 se presentan los diferentes usos de la tierra en el Istmo Centroamericano (FAO, 1984).

La preocupación sobre la sostenibilidad del desarrollo agrícola resulta como una consecuencia de la obvia degeneración de la base de recursos naturales que producen ciertos usos del suelo. Cuando la presión demográfica era baja, el daño a la base de recursos naturales era mínima; se ha estimado que las dos terceras partes del bosque primario en América Central ha sido cortado entre 1950 y 1985. El área natural de bosques en América Central era de 238.640 km^2 en 1970 y 179.160 km^2 en 1987. Aún cuando existe todavía una área considerable de bosque en la región, la mayoría se encuentra en áreas poco pobladas, de tal forma que es escaso su efecto en la reducción de la degradación de suelos o reducida su utilización como fuente de energía de áreas densamente pobladas. El patrón de cambio de uso del suelo de 1972 a 1987, en el Istmo Centroamericano se presenta en el Cuadro 2, evidenciándose que la pérdida más grande de bosque ha ocurrido en Guatemala, Nicaragua y Costa Rica; por otra parte, las áreas con pastizales han aumentado más que las áreas de cultivos.

La producción de alimentos per capita en América Central disminuyó entre 1975 y 1981 (Cuadro 3). Por otra parte, las consideraciones de mercado actuales no favorecen la producción de muchos de los productos agrícolas en los que América Central es deficiente. Paradojicamente, las exportaciones de carne, fruta, hortalizas, azúcar y café, sumaron un total de 2200 millones de dólares en 1983, mientras que las importaciones de cereales, productos lácteos y aceite vegetal, totalizaron solamente 300 millones de dólares (BID, 1985).

Algunos de los sistemas de uso de la tierra actualmente vigentes en América Central pueden ser considerados razonablemente como sostenibles, sin embargo, otros no lo son; mucho depende de la naturaleza de la base de recursos. Café y cacao con sombra pueden ser mantenidos muchos años con muy poca alteración de la base de recursos. A bajas densidades de población, la agricultura trashumante es un método de uso sostenible. En algunos de los mejores suelos de las partes altas en el centro de Guatemala o en la costa del Pacífico de América Central, la producción de cultivos anuales, como se practica actualmente, no ha resultado en una degeneración del recurso suelo. Se puede argumentar que es así en virtud a que estas áreas no sólo tienen un suelo de alta calidad, sino que además se renueva periódicamente por la actividad volcánica (Kass, 1981; 1983). De una forma u otra, existen áreas alrededor de la ciudad de Guatemala que han estado sujetas al cultivo de maíz contínuo por más de 2000 años.

Desafortunadamente en áreas menos favorecidas la alteración de la base de recursos es obvia y la productividad no se puede mantener. Debido a la existencia de usos del suelo económicamente más redituables, la producción de alimentos ha sido desplazada de las áreas planas con suelos profundos, hacia los suelos delgados de ladera, que no sólo son químicamente empobrecidos, sino que de hecho pueden no existir después de dos o tres ciclos de cultivo. Lograr que la producción agrícola en estos sitios sea sostenible puede ciertamente ser una contribución valiosa; desafortunadamente, los retornos económicos obtenidos del cultivo de cereales no pueden financiar los insumos necesarios para hacer que éstos sean sostenibles. La incorporación de cultivos con valores económicos más altos puede proporcionar con mayor probabilidad los insumos necesarios. En forma urgente es indispensable desarrollar sistemas de producción sostenibles para los cultivos de alto valor económico.

La agroforestería ha sido propuesta frecuentemente como una forma de que los cultivos anuales y los pastizales puedan constituirse en sistemas sostenibles; lo anterior ha sido incluso denominado la "hipótesis agroforestal" (Sánchez, 1987). La introducción de árboles leguminosos puede incorporar a los sistemas de cultivos anuales y pasturas, los mismos beneficios que han proporcionado las plantaciones de café y cacao. Debido a que la extracción de nutrientes de los sistemas de cultivos y pasturas en términos generales, es más alta que en los cultivos perennes (Sánchez, 1976), los sistemas agroforestales son promisorios, puesto que pueden producir cultivos de alto valor económico y varios elementos nutritivos, que a su vez pueden ser reciclados. Como ha sido establecido por Sánchez (1987), la mayor parte de la investigación con sistemas agroforestales se ha realizado en suelos de buena calidad, donde se ha demostrado la habilidad de estos sistemas para hacer la producción vegetal y animal sostenible, habilidad que en los suelos delgados de ladera tiene todavía que ser demostrada.

Bajo las anteriores circunstancias uno de los principales impactos que pueda tener la adopción de tecnologías debe ser, entre otros, sobre la degradación de los suelos, el uso racional del agua, los bosques y la fauna. Los aspectos socioeconómicos e institucionales del desarrollo agrícola son igualmente importantes. Estos últimos aspectos están ciertamente influenciados por variadas condiciones ajenas a las comunidades rurales y que son principalmente de naturaleza política, razón por la cual la búsqueda del desarrollo agrícola sostenible no puede concentrar su atención únicamente en los factores ecológicos; debe también referirse a los factores económicos, tecnológicos, institucionales y sociales, todos aspectos relevantes a ser incorporados en el sistema de valores y desarrollo de metodologías.

II. Definición

El concepto de sostenibilidad ha cobrado en forma intempestiva un interés universal; de hecho se ha constituído en un aspecto principal en las agendas de trabajo de los organismos que se dedican principalmente a la investigación agrícola.

En la actualidad, forestales, climatólogos, edafólogos, biotecnólogos, zootecnistas, fitomejoradores, fitopatólogos, estudiosos de la vida silvestre, agrónomos, propician una agricultura con un menor uso de productos químicos. Sin embargo, debido a que el concepto ha surgido de las síntesis elaboradas desde diferentes perspectivas, es poco probable que exista una definición que sea comúnmente aceptada, pero en lo que casi todos están de acuerdo, es que se debe pasar de situaciones declarativas, argumentales y en ocasiones proposiciones concluyentes, a la fase en la que se patrocine la incorporación del concepto sostenibilidad en el trabajo de la tierra que propicie acciones concretas y metodologías operativas que den lugar a un desarrollo agrícola sostenible y que, por ende, la sostenibilidad pueda ser medida..

Es interesante destacar que la sostenibilidad en agricultura más que un atributo, debe constituir un proceso, mediante el cual se puedan alcanzar cada vez mejores niveles de vida y bienestar social, sin comprometer la capacidad productiva y dotación de recursos que tiene la humanidad, a fin de que generaciones futuras puedan satisfacer, en su tiempo y circunstancias, sus adecuados niveles de vida y bienestar. Es decir, una agricultura que sea económicamente viable en el corto plazo y que aún así no degrade el medio ambiente en el largo plazo.

En síntesis, la esencia del concepto de sostenibilidad puede traducirse en el mantenimiento de la productividad de los recursos naturales renovables y no renovables. Más aun en nuestros países en desarrollo, el concepto debe ser compatibilizado, con el de bienestar económico y social, con el mejor nivel de vida e ingresos de las poblaciones rurales.

Muchas instituciones seguramente están aceptando el concepto de agricultura sostenible como una meta abstracta; sin embargo, hay otras que están considerando seriamente las necesidades de tener una productividad sostenida de los recursos en el largo plazo, al tiempo que se procura ofrecer una consideración explícita sobre las necesidades de producción a corto plazo. En otras palabras, estas instituciones están tratando de generar tecnologías basadas en conceptos operativos y metodologías sistemáticas que permitan precisar aspectos concretos, entendibles y sencillos de poner en práctica.

El própósito principal va más allá que el de establecer un marco conceptual sobre la sostenibilidad, se trata de identificar dentro de éste un proceso general de desarrollo e investigación, y en consecuencia definir posibles estrategias que pudieran ser usadas por las instituciones de un país, como guías para el desarrollo y diseminación de la agricultura sostenible.

III. Marco Conceptual

El desarrollo y producción agrícola sostenible puede, en primera instancia, identificarse como una estrategia de manejo y control que propicia una ayuda real al productor para escoger los mejores métodos y prácticas culturales, precisar las dosis óptimas de biocidas y fertilizantes, determinar los cultivos más acordes con la capacidad del suelo, utilizar la disponibilidad de los recursos de su finca para la producción, con el fin de reducir costos de producción, minimizar el deterioro de los sistemas agrícolas en uso y preservar de la mejor forma el ambiente en el cual está inserto.

En otros términos, la agricultura sostenible es un tipo de agricultura que debe evolucionar en forma constante, hacia un óptimo dentro de un sistema, con la máxima eficiencia en su utilidad comunitaria y haciendo el mejor uso de los recursos de la región. De esta forma se espera favorecer un balance satisfactorio entre la capacidad productiva y el medio ambiente circundante.

Existen varios criterios de análisis que corresponden, entre otros, a factores y diferentes niveles de agregación (rubro, finca, región) bajo los cuales se puede analizar la sostenibilidad. Los factores corresponden a una separación de los principales aspectos que intervienen en el proceso de producción agrícola, como son: los tecnológicos, ecológicos, económicos, socioculturales y los institucionales (Cuadro 4). Los niveles de agregación posibilitan procedimientos para cuantificar y medir las características o indicadores del cambio, que resultará de la aplicación de nuevas tecnologías que favorecen una agricultura sostenible.

IV. Proceso de Investigación

Existen jerarquías que deben reconocerse y que sólo mediante la investigación, el estudio y la comprensión de este ordenamiento es que podrá tomarse conciencia de su razón de ser, para que así pueda incorporarse a los usos y hábitos de los agricultores, de la cultura del conjunto de la comunidad y finalmente a las costumbres de una región. Así es como debe analizarse la sostenibilidad de un rubro, una finca o una región. Se puede o tal vez se debe analizar los aspectos relativos a la sostenibilidad a nivel de un terreno sembrado por un agricultor; a nivel de su finca, como un conjunto de terrenos con usos múltiples; a nivel de una comunidad, como un conjunto de fincas establecidas en un área geográfica determinada y finalmente, a nivel de la región, como un conjunto de comunidades establecidas, en lo que puede identificarse como un ecosistema.

Cada uno de los niveles de jerarquía antes mencionado, deberá ser analizado en función de los factores que influyen claramente en el proceso de producción agrícola, razón por la cual deberá incorporar consideraciones específicas en lo tecnológico, ecológico, económico, sociocultural e institucional. Los de tipo tecnológico tienen que ver con la búsqueda de innovaciones tecnológicas fundamentadas en: variedades mejoradas altamente productivas, resistentes a adversidades y con bajos requerimientos de insumos, con mejores y más eficaces sistemas de producción, incluyendo el uso adecuado de las especies forestales y con la utilización más apropiada de la tierra de acuerdo a su capacidad agroecológica y otros recursos regionales para optimizar el máximo potencial productivo de las innovaciones tecnológicas. Los aspectos de tipo ecológico tienen que ver con: la capacidad del suelo, el uso del suelo, la disponibiliad de agua, las condiciones climáticas y la biodiversidad existente entre otros. Los aspectos de tipo económico deben considerar: la existencia de capital, las relaciones de intercambio, las relaciones entre el precio de los productos y costo de los insumos, los costos de producción, etc. Los aspectos de tipo social comprenden: los hábitos, las costumbres, los valores culturales, la historia que existe en el lugar de trabajo, etc. Los aspectos de tipo institucional deben considerar: las disposiciones legales, las políticas de gobierno, las dependencias de apoyo al campo, los organismos internacionales, los convenios y concertaciones existentes. La influencia de cada uno de los factores, en todos y cada uno de los niveles de agregación considerados, es determinante para el desarrollo de una agricultura sostenible.

Es ineludible tomar en cuenta el tipo de productor o clientela en la búsqueda de alternativas que permitan establecer una agricultura sostenible. La clasificación resultante debe responder a la realidad económica presente en la región, marcando una orientación sobre las condiciones sociales e institucionales que existan y su relación con la utilización de los recursos naturales.

Recientemente se hizo una clasificación para América Central*, con motivo de una reunión técnica preparatoria para trabajar sobre transferencia de tecnología en la región y en donde se caracterizaron los siguientes grupos:

1. Productores de artículos de exportación tradicional que no están en crisis (café, banano y plátanos).

2. Productores de artículos de exportación en crisis (azúcar, algodón y carnes).

3. Productores de artículos de exportación no tradicional.

4. Productores empresariales a nivel intensivo (pequeños y medianos agricultores).

5. Productores empresariales a nivel extensivo.

6. Productores de subsistencia o marginales (con capital bajo o sin capital).

Es dable pensar que el tipo de trabajo de investigación debe realizarse en los diferentes niveles de agregación y considerando los diferentes criterios que influyen en el proceso productivo, como son los factores disciplinarios referidos anteriormente, así como los tipos de agricultores presentes en una localidad determinada. Entendiendo,

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* Reunión Técnica Preparatoria. IICA-ROCAP. Conferencia sobre Transferencia de Tecnología. San José. Setiembre 12-17, 1988.

además, de que para cada tipo considerado la tecnología disponible puede ser diferente, si se toma en cuenta las peculiaridades que tienen el o los agroecosistema(s) que lo(s) integra(n).

La Figura 1 al ser analizada muestra la necesidad de remover limitaciones de orden técnico, ecológico, económico, sociocultural e institucional, para alcanzar una agricultura sostenible, obligando a estudiar todas las posibles limitaciones en los tres niveles de jerarquía y tomando en consideración a los actores principales, los productores del lugar.

Hart & Sands (1989) sostienen que la estrategia de la agricultura sostenible y la investigación tecnológica representativa deben tener como objetivo no sólo el incremento de la producción y productividad, sino que también al mismo tiempo permita preservar la productividad de la base de los recursos naturales y la aceptabilidad social. El reto común que todos confrontamos es el de encontrar caminos que permitan eliminar los impedimentos para el logro de estos propósitos.

Un ejemplo de este tipo de agricultura se encuentra evolucionando con conocimiento de causa y en forma sistemática en los Estados Unidos. A nivel de finca los agricultores están sustituyendo los fertilizantes sintéticos por composta y leguminosas; para controlar insectos perjudiciales y malezas, realizan rotación de cultivos, labranza mínima y control mecánico de malezas. En la actualidad se estima que de los 2.7 millones de agricultores en los Estados Unidos, 100.000 están siguiendo este tipo de agricultura sostenible (Smith, 1989).

La ocurrencia de este cambio se debe a la evidencia de los efectos dañinos de las técnicas agrícolas tradicionales, mediante las cuales se estima que los agricultores en los Estados Unidos están aplicando 10.5 millones de toneladas de fertilizante por año y aproximadamente 55.000 toneladas de pesticidas. La agencia de protección del medio ambiente (EPA), ha encontrado en muestreos en los Estados de Iowa, Florida y Minessota, contaminación de productos químicos en el agua del subsuelo, que constituye el 50% de agua potable en esos Estados. Además, como ocurre en otras partes del mundo, la irrigación de terrenos agrícolas está reduciendo los acuíferos y causando un ensalitramiento de áreas agrícolas importantes. Con la práctica de la agricultura intensiva, el efecto del viento y del agua, se estima, que se están erosionando 3.000 millones de toneladas de suelo anualmente en los terrenos agrícolas de los Estados Unidos.

Por lo anteriormente expuesto es que se hace énfasis en las prácticas de agricultura sostenible, para lo cual se utiliza, entre otros, la rotación de cultivos múltiples, en lugar de sembrar grandes extensiones con monocultivos como maíz o trigo. Técnicas de siembras como labranza mínima en que parte de los residuos del año anterior permanecen en la superficie, así como el deshierbe mecánico, son prácticas agropecuarias que se están reincorporando.

Sin embargo, no cabe duda que la agricultura sostenible debe poseer un conocimiento científico importante, pero también requiere de un mejor agricultor, más informado, motivado y estimulado para poner en práctica este tipo de agricultura. A ese agricultor hay que formarlo. Actualmente sólo una fracción de los 600 millones de dólares que el

Departamento de Agricultura de los Estados Unidos destina a la investigación y extensión agrícola, están asignados a estudios sobre agricultura sostenible. El programa de agricultura sostenible con bajos insumos (LISA), con un financiamiento disponible de US$8.4 millones aproximadamente ha recibido más de 800 solicitudes en los últimos 2 años y de éstas sólo 105 fueron aprobadas y apoyadas con financiamiento (Janke, 1990). No obstante, se ha iniciado la época en la que los agricultores, por convencimiento propio, encuentran alternativas fuera de las técnicas convencionales de la "Revolución Verde", vigentes desde hace años, hacia otras formas de agricultura que permitan un beneficio de corto plazo y aseguren una productividad de la base de recursos naturales a largo plazo. Se observa entonces que se ha iniciado todo un movimiento, modesto si se quiere, que debe ser apoyado en la forma más enérgica posible por medio de la investigación científica, la comunicación, la transferencia de conocimientos y las actividades educativas.

El trabajo que se está realizando en la actualidad, es la simple aplicación de conocimientos existentes, sin embargo, es necesario reconocer que el análisis y el trabajo de investigación a realizarse debe considerar diferentes factores o dimensiones, como se indica en el Cuadro 4. En él se presenta un intento para inducir a los investigadores a reflexionar no sólo en cuanto al tipo de trabajos que pueden ser relevantes al própositо de sostenibilidad, sino que más importante aún, en el tipo de características que deben ser tomadas en cuenta para medir los posibles cambios obtenidos y el impacto que los resultados de esas investigaciones, deban tener en el propósito de generar una agricultura sostenible que sea económicamente viable, ecológicamente segura y socialmente aceptable (Swaminathan, 1990).

Existen pocos antecedentes sobre lo anterior, debido a que resulta muy complejo medir las interacciones entre los componentes dentro de una finca. Igualmente lo es la interacción entre la finca y el entorno socioeconómico, el ecológico y el institucional. En este caso se están analizando las interacciones de primer orden; cualquier otro nivel de interacción, además de ser complejo en su estudio, resulta muy complicado en su interpretación. De todas maneras, no sólo debe intentarse, sino que es conveniente penetrar en el análisis de este tipo de relaciones que den lugar a la definición de una situación estática, así como al análisis y conocimiento de la dinámica del proceso.

El estudio integral de estos fenómenos requiere de un nivel de complejidad operativa que es considerado por muchos como más allá de lo factiblemente realizable. De todas maneras, es necesario reconocer que cualquier intento de alcanzar el anterior propósito, debe ser identificado, conocido, interpretado y decididamente apoyado a fin de avanzar en el trabajo sistemático e integral de la compleja situación descrita.

Existe un elemento que es fundamental e imprescindible en este tipo de trabajos con un enfoque holístico, como es el alcanzar y cuantificar la interacción entre disciplinas cuyo efecto se espera trascienda y supere significativamente sobre el efecto de las disciplinas individualmente consideradas, sirviendo de esta manera en mucho mejor forma a describir y mejorar el fenómeno bajo análisis (Conway, 1985; Hart & Sands, 1989). El trabajo es interdisciplinario, integrado, y necesariamente pluriorganizacional. Es un requisito indispensable para realizar acciones en sostenibilidad a nivel de rubro, finca y región (Tarté & Casas, 1989).

V. Estrategia Operativa

Ultimamente, como resultado de un amplio ejercicio de planificación de desarrollo en el CATIE, se ha llegado a plantear la posibilidad de estudiar y generar conocimientos sobre agricultura sostenible, trabajando en regiones estratégicamente seleccionadas, de tal manera que sea posible involucrar a:

1. los diferentes niveles de agregación

2. las disciplinas que intervienen en el proceso productivo

3. los actores fundamentales de este proceso: los productores.

Se pretende realizar dentro de un enfoque holístico, pero asegurando el análisis y cuantificación de los efectos disciplinarios y sus interacciones, en los componentes críticos de un sistema de producción, en los diferentes niveles de jerarquía y grupos sociales que hacen la agricultura. La investigación que se ha propuesto tiene una perspectiva regional, que enfoca la problemática más allá de los límites de la finca, seguramente incorporando varias comunidades e integrando los elementos de producción con el de manejo de los recursos naturales a nivel de ecosistema. El lugar donde se lleve a cabo este tipo de trabajo se ha denominado Area Piloto de Investigación en Agricultura Sostenible (AP). En ellas es indispensable armonizar el concepto de sostenibilidad del desarrollo agrosilvopecuario, con la búsqueda agresiva de innovaciones científicas y tecnológicas, que respeten las políticas ambientales (Tarté & Casas, 1989).

Las Areas Piloto de Investigación en Agricultura Sostenible pueden definirse como el sitio donde funcionan proyectos integrados, basados en la investigación y la enseñanza, los cuales son concebidos y ejecutados dentro de una perspectiva de manejo integrado para el desarrollo de una región en particular. Deberán ser establecidas en regiones que constituyan una alta prioridad nacional para el desarrollo, que posean una importante población y en donde las instituciones nacionales puedan comprometer al menos una parte de sus limitados recursos (Tarté, Casas y Fonseca, 1989). Es importante tener en cuenta que los agricultores deben, conjuntamente, como parte de las comunidades que se incorporan a este trabajo, involucrarse en el proceso de investigación y desarrollo, el cual debe ser con un enfoque regional y haciendo énfasis a la investigación de los componentes críticos, capaz de producir innovaciones tecnológicas y aprovechando eficazmente la base de los recursos naturales.

La participación concertada de las instituciones nacionales en las AP deberá permitir establecer uno o más usos apropiados de los recursos en virtud de que en cada país, diferentes instituciones manejan distintos aspectos, debido a lo cual si estas instituciones se coordinan con los organismos internacionales que operan en la región, posibilitará potenciar los esfuerzos y hacer una mejor priorización, compartirlos y compatibilizarlos, en particular entre los enfoques por rubros y por ecosistemas (fincas), en donde se integran las perspectivas de producción y de conservación de la base recursos.

El concepto propuesto es a no dudar válido para los propósitos de ensayar mecanismos sistemáticos de agricultura sostenible. Es decir, las AP pueden entregar una oportunidad de probar diferentes opciones de agricultura sostenible que permitan no sólo medir los efectos de los diferentes factores incorporados dentro de una estrategia de investigación y desarrollo concertado, sino que permitiría medir la magnitud y grado de importancia relativa de las diferentes interacciones entre el sistema de producción en fincas, de cierto tipo o conjunto de productores y los distintos entornos a los que se encuentra expuesto dicho sistema y sus componentes dentro de una finca.

La metodología para establecer este tipo de trabajos es relativamente conocida, con ciertas variantes en la secuencia de actividades y la integración de los equipos técnicos de campo. Lo propuesto al respecto por el CATIE está explicado en el documento sobre Areas de Investigación en Agricultura Sostenible (Casas y Tarté, 1989); sin embargo, es necesario enfatizar que el trabajo real que se ejecute en el campo y su aplicabilidad práctica, depende desde luego del grado de detalle que se tenga en la información que se colecte, el análisis e interpretación que se realice.

Los trabajos que se lleven a cabo con mayor frecuencia, tendrán necesariamente que partir del primer nivel de detalle en la información, que puede obtenerse mediante metodologías sobre las cuales existen descripciones en la literatura. En todo caso el propósito, desde este primer estadío, es pugnar por integrar, en un ensayo de Areas Piloto de Investigación en Agricultura Sostenible un plan operativo que puede denominarse Plan de Manejo de Recursos, que incorpore los propósitos mencionados de producción y que posibilite la ejecución del mismo como económicamente viable. Igualmente, que este plan indique las máximas posibilidades de asegurar la productividad a largo plazo y finalmente, que sea socialmente aceptable por los diferentes tipos de productores que integren las comunidades en la región.

En esta forma el CATIE aspira a estimular y apoyar de la manera más efectiva posible, que los programas nacionales de investigación concedan la mayor atención y prioridad a los esfuerzos de sostenibilidad, ayudando a facilitarles su capacidad para cumplir con este propósito. El incorporar la perspectiva de sostenibilidad en el enfoque de investigación agrícola constituye un imperativo primordial y prioritario del CATIE. También el CATIE ha decidido dar prioridad a la incorporación de esta perspectiva de sostenibilidad en los programas formales de enseñanza y los de capacitación.

Finalmente, el CATIE continúa explorando, específicamente en el establecimiento de las Area Piloto de Investigación en Agricultura Sostenible, la colaboración con otras instituciones de investigación nacionales públicas y privadas con el propósito de fortalecer la investigación relacionada con la sostenibilidad.

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Cuadro 1. Uso de la tierra en el Istmo Centroamericano (km^2)

PAIS	Superficie Total	Superficie Cultivable	Cultivos Agrícolas	Cultivos Perennes	Pasturas Permanentes	Bosques	Otras Tierras
Belice	22,960	22,800	460	70	440	10,120	11,710
Costa Rica	50,700	50,660	2,830	3,520	21,670	15,980	6,660
El Salvador	21,040	20,720	5,600	1,650	6,100	1,220	6,150
Guatemala	108,890	108,430	13,300	4,850	13,340	43,100	33,840
Honduras	112,090	111,890	15,700	2,000	34,000	38,200	21,990
Nicaragua	130,000	118,750	10,950	1,720	50,500	41,500	14,080
Panamá	77,080	75,990	4,620	1,220	11,610	40,800	17,740
TOTAL	522,760	509,240	53,460	25,030	137,660	190,920	112,170
(%)			10.4	2.9	27.0	37.4	22.0

FAO, 1984

CUADRO 2. Patrón de cambio de uso del suelo (km^2)

PAIS	AREA TOTAL DE SUELO	CULTIVOS ANUALES	CULTIVOS PERENNES	PASTIZALES	BOSQUE	AREAS PROTEGIDAS (1984)
BELICE						
1987	22800	440	110	480	10120	0
1972		400	60	370	10120	
COSTA RICA						
1987	51060	2850	2410	23000	16400	4125
1972		2850	2120	13900	24200	
EL SALVADOR						
1987	20720	5650	1680	6100	1040	0
1972	20850	4880	1630	6100	1760	
GUATEMALA						
1987	108430	13800	4850	13700	39900	596
1972		11200	4600	12200	50400	
HONDURAS						
1987	111890	15750	2100	23500	35000	4226
1972		14100	1700	22400	47200	
NICARAGUA						
1987	111875	10950	1730	52500	37100	173
1972		10400	1700	44500	53900	
PANAMA						
1987	75990	4400	1350	13200	39600	6609
1972		4320	1110	11700	44100	
TOTAL						
1987		53840	14230	134280	179160	
1972		47950	12920	111170	231680	

FUENTE: FAO Production Yearbook, 1988.

CUADRO 3. Producción *per capita* de cereales, 1975-1981

	kg cereal *per capita*/año 1975	1981	Cambio (%)
GUATEMALA	179	161	-10.1
EL SALVADOR	168	144	-14.3
HONDURAS	144	112	-22.2
NICARAGUA	159	155	-2.5
COSTA RICA	156	148	-5.1
PANAMA	150	153	+2.0
Promedio para CENTRO AMERICA	159	146	-8.2
Promedio para AMERICA LATINA y el CARIBE	181	291	+60.8

FUENTE: FAO, 1984

Figura 1. Factores de análisis, jerarquía de sistemas y tipos de agricultor a ser considerados en la investigación sobre Agricultura Sostenible.

1. Productores de artículos de exportación tradicionales que no están en crisis (café, banano, plátano).
2. Productores de artículos de exportación en crisis (azúcar, algodón y carne).
3. Productores de artículos no tradicionales de exportación.
4. Productores empresarios intensivos (pequeños y medianos agricultores).
5. Productores empresariales extensivos.
6. Productores de subsistencia (con bajo o no capital).

Cuadro 4. Matriz de Investigación y Prácticas en Agricultura Sostenible

NIVEL	FACTORES				
	TECNOLOGICAS	ECOLOGICAS	ECONOMICAS	SOCIO-CULTURALES	INSTITUCIONALES
A- RUBRO	Innovaciones fundamentadas en: -Aprovechamiento del potencial de recursos genéticos autóctonos y de la biodiversidad tropical. -Nuevos métodos biológicos de producción. -Variedades mejoradas altamente productivas resistentes a adversidades y con bajos requerimientos de insumos.	-Uso de prácticas que no contaminen el ambiente y contribuyan a disminuir significativamente el uso de agroquímicos. -Desarrollo de las actividades productivas conforme a sus requerimientos edáficos y climáticos.	-Uso de prácticas de bajo riesgo que contribuyan a reducir costos sin afectar negativamente los rendimientos. -Disponibilidad de mano de obra, servicios de crédito, insumos y comercialización apropiada, así como de políticas que incentiven la producción.		-Disponibilidad adecuada de recursos institucionales (humanos, físicos y financieros) y capacidad para responder eficazmente. -Capacitación continua de de los recursos humanos (científicos, administradores, técnicos, decisores y productores). -Adecuada coordinación de políticas, planes y acciones de investigación transferencia y fomento de la producción y el consumo
B- FINCA	-IDEM A más Innovaciones orientadas a: -Obtener mejores y más productivos sistemas de producción incluyendo el uso apropiado de especies forestales. -Desarrollar métodos de apoyo a la toma de decisiones para mejorar la transferencia y adopción de conocimientos	-IDEM A más uso de prácticas de manejo y conservación de suelos y agua.	-IDEM A más incrementar la productividad de la tierra y el trabajo.	-Uso de tecnología y prácticas socialmente aceptables y fáciles de aplicar por los productores de escasos recursos.	-IDEM A
C- REGION	-IDEM A + B más: -Planificación apropiada del uso de la tierra y otros recursos regionales -Optimización de la capacidad de uso de los recursos.	-IDEM A + B más: -Manejo y conservación de los recursos naturales regionales (suelos, agua, bosques naturales, áreas protegidas, biodiversidad, etc.) -Rehabilitación de recursos naturales degradados (reforestación, etc.) -Protección del medio ambiente.	-IDEM A + B más: -Utilizar racionalmente los recursos naturales regionales manteniendo su productividad. -Organización de la producción y comercialización. -Desarrollo de oportunidades fuera de la agricultura.	-IDEM A + B más: -Respeto de los valores socio-culturales. -Mejorar los sistemas de tenencia de la tierra. -Atención de necesidades comunitarias (salud, agua, educación, etc.)	IDEM A + B más: -Adaptación institucional para el trabajo multidisciplinario y pluri-organizacional integrado. -Integración de esfuerzos que incorpore las dimensiones ecológicas a las tecnológicas, económicas y socio-culturales. -El establecimiento de vínculos dentro y fuera del sector agropecuario.

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REGIONAL OFFICE FOR CENTRAL AMERICAN PROGRAMS (ROCAP)

SEMINAR "Mobilizing Agricultural Technology to

Meet Central American Challenges"

TECHANOLOGICAL CHANGE AND SOURCES OF CHANGE IN AGRICULTURAL PRODUCTION IN CENTRAL AMERICA

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TECHNOLOGICAL CHANGE AND SOURCES OF CHANGE IN AGRICULTURAL PRODUCTION IN CENTRAL AMERICA[1/]

INTRODUCTION:

The countries covered by this paper included Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. These contain about 192,000 square miles, about equal to the area of Spain. In the 1960's, there were about 1.1 million farms involving 15.8 million hectares averaging 14 hectares with about two-thirds of the farms less than ten hectares. The same picture on farm size is evident in the 1970's. The region, in 1987, had some 23 million people producing a gross national product of $28.2 billion, with a per capita income averaging almost $1,220. The range in per capita incomes was from $810, in Honduras, to $2,240 in Panama.

However, using incomplete data from the 1970's, income distribution in the region was highly skewed. The lowest quintile received 3.6 percent of total income, while the highest quintile of the population commanded 54 percent of the income. Further the lowest 40 percent of the population received about 12 percent of the total income and the highest 40 percent, 79 percent of the total.

These income-distribution data support the limited data available on levels of nutrition. In 1983, only two countries, Costa Rica and Nicaragua, enjoyed daily caloric intake levels, per capita, higher than those recommended.

Another general characterization of the region in 1987 was that agriculture accounted for about 17 percent of the gross domestic product while industry accounted for more than 25 percent. However, the dominance of industrial activities associated with agricultural inputs and agricultural processing suggests that the importance of the agricultural sector may

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represent 30 to 35 percent of the gross domestic product of the region. Further, if one considers the financing and transport components of the region's economy associated with agriculture, then clearly the contribution to the region's gross domestic product from agriculture may approach 40 percent.

Despite the importance of the agricultural sector, regional annual average agricultural-growth rates over a twenty-year period, 1965 to 1985, have lagged behind regional annual average population-growth rates. Throughout this period agricultural-growth rates averaged 2.3 percent while population rates averaged 2.9 percent. The same data for the period 1975 to 1985 are more discouraging, with annual average agricultural-growth rates of 1.4 percent contrasted with the same 2.9 percent rate for population growth. The agricultural sector, along with employment and nutritional levels, were negatively impacted by structural adjustment policies initiated in the early 1980's. The issues of overvalued exchange rates, industrial import-substitution policies, public treasury austerity, balance of payments, and debt resolution had important implications for the region's agricultural sector throughout the 1980's.

In addition to high population growth rates, the demand for food responds to changes in real income. Over four decades, 1950's to 1980's, average annual income growth rates (GNP per capita) were low, averaging slightly more than one-half of one percent per year. During the 1970's, the annual income growth rates exceeded 1.5 percent. Clearly income and population growth rates combined suggest that agricultural growth rates have been substantially below desired levels.

OBJECTIVES:

The overall objective of this paper is to assess changes in agricultural production and the sources for those changes in production. More specifically the objectives are:

1. To describe agricultural production changes by decades since 1950 and to relate these changes to population, real income and nutritional level;
2. To track the sources of change in agricultural production that derive from changes in areas of production, areas under irrigation, changes in productivity levels and, possibly, changes in post-harvest loss reductions;
3. To assess the sources of changes in productivity associated with technology-adoption rates for fertilizers, seeds, pesticides, and mechanization; and
4. To assess, where possible, the relationship between modes of agricultural extension, client-group classes, and production or productivity changes.

CHANGES IN AGRICULTURAL PRODUCTION:

Throughout the period 1950 to 1985 the food production index for Central America increased about three-fold (see Table 1). During the decade of the 1960's, the average annual rate exceeded three percent while during the decade of the 1980's the average annual rate was less than one percent. These rates refer to all food and livestock production.

Total food and fiber production in Central America is primarily for domestic food consumption (corn, rice and beans) and for export (sugar, coffee and seed cotton). Those three food staples accounted for approximately 70 percent of all foods produced in 1975. Similarly, it is estimated that these three export crops accounted for approximately 70 percent of all food and fiber exports produced in 1975.

Table 1: The Food Production Index for Central America, 1950 to 1985.

Country	1950	1960	1970	1980	1985
Costa Rica	40.70	52.15	88.60	121.98	123.45
El Salvador	49.98	70.58	91.64	125.75	132.36
Guatemala	47.08	67.93	91.98	141.39	155.00
Honduras	43.87	58.20	88.20	107.77	115.04
Nicaragua	37.80	55.80	91.78	102.01	113.38
Panama	44.16	62.60	91.95	121.89	129.83
Average	43.93	61.21	90.86	120.13	128.18

Source: FAO Yearbook (1971-1973 = 100).

Among the major export crops (sugar, coffee, cotton) sugarcane was the dominant crop (see Table 2). Total export crop production increased almost six times, sugarcane about the same, while cotton increased throughout the period by almost 7.5 times.

Table 2: Export Food Production by Commodity for Central America, 1950 to 1985.

Commodity	1950	1960	1970	1980	1985
			(000 M.T.)		
Sugar	3,672	4,842	10,086	17,769	21,831
Coffee	191	314	416	567	579
Seed Cotton	33	176	287	420	248
Total	3,896	5,332	10,789	18,756	22,658

SOURCE: FAO Yearbooks

For the total region, staple food production (corn, rice and beans) was 1.41 million metric tons in 1950 and 3.64 million metric tons in 1985 (see Table 3). During the period 1950 to 1985, the total output of rice increased by over 275 percent, which exceeded a population increase of 203 percent for the period. Both corn and beans increased by substantially less than population with 138 and 145 percent, respectively. The predominant food was corn among this group of staples, which accounted for over 75 percent of the total production of these staple foods for the region throughout these 35 years.

Table 3: Staple Food Production by Commodity for Central America, 1950 to 1985.

Commodity	1950	1960	1970	1980	1985
	(000 M.T.)				
Corn	1,085	1,219	1,754	2,272	2,584
Rice	202	244	381	523	761
Beans	120	118	220	233	294
Total	1,407	1,581	2,355	3,028	3,641

SOURCE: FAO Yearbooks

These total food production changes can be compared with regional aggregates for population and real GDP per capita income changes by decades. These data suggest that population and income changes have exceeded changes in agricultural production throughout the period 1950-1987 (see Table 4). In general terms, these data suggest the prospect of imports, probable declines in nutrition levels, both qualitative and quantitative, and changes in family diets. The decade of the 1980's was particularly difficult for the region, with respect to both growth in population and decreases in purchasing power.

Table 4: Ratios Between Percentage Changes in Food Production, Population and Per Capita Incomes by Decades 1950 to 1985.

Decades	FPI/Population	FPI/GDP	FPI/Population x GDP
	(percent)		
1950-1960	1.11	1.08	0.76
1960-1970	1.32	0.81	0.67
1970-1980	0.84	0.54	0.60
1980-1985/87 1/	0.37	1.40	0.86
1950-1985/87	0.93	0.40	0.19

1/ Population and income data refer to 1980-1987.
Source: FAO Yearbooks.

Another set of data, roughly by decades, for the 1960's, 1970's and 1980's reveal similar trends. With a few exceptions annual rates of change in agricultural production lagged rates of change in population growth (see Table 5). Throughout the period 1965 to 1985, average annual production rates were 2.3 percent while the average annual population rate was 2.9 percent.

Table 5: Average Annual Rates of Change by Countries in Food Production and Population from 1965 to 1985.

Countries	1965-1973		1973-1984		1980-1985	
	Production	Population	Production	Population	Production	Population
	(annual rates of change in percent)					
Costa Rica	7.0	3.0	1.9	2.9	2.1	2.7
El Salvador	3.6	3.4	0.4	3.0	-2.9	2.9
Guatemala	5.8	2.8	1.9	2.8	-0.6	2.9
Honduras	2.2	2.9	3.6	3.5	2.2	3.5
Nicaragua	2.8	3.2	1.4	3.0	1.4	3.4
Panama	3.4	2.8	2.1	2.3	2.7	2.2
Average	4.1	3.0	1.9	2.9	0.8	2.2

SOURCE: World Development Reports, 1986 and 1988.

From 1965 to 1985, average daily caloric supplies per capita for the region have steadily increased to acceptable levels (see Table 6). However, the caloric supply in El Salvador and Honduras continue to lag required levels.

To sustain these reasonable levels of caloric supplies there have been substantial increases in the importation of food staples. Since 1950, staple-food imports into Central America have increased almost four-fold. By decades, since 1950 to 1980, staple-food imports have increased 15, 83 and 97 percent, respectively (see Table 7). As noted in the table, imports declined between 1980 and 1985; however, this may have been due to fiscal austerity and balance of payment problems rather than a reflection of need or demand.

Table 6: Daily Caloric Supply per Capita by Countries for Selected Years.[1/].

Countries	Year 1965	1983	1985
Costa Rica	2,366	2,556	2,803
El Salvador	1,859	2,060	2,160
Guatemala	2,027	2,071	2,307
Honduras	1,963	2,135	2,068
Nicaragua	2,398	2,268	2,495
Panama	2,255	2,228	2,380
Average	2,145	2,228	2,380

1/ Required levels range from 2,200 to 2,300 calories per day

SOURCE: World Development Reports, 1986, 2989.

Table 7: Imports of Staple Foods by Countries, 1950 to 1985.

Country	1950	1960	1970	1980	1985
	(1,000 MT)				
Costa Rica	51.7	48.5	130.4	194.7	150.9
El Salvador	39.3	80.6	75.3	164.8	242.3
Guatemala	55.3	52.6	115.9	193.4	165.8
Honduras	28.6	24.2	61.7	143.5	99.8
Nicaragua	18.5	21.3	52.2	170.2	124.0
Panama	35.7	37.6	50.0	90.9	122.1
Average	38.2	44.1	80.9	159.6	150.8

Source: FAO Yearbooks

SOURCES OF PRODUCTION GROWTH:

Changes in total food and fiber production are associated with agricultural development strategies conditioned by changes in relative prices (including governmental interventions, market conditions and infrastructural changes), and such factors as shifts in land ownership or tenancy patterns.

Most developing countries employ one of two broad agricultural development strategies. One focuses on increased use of such fixed natural resources as land and water. The other strategy uses agricultural science as the basis for initiating and supporting changes in land, labor and capital productivity. Under both strategies, there are sets of agricultural policy alternatives, such as the choice between export-led or import-substitution orientations.

Under a natural resource strategy, the prime source of increased production is to expand the area of cultivated land. There are variations associated with intensive use of land (double cropping, alley cropping, etc.) and an expansion of the quantity of land under irrigation, using various technology regimes (from traditional to some level of modernization).

Another strategy, that is gaining in importance and acceptance, is that of a science-based agricultural growth model. Under this strategy the focus is on substituting knowledge for scarce resources. The desired outcome is that of increases in profitability per hectare associated with increases in productivity and reduced costs per hectare (biological science intervention). Another element of this strategy is to reduce crop losses associated with pre- and post-harvest handling, storage and transfer of agricultural products.

There are data on classes of land use as shown in Tables 8 and 9. Unfortunately, there are very limited data sets on land productivity classes; without such data it is impossible to estimate the impacts of shifts in land use on environmental degradation.

The data on land use for 1984 indicate that about 11 percent of the total land stock was arable or was potentially available for continuous cropping. Assuming only modest levels of land in perennial crops and pastures suitable for continuous cropping, this suggests there is less than a quarter of a hectare per person of regularly tillable land. Such a low level is suggestive of the potential for serious environmental degradation.

Table 8: Land Use for Central America, 1984.

Country	Total Area	Arable Land	Perennial Crops	Meadows and Pastures	Woodland	Other
	(000 ha.)					
Costa Rica	5,070	283	354	2,167	1,560	702
El Salvador	2,104	560	165	610	116	621
Guatemala	10,889	1,330	485	1,334	4,230	3,464
Honduras	11,209	1,575	202	3,400	3,740	2,272
Nicaragua	13,000	1,095	172	5,100	4,040	1,468
Panama	7,708	438	126	1,161	4,050	1,824
Total	49,980	5,281	1,504	13,772	17,736	10,351

Recognizing the severe data limitations and irregularities, the total hectarage in arable land, perennial cropland and pastures increased from 11.6 million hectares in 1950 to 20.6 million by 1984 (see Table 9). This change represents close to a doubling of the area devoted to these three uses of land. Over the last two decades (1970 and 1980), arable land use increased by 230,000 hectares and that devoted to perennial crops 369,000 hectares. These increases were accompanied by a 2.9 million hectare increase in pastures and meadowlands for the same period. Clearly, there have been large land use changes along with reductions in the quantities of woodlands. This implies a resources-exploitive production strategy.

Between 1950 and 1985, arable land and land in perennial crops increased by 1.3 million hectares, while the total hectarage planted to corn, rice, beans, sugarcane, coffee and cotton also increased by 1.3 million between 1950 and 1980. This interesting similarity cannot account for the total increase in the production of these major crops over the same period. The total production of these crops increased by 16.5 million tons

Table 9: Classes of Land Use in Central America by Country by Decades, 1950 to 1980.

Description	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama	Total
	(000 ha)						
1950's[1/]							
Total[2/]	5,090	2,000	10,889	11,209	14,900	7,447	51,447
Arable	281	544	1,473	997	1,793	450	5,538
Perennial	NA	NA	NA	NA	NA	NA	NA
Pastures	722	704	582	2,000	1,500	552	6,060
1960's							
Total	5,070	2,139	10,889	11,209	13,000	7,565	49,872
Arable	609	487	1,165	823	1,715	564	4,363
Perennial	NA	NA	319	NA	158	NA	477
Pastures	935	604	1,015	3,413	920	831	7,718
1970's							
Total	5,070	2,104	10,889	11,209	13,000	7,708	49,980
Arable	285	464	1,220	1,380	1,270	432	5,051
Perennial	208	169	323	158	165	112	1,135
Pastures	1,351	610	940	3,400	3,384	1,141	10,826
1980's							
Total	5,070	2,104	10,889	11,209	13,000	7,708	49,980
Arable	283	560	1,330	1,575	1,095	438	5,281
Perennial	354	165	485	202	172	126	1,504
Pastures	2,167	610	1,334	3,400	5,100	1,161	13,772

1/ 1950 - selected years (1950 and 1953 data)
1960 - selected years (1962 and 1963 data)
1970 - 1983 data
1980 - 1984 data

2/ Total land includes arable, perennial, permanent pastures, forests and other.
Arable or annually cultivated land.
Perennial crops.
Permanent meadows and pastures

SOURCE: FAO Yearbooks, Latin American Statistical Abstracts and an assortment of studies for individual countries.

(1.6 for staple crops and 14.9 for export crops, respectively) or over 400 kg per hectare per year. It is difficult to accept such a sustained change in productivity.

Had there been no increases in crop productivity, total output in 1980, assuming the land-use increase and 1950 average yields, would have produced a 9.2 million ton total increase 0.7 for staple foods and 8.5 for export crops. Clearly, there are output per hectare increases among other factors that explain the 7.3 million ton differential between estimated and the actual increases in total output between 1950 and 1980.

In an attempt to explain the sources of these aggregate total production increases, estimates were made of average annual rates of change in production, area and output per hectare for staple foods and export crops.

Although aggregates of staple and export crop average annual rates may mask some information, they also offer some insights. For the staple foods, average annual yield increases are dominant sources of change in the periods 1960 to 1970 and 1970 to 1980 (see Table 10). These are yield increases that are dominant for corn and rice but excludes beans except for the 1960 to 1970 period. More detailed growth estimates are shown in Table 11. For the export crops, annual increases in area planted are dominant for the 1960 to 1970 and 1970 to 1980 time periods (see Table 10). The average annual growth rates by decades of the area planted and output per hectare are similar for the period 1950 to 1960 (see Table 12).

In these last three tables (10-12) there is a residual growth rate column. On an annual basis the residuals or data errors are quite small except for export crops between 1950 and 1960.

Table 10: Average annual growth rates classified by decades of total production, area planted, and output per hectare for staple food and export crops for the Central American region, 1950-1980.

Crop Type and Decades	Total Production	Area Planted	Output per Hectare	Residual
	(per cent)			
Staple Crops				
1950-1960	1.05	2.12	-2.47	1.40
1960-1970	5.60	1.32	3.57	0.71
1970-1980	2.23	0.79	1.22	0.22
Export Crops				
1950-1960	20.61	6.43	6.50	7.68
1960-1970	5.93	5.53	0.36	0.04
1970-1980	5.31	2.67	1.96	0.68

SOURCE: FAO Yearbooks and other sources.

During the decade of the 1950's and 1980's, area planted rather than productivity changes are largely responsible for production changes (see Table 11). Again with a few exceptions, the picture is reversed for the decades 1960's and 1970's. Clearly, for corn and rice, productivity change was dominant from 1960 to 1980.

For the three export crops, productivity changes, with a few exceptions, were dominant throughout the 1950's and 1970's. The period 1960 to 1970 was quite different, increases in area planted were primarily responsible for average annual growth rates in total production.

Table 11: Average Annual Growth Rate Changes Classified by Decades for the Staple Food Commodities for Total Production, Area and Output per Hectare for the Central American Region.

Time Periods	Total Production	Area Planted	Output per Hectare	Residual
	---------------- (percent) ----------------			
1950-1960				
Corn	1.24	1.12	-0.65	0.77
Rice	2.08	3.82	0.05	-1.79
Beans	-0.17	1.56	-1.86	0.13
1960-1970				
Corn	4.39	1.17	2.48	0.74
Rice	5.62	0.42	4.18	1.02
Beans	8.64	2.36	3.86	2.42
1970-1980				
Corn	2.95	0.49	1.61	0.86
Rice	3.73	0.74	2.62	0.36
Beans	0.59	1.14	-1.79	1.24
1980-1985				
Corn	1.37	0.29	1.73	-0.65
Rice	4.56	2.74	1.39	0.43
Beans	2.70	2.61	0.17	-0.08

SOURCE: FAO Yearbooks

Table 12: Average Annual Growth Rate Changes Classified by Decades for the Export Crops for Total Production, Area and Output per Hectare for the Central American Region.

Time Periods	Total Production	Area Planted	Output per Hectare	Residual
	------------- (percent) -------------			
1950-1960				
Sugarcane	3.19	1.60	1.94	-0.35
Coffee	6.45	1.25	4.77	0.43
Seed Cotton	52.18	16.44	12.78	22.97
1960-1970				
Sugarcane	10.83	7.02	1.98	1.83
Coffee	3.24	2.28	0.77	0.19
Seed Cotton	3.71	7.29	-1.66	-1.92
1970-1980				
Sugarcane	7.62	6.07	0.92	0.63
Coffee	3.64	1.04	2.78	-0.18
Seed Cotton	4.66	0.88	2.18	1.60

SOURCE: FAO Yearbooks

MORE ON PRODUCTIVITY CHANGES:

This section adds more detail on productivity changes for selected crops by countries. In addition there are discussions on comparative yield data for the major food and export crops.

For the three staple foods (corn, rice and beans), only rice has shown reasonably favorable growth rates in per hectare productivity levels over the period 1950 to 1985 (see Table 13). Between 1950 and 1985 rice yield levels have increased about 2.4 percent per year. Most of these gains have occurred in Costa Rica and El Salvador.

Table 13: Average Yields per Hectare by Countries for Staple Food Crops by Decades.

Country	1950	1960	1970	1980	1985
	------------ (metric tons per hectare) -------------				
CORN					
Costa Rica	1.32	1.07	1.09	1.49	1.75
El Salvador	1.05	0.93	1.77	1.81	2.14
Guatemala	0.81	0.83	1.04	1.57	1.43
Honduras	0.73	1.03	1.27	0.99	1.57
Nicaragua	1.03	0.85	0.90	1.16	1.45
Panama	0.96	0.81	0.81	0.96	1.00
Average	0.98	0.92	1.15	1.33	1.56
RICE					
Costa Rica	1.42	1.06	1.84	3.00	3.79
El Salvador	1.69	1.85	3.72	3.62	3.99
Guatemala	1.18	1.43	1.55	3.22	2.79
Honduras	1.64	1.69	1.17	1.67	1.44
Nicaragua	1.39	1.58	2.73	2.32	3.81
Panama	1.33	1.08	1.33	1.73	1.90
Average	1.44	1.45	2.06	2.59	2.95
DRY BEANS					
Costa Rica	0.41	0.37	0.40	0.52	0.58
El Salvador	0.81	0.52	0.83	0.76	0.83
Guatemala	0.47	0.52	0.65	0.69	0.69
Honduras	0.44	0.44	0.75	0.53	0.60
Nicaragua	0.66	0.59	0.84	0.78	0.66
Panama	0.54	0.27	0.29	0.31	0.30
Average	0.56	0.45	0.63	0.60	0.61

Source: FAO Yearbooks

In the case of rice, some data from CIAT are informative on the adoption of new varieties.[1/] The CIAT report on three of the region's countries suggests large areas of rice plantings with improved varieties. The data show:

1/ CIAT Annual Report, 1981, page 50.

Country	Yields 1967	Yields 1978	Yield Increase	Area Planted with Improved Varieties
	(tons/hectare)		(%)	
Costa Rica	1.4	2.6	85	100
Guatemala	1.5	2.3	53	50
Nicaragua	2.4	3.8	58	78

For corn, annual growth rates are 1.5 percent, while for beans a dismal 0.5 percent.

In the case of the three major export crops, the average annual increases in yields per hectare of seed cotton and coffee have been creditable. Between 1950 and 1985, seed cotton yields increased almost 4.3 percent per year and coffee 2.5 percent per year. The sugarcane yields have increased about 1.4 percent per year. Except for Guatemala and El Salvador sugarcane yield increases have been very modest (see Table 14).

To get another assessment on productivity changes, comparisons within the region are informative. One approach is to identify which Central American countries have shown the most favorable growth rates in output per hectare. In the next two tables, regional average yields per hectare are shown along with those countries exceeding these regional averages by decades by crops (see Tables 15 and 16).

For all the staple food crops, El Salvador has recorded the most consistent increases in yields. El Salvador has been dominant in rice and corn yield.

Table 14: Average Yields per Hectare by Countries for Export Crops by Decades.

Country	1950	1960	1970	1980	1985
	------------ (metric tons per hectare) -------------				
SEED COTTON					
Costa Rica			0.33	1.26	3.30
El Salvador	0.61	1.89	1.49	1.41	1.34
Guatemala	0.52	1.29	1.37	2.25	1.61
Honduras	0.56	1.44	1.51	1.27	1.10
Nicaragua	0.76	0.96	1.12	0.90	0.93
Average	0.61	1.40	1.16	1.42	1.66
SUGARCANE					
Costa Rica	39.10	36.26	49.50	51.69	46.67
El Salvador	58.70	63.38	52.44	64.79	68.00
Guatemala	37.60	50.55	73.53	68.81	83.52
Honduras	25.00	20.64	27.49	33.18	34.74
Nicaragua	40.10	56.90	46.30	76.84	60.92
Panama	20.60	36.31	66.93	49.87	54.05
Average	36.85	44.26	53.29	55.17	57.98
COFFEE					
Costa Rica	0.44	0.89	0.79	1.33	1.42
El Salvador	0.71	0.83	0.99	0.89	0.83
Guatemala	0.32	0.50	0.50	0.62	0.59
Honduras	0.18	0.26	0.38	0.61	0.63
Nicaragua	0.29	0.31	0.39	0.50	0.54
Panama	0.25	0.27	0.24	0.25	0.45
Average	0.35	0.51	0.55	0.70	0.74

SOURCE: FAO Yearbooks.

Table 15: Regional Average Yields per Hectare for Staple Food Crops and Central American Countries Exceeding Regional Average Yields by Decades, 1950 to 1985.

Crop and Country	1950	1960	1970	1980	1985
	(metric tons/hectare)				
Corn					
Regional Average	0.98	0.92	1.15	1.33	1.56
Countries exceeding	Costa Rica El Salvador Nicaragua	Costa Rica El Salvador Honduras	El Salvador Honduras	Costa Rica El Salvador Guatemala	Costa Rica El Salvador Honduras
Rice					
Regional Average	1.44	1.45	2.06	2.57	2.95
Countries exceeding	El Salvador Honduras	El Salvador Honduras Nicaragua	El Salvador Nicaragua	Costa Rica El Salvador Guatemala	Costa Rica El Salvador Nicaragua
Beans					
Regional Average	0.56	0.45	0.63	0.60	0.61
Countries exceeding	El Salvador Nicaragua	El Salvador Guatemala Nicaragua	El Salvador Guatemala Honduras Nicaragua	El Salvador Guatemala Nicaragua	El Salvador Guatemala Nicaragua

Table 16: Regional Average Yields per Hectare for Export Crops and Central American Countries Exceeding Regional Average Yields by Decades, 1950 to 1985.

Crop and Country	1950	1960	1970	1980	1985
	(metric tons/hectare)				
Seed Cotton					
Regional Average	0.61	1.40	1.16	1.42	1.66
Countries exceeding	Nicaragua	El Salvador Honduras	El Salvador Guatemala Honduras	Guatemala	Costa Rica
Sugarcane					
Regional Average	36.85	44.26	53.29	55.17	57.98
Countries exceeding	Costa Rica El Salvador Guatemala Nicaragua	El Salvador Guatemala Nicaragua	Guatemala Panama	El Salvador Guatemala Nicaragua	El Salvador Guatemala Nicaragua
Coffee					
Regional Average	0.35	0.51	0.55	0.70	0.74
Countries exceeding	Costa Rica El Salvador	Costa Rica El Salvador	Costa Rica El Salvador	Costa Rica El Salvador	Costa Rica El Salvador

The same data set for major export crops shows greater diversity. However, El Salvador and Costa Rica are dominant in coffee but Guatemala in sugarcane. For both coffee and seed cotton, most countries in the region are well below regional average increases in yields.

Another productivity comparison assesses the most favorable per hectare yield levels by commodity with data from other countries (see Table 17). The country within the region with the highest yield levels for the mid-1980's compares favorably on corn, rice, seed cotton and coffee.

Table 17: Comparison of Average Farmer Yields by Crops for the mid-1980's: Highest Ranking in Central America and Other countries.

Crop	Highest Rank in Central America	Central American Country	Comparisons
	------- (metric ton/hectare) ---------		
Corn	2.14	El Salvador	1.80 South America 2.40 Peru
Rice	3.99	El Salvador	3.28 South America 4.34 Peru 2.97 Ecuador
Beans	0.83	El Salvador	1.01 Peru 1.01 Ecuador
Seed Cotton	3.30	Costa Rica	1.14 South America 1.79 Peru 0.97 Ecuador
Sugarcane	83.52	Guatemala	153.50 Peru
Coffee	1.42	Costa Rica	0.74 South America 0.26 Ecuador 0.60 Peru

SOURCE: FAO Yearbooks and C. Pomareda, "La Banca de Desarrollo y Financiamiento de la Generacion y Transferencia de Tecnologia Agropecuaria," Lima. November 1986.

Comparative data on beans and sugarcane reveal substantial gaps with other countries.

A final comparison, using data from Guatemala, assesses potential yield increase opportunities. The comparisons are for per hectare yields for six crops between levels realized on experimental fields, demonstration fields and actual on-farm yields for the period 1985 to 1988 (see Table 18). From these data, agriculture in Guatemala, with the exception of cotton, is characterized by relatively low levels of productivity as measured by yields. Farmer yield levels for major crops are low relative to farmer yields in other countries and when compared with research results in Guatemala. The yield gap between actual farmer versus demonstration results across crops ranges from 1.1 to over 3-fold.

Table 18: Yield per Hectare Comparisons (Experimental, Demonstration and Farmer) in Guatemala and Selected Countries, 1985-1988.

Commodities	Experimental Yields	Demonstration Yields	Farmer Average Yields	Other Countries Farmer Yields	Country
	(metric tons per hectare)				
Corn	5.22	3.90	1.65	2.40	Peru
Rice	5.59	3.80	2.16	5.32	U.S.A.
				4.34	Peru
Beans	2.27	1.27	0.62	2.30	Argentina
Seed Cotton	3.23	-	1.30	1.40	U.S.A.
Sugarcane	95.00	85.00	78.00	153.00	Peru
				100.00	Brazil
Coffee	2.23	2.00	0.64	1.42	Costa Rica
				1.00	Mexico

SOURCE: Various sources for Guatemala from ICIA, Bank of Guatemala, Annual FAO Yearbooks and others.

These comparative data sets are quite incomplete. There are yield variations within and among crops across countries. Further, yields refer to potential productive capacity and are only partial measures of overall productivity. Information on other productivity measures related to output per worker and capital productivity would be desirable. In the case of labor, the low level of wages and incomes in rural areas are strong indicators of low labor productivity or limited opportunities elsewhere. However, general data limitations prevent a more complete assessment of productivity.

SOURCES OF PRODUCTION AND PRODUCTIVITY CHANGE:

Total agricultural production changes for staple foods and for export crops occur primarily because of expansion of area cultivated, changes in cropping-systems, increases in yield levels associated with technological advances. However, there are other factors that can influence the rates of growth in production such as shifts in relative prices, credit, agrarian reform, as well as changes in government policies.

Perhaps the leading resource associated with production and productivity changes is that of human capital. The quantity and quality of this resource is critical for managerial, research, technology transfer, agribusiness development, agricultural policy and overall agricultural sector strategy success. In very general terms, over the last 20 years educational involvement has improved in primary, secondary and post-secondary level (See Table 19). Between 1965 and 1986, secondary enrollment doubled and higher education increased about five-fold. Relatively, the region's enrollments compare favorably with the lower middle level of middle-income countries (World Bank classification). However, relative to high-income countries secondary enrollments lag by over 50 percent and for higher education by about 25 percent.

There appear to be some opportunities for increasing the area under irrigation. In 1980 only 6.3 percent of land in arable crops and perennial crops, excluding pastures, had irrigation (see Table 20). Increases in areas irrigated combined with the use of advanced production technologies could be an important source of production growth. However, as in the case of most broad recommendations, much more detailed study is required to assess this option.

Table 19: Enrollment in Primary, Secondary and Higher Education in Central America, 1965 and 1986.

Country	Enrollment in Primary 1965	Enrollment in Primary 1986	Enrollment in Secondary 1965	Enrollment in Secondary 1986	Enrollment in Higher Education 1965	Enrollment in Higher Education 1986
	(% of age group)					
Costa Rica	106	102	24	42	6	24
El Salvador	82	70	17	24	2	14
Guatemala	50	76	8	20	2	9
Honduras	80	102	10	36	1	10
Nicaragua	69	98	14	42	2	9
Panama	102	106	34	59	7	28

SOURCES: World Development Reports, 1986 and 1989

Table 20: Quantity of Irrigated Land in Central America by Decades and 1984.

Country	1950	1960	1970	1980	1984
	(000 hectares)				
Costa Rica	-	26	26	61	84
El Salvador	5	-	20	110	110
Guatemala	-	32	57	68	75
Honduras	-	50	69	82	85
Nicaragua	2	29	40	80	83
Panama	-	14	20	28	30
Total Irrigated	7	151	232	429	467
Total Arable	5538	5253	4955	6796	
Percentage Irrigated		2.8	4.6	6.3	

SOURCE: FAO Yearbooks.

Another major source of change in total production relates to changes in productivity per worker. A very approximate indicator of probable changes in labor productivity, and a measure of the degree of mechanization, may be inferred from changes in tractor numbers (see Tables 21 and 22). The large increases in tractor numbers occurred during the 1950's with more modest increases throughout the 1960's and 1970's. These data on mechanization compare favorably with other middle-income developing countries.

Table 21: Tractor Use in Central America by Decades, 1950-1980.

Country	1950	1960	1970	1980
	(numbers)			
Costa Rica	0	4,311	5,617	6,101
El Salvador	0	1,800	2,917	3,360
Guatemala	0	2,250	3,683	4,060
Honduras	283	331	2,829	3,315
Nicaragua	0	n.a.	1,047	2,350
Panama	1,468	789	3,667	4,140
Average	292	1,580	3,293	3,888

SOURCE: FAO Yearbooks

Table 22: Changes in Tractor Numbers per 1,000 Hectares and Annual Growth Rate in Central America.

	Tractors per 1,000 hectares of arable land including perennial crops				Average Annual Rate of Growth in Tractor Numbers	
Countries	1950	1960	1970	1980	1960-70	1970-80
	(numbers)				(percent)	
Costa Rica	-	7.08	11.39	9.60	3.0	0.9
El Salvador	-	3.69	4.68	4.63	6.2	1.5
Guatemala	-	1.52	2.36	1.83	6.4	1.0
Honduras	0.28	0.40	3.37	1.87	7.5	1.7
Nicaragua	-	2.43	1.19	1.85	-7.7	12.4
Panama	3.26	1.39	6.77	6.66	4.1	1.8

SOURCE: FAO Yearbooks

As related to land productivity, output per hectare, data on factors impacting these changes are scarce. A minimum desirable data set would include time-series data on available farm credit, a consistent set of factor and product movement and prices, quantities and adoption rates of improved seeds, use-levels of pesticides, and data on shifts in tenancy as related to production and productivity.[2]

This study has had to limit its efforts to time-series data on fertilizer use and comparative investment levels in agricultural research and extension. Between 1970 and 1986, average fertilizer levels have increased by 44 percent (see Table 23). With the exception of South Korea, these fertilizer-use levels compare favorably with three countries that have had average agricultural-growth rates of more than 4 percent since 1960.

The region compares very poorly with other Latin American countries with respect to levels of investment in agricultural research (see Table 24). Research expenditures as a percent of the value of agricultural output averaged about 0.25 percent. Compared with Argentina, the region devotes about one-sixth as much to this major source of productivity growth.

The region compares much more favorably with Latin America on expenditures per researcher and extensionist (see Table 25). These data suggest a strong bias towards investments in agricultural extension as compared with middle-income developing countries.

2/ There are a few individual country studies on adoption rates of improved varieties, some data on imports of chemicals and a few reports on shifts in land tenancy. However, the lack of time series and large data gaps made these sources unacceptable.

Table 23: Relative Levels of Fertilizer Use on Arable Land for Central America and Three High Agricultural Growth Rate Countries, 1970, 1983 and 1986.

Countries	1970	1983	1986
	(kg/ha)		
Costa Rica	100	132	162
El Salvador	104	113	91
Guatemala	30	47	62
Honduras	16	16	22
Nicaragua	22	48	54
Panama	39	40	62
Average	52	66	75
Kenya	24	38	52
South Korea	245	345	385
Algeria	16	21	36

SOURCE: Converted World Development Reports, 1988 and 1989.

Table 24: Relative Levels of Investment in Agricultural Research in Selected Central and Other Latin American Countries, 1980.

Countries	Agricultural GDP	Research Expenditures	Share
	(constant 1975 $US in 000)		(percent)
Costa Rica	562,700	1,360	0.24
El Salvador	647,000	3,300	0.51
Honduras	399,500	640	0.16
Nicaragua	484,800	1,310	0.27
Argentina	6,640,400	108,700	1.64
Chile	833,900	6,800	0.82

SOURCE: Peter A. Oram and Vishva Bindlish, Resource Allocations to National Agricultural Research: Trends in the 1970's (A Review of Third World Systems, Washington, DC and The Hague: ISNAR and IFPRI, November, 1981.

Table 25: Expenditures per Science Man Year and per Extension Worker for Central America and Selected Regions and Countries.

Country/Region	Research per Science Year			Extension per Worker		
	1959	1970	1980	1959	1970	1980
	(constant 1980 US$ in 000)					
Costa Rica	19	45	29	23	29	17
El Salvador	24	17	31	13	7	6
Guatemala	45	47	43	17	51	10
Honduras	32	28	18	11	12	5
Nicaragua	56	65	37	32	31	24
Panama	31	19	49	19	18	10
Average	35	37	35	19	25	12
Middle Income Developing Countries	42	44	47	7	7	6
Latin America	56	44	54	18	19	18
Spain	8 1/	73	61	17	19	16
South Korea	9	31	30			
Kenya	49	37	57			
Algeria	133	125	112			

SOURCE: R. E. Evenson, 1987. The International Agriculture Research Centers: Their Impact on Spending for National Research and Extension, CGIAR Study Paper Number 22, Washington, DC: World Bank

1/ The data on research for Spain, Korea, Kenya and Algeria are for 1962.

EXTENSION CLIENT GROUPS:

The final objective of this effort was to assess production and productivity changes related to the extension client groups. Time and data constraints did not allow an assessment of these relationships. It is extremely difficult to define production categories. For example, sugarcane, coffee and cotton are not all produced by large growers. In Costa Rica over 30 percent of the total production of coffee, sugarcane and cacao was produced on farms of less than 5 hectares. Similarly, for rice in Costa Rica about 9 percent of this crop was produced on farms of more than 50 hectares.

To have initiated a preliminary effort would have required disaggregated sets of time series data. Some important data sets would have included:

1. An appraisal of changes in official agricultural extension philosophies as to priority client groups, export versus domestic food production priorities, and to priorities on commercial or market surplus producing farmers versus subsistence type producers.

2. An appraisal of changes in tenancy conditions which might have allowed inferences to be drawn on how public extension efforts could be restructured by client groups.

3. An appraisal of changes in farm size distributions as related to shifts in extension priorities associated with farm reorganizations related to export or domestic staple food crop production and productivity.

4. An appraisal of the sources of technical knowledge for export crop producers as contrasted to similar informational sources for domestic food suppliers.

5. An appraisal of the impact of severe fiscal austerity conditions on the implementation of extension client-group modes.

6. Also, an appraisal of private extension modes as complements or competitors to a client-group mode for public agricultural extension.

Lacking this set of appraisals, we are unable to accomplish the specified objective. However, the following historical type comments on this broad issue are presented as some general guidelines.

Technical-assistance (extension, outreach, technology transfer) efforts have been in place in virtually every country in the region since the late 1940's. The actual modes of technology transfer have taken on national characters but extension, as such, has been part of every national agricultural sector development scheme since that time. However, based on the data presented in this paper, it is apparent that many of the recipient clientele groups have not adopted the new technologies that have been presented to them. Therefore, rates of change in productivity have been modest and disappointing.

There are several factors that have contributed to this history. Not the least of these is political stability or, perhaps better said, the instability of policy. It appears to be a truism that, as a generalization, the region has not accepted the proposition that, under prevailing circumstances, the agricultural sector must be sound and healthy if it really is to be the engine of change. The regional literature on this subject is extensive. The conclusion is relatively straightforward; i.e., regardless of the party in power, productivity changes will not occur in the absence of supportive policies and initiatives. Further, it is apparent that many adjustments have been made without regard for their impact on the sector.

Given rational sector-development policies, and given reasonable funding, the most apparent constraint is that of available, trained human capital. Once again, this essential component of a viable outreach establishment has, all too often, been one of the first victims of policy change. Without well-trained, adequately supported personnel in the system it cannot help but fail.

One might offer the simplistic idea that technology is not adopted for one of three reasons: a) the technology is not appropriate to the situation; b) the mode of transfer is inadequate to the circumstances; or c) both of the above. We submit that a science-based development strategy would circumvent each of the above constraints. Coupled with a supportable educational component, a system based on science, as applied to national agricultural priorities, would assure the on-going generation of appropriate technology, would be sensitive to the needs of individual clientele groups, would facilitate the transfer of these appropriate technologies to the transfer agents, and would be responsive to the feed-back from those agents.

Finally, it bears mentioning that when good science generates good technology the credibility of the organization is enhanced. As credibility increases, support increases. As support increases, the potential for private-sector involvement becomes more real. And as the private sector becomes more involved, the viability of the organization becomes more promising. This is apparent in the fact that, in many countries, producer groups have formed their own research/extension systems and are willing to support them financially. That is the ultimate manifestation of credibility.

The degree to which each of these constraints is operative in the countries of the region is a matter for discussion in the workshops that follows. It is our contention that, unless these kinds of decisions are made and promulgated, the future trends in productivity will be no different than those of the past.

IMPLICATIONS FOR THE 1990's:

The evidence presented in this report is very aggregative for Central America. However, some limited inferences may be drawn. In general terms, the region has not substantively challenged the issue of substituting an agricultural science strategy for a natural- resource exploitation strategy for agricultural development.

Growth rates in agricultural production lag those in population, production changes derive about equally from area expansion and productivity, staple food imports continue to increase, and there are few indicators that investment levels in either education or agricultural research reflect a basic strategy change. To address these generally negative trends will likely require some difficult choices.

A strong commitment to the agricultural sector will likely focus on options such as: a science driven agricultural-growth strategy, enhanced efforts to diversify exports, a concentration on value added alternatives for the agri-business sector and, among others, the continued pursuit of governmental policy interventions designed to increase the region's competitive position. On the agricultural science option, specific attention must be given to human capital formation, prioritizing research investments, prioritizing extension efforts by locations by identified clientele, as well as on producers of market surpluses, greater specialization of research efforts within the region, increasing the linkages with the international science-community as a substitute for regional investments and overall, a reconsideration of a regional thrust on agricultural science.

Over the next decade it is reasonable to expect continued fiscal austerity to prevail. The implications for public support of agricultural science will be serious. Clearly, the situation will require a concentration or prioritizing of agricultural research, extension and educational efforts. There will likely be an enhanced effort to substitute private sector for public sector actions relating to agricultural research, extension and education.

Even these actions relating to agricultural science may be inadequate if reasonable efforts are not made to maintain social stability. High on almost any such investment schedule should be efforts to increase rural non-farm employment; to enhance priority infrastructural investments; to implement viable, targeted food-distribution systems; and to substitute civil for military investments.

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AREA DE APOYO AL DESARROLLO INSTITUCIONAL DE LA GENERACION Y TRANSFERENCIA DE TECNOLOGIA

El objetivo de estos proyectos es establecer la capacidad del IICA para trabajar en apoyo del desarrollo institucional de la generación y transferencia de tecnología.

Esto significa mejorar la capacidad de los sistemas nacionales para establecer e implementar políticas, modernizar las organizaciones que operan en este campo y hacer una gestión eficiente y efectiva de los recursos disponibles.

Para esto se plantea:

- desarrollo conceptual (alimentar el planeamiento estratégico)

- apoyo técnico para la definición de políticas y el diseño e implementación de ajustes organizacionales

- capacitación en aspectos gerenciales

- distribución de información relevante en los campos de políticas, organización y gerencia de la generación y transferencia de tecnología.

En términos de acciones directas, estamos hablando de:

- estudios sobre temas relevantes y prospectivos

- seminarios de alto nivel orientados a concientizar a la dirigencia nacional y regional sobre temas estratégicos

- misiones de apoyo técnico para: i) definir procesos de ajuste de políticas y organizacionales; ii) en temas específicos dentro de dichos procesos ie apoyo a la preparación de nuevos instrumentos legales, el diseño de mecanismos de vinculación sector público-privado, el diseño de nuevos mecanismos de financiamiento, la implementación de procesos como descentralización, la instalación de nuevos mecanismos de planificación, programación, monitoreo y evaluación, etc.

- organización de actividades de capacitación en temas o áreas de gerencia específicas en apoyo de los procesos de ajuste

- organización y operación del banco de información bibliográfica sobre políticas organización y administración (distribución de información).

En términos de programación, es posible definir con bastante precisión los componentes de estudios, seminarios y cursos regionales, y en menor medida, lo referido a misiones y capacitación nacional. Estos últimos componentes dependen de los procesos de ajuste organizativo a nivel nacional y por su propia naturaleza deben ser definidas sobre la marcha, en función de cómo evolucionen dichos procesos. Sin embargo, esta flexibilidad no implica que no se pueda programar; lo que si hace falta son algunos ajustes al sistema de programación para reconocer las realidades de los procesos o del área de desarrollo institucional.

Una alternativa podría ser la siguiente:

1. Definir todo lo hemisférico relativo a:

   - estudios

   - seminarios de políticas

   - apoyo (backstopping) en capacitación.

2. Definir lo regional relativo a capacitación.

3. Establecer un mecanismo para las misiones que incluya: i) una cuantificación en términos de número y meses/hombre y tipos de emisiones (preparatorias, de revisión de sistemas, apoyo en temas específicos); y ii) un "memorandum" de apoyo que justifique al comienzo del año, la cuantificación en función de los eventos que se anticipen, tales como cambios de gobierno, concreción de préstamos importantes, evolución de procesos ya en marcha, etc. Este "memorandum" será preparado por el jefe del proyecto regional luego de una adecuada concertación con los representantes, acerca de las actividades para el año. Debe tener la aprobación del responsable del área de desarrollo institucional dentro del Programa II. El "memorandum" sería parte del proceso de programación operativa y serviría como instrumento de seguimiento y, eventualmente, evaluación.

INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE (I.I.C.A.)
PROGRAM II: TECHNOLOGY GENERATION AND TRANSFER

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)
REGIONAL OFFICE FOR CENTRAL AMERICAN PROGRAMS (ROCAP)

SEMINAR "Mobilizing Agricultural Technology to

Meet Central American Challenges"

TRANSFERENCIA DE TECNOLOGIA AGROPECUARIA EN CENTROAMERICA: LA EXTENSION TRADICIONAL Y LOS NUEVOS ENFOQUES

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TRANSFERENCIA DE TECNOLOGIA AGROPECUARIA EN CENTROAMERICA: LA EXTENSION TRADICIONAL Y LOS NUEVOS ENFOQUES

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I. Introducción

Cada día parece más claro que para poder dar respuesta a los múltiples retos que enfrenta la agricultura regional (cambios en los mercados, ajuste estructural, problemas sanitarios, pobreza rural, etc.), será necesario incorporar cambios tecnólogicos que tendrán que ser emprendidos voluntariamente por un gran número de productores agropecuarios. Para que esto ocurra, será imprescindible: (a) hacer conocer los resultados de investigaciones nuevas, (b) acelerar la identificación, adaptación y difusión de tecnologías importadas y (c) expandir la utilización de materiales y prácticas beneficiosas ya conocidas en la región.

Sin embargo, los servicios de extensión agrícola, y aún el concepto mismo de extensión, que tradicionalmente fueron los encargados de la tarea de transferir tecnología, entraron desde hace algunos años en una profunda crisis, que sin dudas llevará a su transformación.

En términos generales, los servicios de extensión han probado ser incapaces de liderar un proceso dinámico de transferencia de tecnología. En parte por una falta crónica de recursos, pero también y más importante aún, por arrastrar debilidades en los lineamientos básicos que definen su accionar. Estas debilidades se han vuelto cada día más agudas conforme la agricultura centroamericana se ha tornado más compleja.

Frente a la necesidad imperiosa de dar un nuevo impulso a la transferencia de tecnología y a la incapacidad de los viejos esquemas y servicios de extensión para hacer frente a ese reto, desde hace unos años se observa un número creciente de enfoque institucionales y metodologías.

Este trabajo tiene el propósito de presentar un punto de partida para una reflexión sobre estas nuevas alternativas de transferencia. Comienza con una síntesis de la experiencia de los servicios tradicionales de extensión y luego se discute la crisis de estos servicios y algunas propuestas recientes para superar esa crisis. A partir de este análisis se propone una tipología de las nuevas alternativas de transferencia de tecnología que han ido apareciendo.

La siguiente sección examina ocho casos recientes de transferencia de tecnología novedosa para la agricultura de Centroamérica. Los casos fueron escogidos por ser relativamente innovadores y exitosos. Se seleccionó una muestra diversa en cuanto a clientelas, demandas tecnológicas, metodologías y tipos de institución. Para cada caso se describe las características principales y el impacto que han tenido. El material para estas descripciones ha sido tomado de cinco documentos especialmente preparados para este Seminario y tres documentos adicionales, de interés para los propósitos de este trabajo.

Se concluye que existen algunas tendencias generales en todas las estrategias nuevas de transferencia de tecnología. No obstante, la estrategia de transferencia de tecnología que puede ser apropiada para los productores, depende en gran medida del tipo de clientela a ser servida y del problema tecnológico que se enfrenta.

II. La experiencia histórica de los servicios de extensión

Los servicios nacionales de extensión tuvieron una larga trayectoria en la región, que puede ser analizada tomando en cuenta la existencia de un modelo implícito para su funcionamiento.

En Centroamérica ese modelo implícito estuvo íntimamente ligado a los llamados "Servicios de cooperación técnica agropecuaria" impulsados por los Estados Unidos en los años cincuenta (STICA en Costa Rica y Honduras, STAN en Nicaragua, SCIDA en Guatemala, SCASA en El Salvador y SICAP en Panamá), que proporcionó las bases conceptuales y también financiera para el desarrollo de los servicios públicos de extensión.

En algunos países la extensión comenzó con estos servicios. En otros, ya existían algunos esfuerzos anteriores. Pero en toda la región, el modelo asociado con los "Servicios" dominó las discusiones sobre extensión durante varios años. Este modelo fue también promovido por el IICA hasta finales de los años sesenta.

Las características básicas del enfoque tradicional de extensión asociado con los servicios públicos de extensión agrícola eran las siguientes (Rice, 1971):

a. Campos de acción y clientela:

1. Los objetivos de los servicios eran generales, tales como "mejorar el nivel de vida del agricultor". Los servicios cubrían varios cultivos, áreas agroecológicas, clientelas y tipos de tecnología;

2. Los servicios se dedicaban exclusivamente a difundir información tecnológica y no a facilitar la asignación de otros recursos tales como crédito, insumos, tierra, maquinaria, facilidades de ingreso al mercado, que resultaban igualmente importantes para el desarrollo de la actividad agropecuaria.

3. La extensión estaba orientada principalmente a "productores progresistas", es decir, productores con cierta capacidad de invertir, acceso a mercados, proximidad a las agencias de extensión y una preocupación preexistente por mejorar sus técnicas de producción. Consideraba poco a los productores más pequeños caracterizados por disponer de fincas de extensión limitada, escaso capital o menor capacidad para asumir riesgos.

b. Aspectos institucionales:

4. Los servicios gozaron de una relativa autonomía administrativa. La mayoría no dependía administrativamente de los Ministerios de Agricultura, sino de las agencias donantes;

5. Los servicios contaban con recursos financieros adecuados para el trabajo de los extensionistas, aunque el número de extensionistas era relativamente bajo. Los extensionistas disponían de vehículos, fondos para gastos operacionales y contaban con salarios competitivos;

6. Se suponía que los técnicos estaban motivados. Los servicios de extensión contaban con asesores extranjeros que estaban dispuestos a realizar trabajo de campo, e identificaban su trabajo con un ambiente de entusiasmo y "misión". La extensión era una actividad prestigiosa y relativamente bien compensada; y

7. Se empleaba extensionistas con un bajo nivel académico. Con excepción de los asesores extranjeros, casi todos los extensionistas eran bachilleres agrícolas, no ingenieros agrónomos. Esto se debía en gran parte a la escasez aguda de personal capacitado en la región, pero también a la idea predominante del extensionista como un transmisor de mensajes.

c. Metodología de trabajo y fuentes de información:

8. Los servicios enfatizaban los medios más que los mensajes. La capacitación de los extensionistas se concentraba en métodos para enseñar a los agricultores, en comunicaciones o en los métodos de la extensión, en lugar de profundizar en conocimientos sobre temas técnicos o socioeconómicos. Las evaluaciones se centraron sobre el número de actividades realizadas en lugar de hacerlo en el contenido de éstas o su efectividad para resolver los problemas del agricultor;

9. Se suponía implícitamente, que ya existía la tecnología necesaria para modernizar la agricultura centroamericana (básicamente la tecnología proveniente de Estados Unidos); y que los extensionistas, por haberse graduado como bachilleres agrícolas, ya tenían un conocimiento adecuado de esa tecnología;

10. Los servicios promovían recomendaciones generales. Muchas veces se daba la misma recomendación para todas las regiones de un país o para todos los productores de un rubro, independientemente de su nivel de recursos o condiciones agroecológicas.

11. No se consultaba formalmente con los agricultores sobre sus necesidades, ni se realizaban diagnósticos rigurosos. Se consideraba que los extensionistas ya conocían cuáles eran las necesidades de los productores y las tecnologías que tenían que ser diseminadas.

12. No se evaluaba la rentabilidad de las nuevas tecnologías. Se suponía que cualquier inovación que aumentara los rendimientos sería rentable.

III. La crisis de los servicios tradicionales de extensión

En los años cincuenta y sesenta hubo un gran número de cambios tecnológicos relevantes para la agricultura centroamericana. Aumentó significativamente el uso de fertilizantes, plaguicidas y maquinaria agrícola; se importaron animales para mejorar el hato bovino y se incrementó el uso de productos veterinarios. También aumentó, aunque no en las mismas proporciones, el uso de variedades agrícolas importadas o generadas nacionalmente por los sistemas de investigación (Rosado y Laboy, 1970: 118).

El papel de los servicios de extensión frente a estos cambios resultó poco significativo. Si bien los servicios pudieron haber jugado un rol en promover cambios tecnológicos, la aparición de una amplia red privada de distribuidores de maquinaria e insumos, así como la rápida expansión de las facilidades de crédito institucional, parecen haber sido más importantes que la contribución de los servicios de extensión en este proceso.

A pesar de las mejoras en los indicadores del sector, las agencias de extensión no pudieron hacer que los productores más pequeños y marginales incorporaran las mejoras técnicas. En muchas de las explotaciones más grandes tampoco se aplicaron las recomendaciones tecnológicas sugeridas.

Si bien hubo avances importantes en café en El Salvador y Costa Rica, en maíz en El Salvador, en trigo en Guatemala, en algodón y arroz en varios países y en una franja del sector ganadero, el progreso fue mucho menos notable en la mayoría de los restantes rubros del sector agropecuario de la región. O los extensionistas no llegaban a esos productores, o las tecnologías que promovían no correspondían a los objetivos de los productores, ni a las condiciones agroecológicas, ni al nivel de recursos disponible para llevarlas adelante.

En todo caso, en ningún país de la región el servicio de extensión alcanzó a atender a más del 15 por ciento de los productores, y en Guatemala, Honduras, Nicaragua y Panamá este índice fue sustancialmente menor.

a. La crisis institucional de los servicios de extensión

Ya para finales de los años sesenta, y probablemente antes, los servicios de extensión comenzaron a padecer una fuerte crisis institucional. Fueron asumidos técnica y administrativamente por los Ministerios de Agricultura y perdieron la autonomía y flexibilidad institucional que habían gozado.

Aunque en general los presupuestos crecieron, este crecimiento fue menor al que experimentó el número de agencias y extensionistas; de manera que los salarios, gastos operativos y acceso a transporte, se redujeron en términos relativos, a pesar de constituír los principales insumos para su funcionamiento.

Los servicios perdieron también el sentido de "misión" o vocación que habían tenido. La salida de la primera generación de asesores norteamericanos, la reducción relativa de recursos y de autonomía, y la falta de un impacto claramente reconocible en la mayoría de los casos, afectaron sensiblemente la motivación del personal. Esto ocasionó la salida adicional de muchos de los mejores técnicos que tenían los servicios; y debido a la dificultad de supervisar las actividades de extensión que se estaban prestando, esta baja motivación creó problemas de indisciplina y bajos niveles de esfuerzo, que repercutieron a su vez en una menor credibilidad que desde entonces tienen los servicios públicos de extensión.

Los servicios justificaron entonces su existencia en la necesidad de servir a los pequeños productores que no habían entrado en el proceso de cambio tecnológico. Pero a pesar de que estos productores no podían acceder a las mejoras tecnológicas sin la asistencia del sector público, la realidad fue que de todos modos no incorporaron mejoras significativas.

b. La crisis conceptual de la extensión

La crisis de la extensión fue más que un problema de recursos y flexibilidad administrativa. Fue sobre todo, una crisis de conceptos. Se empezó a dudar de la existencia de alternativas técnicas factibles que fueran aplicables a una gran variedad de condiciones agroecológicas y tipos de productores, y tan sencillas que pudieran ser manejadas por extensionistas generales, sin estudios universitarios y con poca experiencia.

La insuficiencia de las recomendaciones generales se volvió más evidente todavía con la creciente complejidad de la agricultura. Por un lado ya existía un grupo grande de productores que efectivamente habían incorporado el paquete básico de nuevas técnicas (fertilizantes, semillas mejoradas, plaguicidas) y buscaban recomendaciones mucho mas específicas a sus problemas. Por otro lado, se empezó a cuestionar la relevancia de muchas de las tecnologías promovidas para productores de escasos recursos. Ambos aspectos hicieron pensar que efectivamente la calidad del mensaje técnico de los extensionistas era más importante que los canales de comunicación utilizados. Para tener un mensaje de calidad hacía falta un estrecho vínculo, prácticamente inexistente, entre extensión, investigación, fuentes externas de tecnología y el conocimiento acumulado de los productores.

También fue seriamente cuestionada la viabilidad de promover el cambio tecnológico entre pequeños productores sin ligar directamente las innovaciones a la provisión de crédito, insumos y acceso a la tierra. En respuesta a ésto, varios países comenzaron a dar a sus extensionistas responsabilidades de supervisión de crédito y otros países a combinar funciones de extensión con las otras actividades de desarrollo rural integrado o fueron reorientados para apoyar procesos de reforma agraria y desarrollo cooperativo.

IV. Propuestas para superar la crisis de los servicios de extensión

Cada una de las doce características básicas del enfoque tradicional de extensión que fueron señaladas en la segunda sección de este trabajo, dan lugar a un análisis crítico del cual se puede derivar un enfoque alternativo. A efectos de organizar la presentación de las alternativas que han surgido en los últimos años, y para tener un marco conceptual comparativo, se presenta el siguiente esquema de opciones que toma como base estas características.

La construcción de un nuevo modelo de transferencia de tecnología en la región, debería considerar:

a. Objetivos, campos de acción y clientela:

1. Alternativas que buscan la especialización, ya sea por cultivo, área agroecológica, clientela o tipo de tecnología. Estas alternativas permiten tomar en cuenta conocimientos especializados en áreas determinadas y diseñar políticas y estrategias específicamente orientadas a la problemática de la clientela. Algunos ejemplos de especialización en la transferencia son las instituciones dirigidas a un solo rubro (café, algodón, azúcar, tabaco), o los programas regionales de desarrollo, o bien los esfuerzos de regionalización de los servicios de extensión;

2. Alternativas que combinan la difusión de información con la provisión de otros recursos. La asistencia técnica podría ser provista como parte de un contrato de producción que incluye crédito y la compra del producto. También se podrían incorporar recomendaciones tecnológicas a proyectos de desarrollo rural o de reforma agraria, o enfocar la tecnología dentro del desarrollo comunitario como lo proponen los organismos no gubernamentales;

3. Alternativas para atender necesidades tecnológicas diversas y no sólo para promover el uso de maquinaria, agroquímicos y semillas mejoradas entre los productores de mayor desarrollo. Los esquemas de manejo podrían ser diferenciados según se trate de atender problemas específicos de productores de muy escasos recursos, de productores en zonas de frontera agrícola, de productores que buscan aumentar su rentabilidad por la vía de reducir costos o de productores dispuestos a experimentar con productos no tradicionales.

b. Aspectos institucionales:

4. Alternativas para restablecer la autonomía administrativa de la transferencia de tecnología. Incluirían las que procuran sustraer la transferencia de tecnología de la rigidez del ámbito ministerial, ubicándola en empresas privadas, o en organismos no gubernamentales, o en entidades públicas autónomas, y las que buscan descentralizar la administración de los servicios públicos de extensión;

5. Alternativas para aumentar los recursos financieros. Algunas posibilidades pueden encontrarse en el apoyo de donantes externos, el enlace entre política de crédito y servicios de asistencia técnica obligatorios, el cobro de los servicios de extensión o los gravámenes sobre ventas y exportaciones de productos agropecuarios;

6. Alternativas para supervisar o motivar a los técnicos. Una forma de conseguir esto sería aumentar el número de supervisores y hacer más rutinario el trabajo del extensionista para poder supervisarlo mejor. Otra forma sería acentuar la eficiencia de los extensionistas por medio de una cultura institucional de servicio al productor y/o el estímulo y fomento de una "vocación" de trabajo, como hacen los organismos no gubernamentales, las empresas privadas y algunos movimientos políticos. También se podría utilizar agricultores como transferidores, debido a que ellos generalmente tienen un mayor compromiso con las necesidades de sus comunidades.

7. Alternativas para aumentar el nivel académico de los transferidores. Los medios posibles incluirían exigir mayor nivel académico a los nuevos extensionistas que ingresan a la actividad, capacitacitar en servicio a los extensionistas y emplear otros tipos de personal, como los investigadores y especialistas en materias técnicas, para ciertas tareas de transferencia que así lo requieran.

c. Metodología y fuentes de información:

8. Alternativas que enfaticen la necesidad de aclarar el mensaje a ser transferido. Estas promueven la posibilidad de transferir un número reducido de tecnologías específicas y por tanto de mayor utilidad.

9. Alternativas para ligar la generación, importación, adaptación y transferencia de tecnología. Los mecanismos incluirían los esfuerzos de capacitación a los extensionistas en resultados de investigación, o en el desarrollo de mecanismos para integrar diferentes fuentes de información y traducirlas en recomendaciones, y también la

organización de actividades conjuntas entre investigadores y transferidores;

10. Alternativas para adaptar las recomendaciones técnicas a las necesidades específicas de diferentes tipos de productores y zonas agroecológicas. Algunas actividades posibles son: realizar diagnósticos para conocer el potencial y limitantes de la producción de diferentes agricultores y zonas, recabar más apoyo de la investigación adaptativa, aplicar el concepto de dominios de recomendación, y tener transferidores capaces de reconocer cuándo una recomendación se puede aplicar o no, o cómo puede ser adaptada según el caso.

11. Alternativas para consultar formalmente con los agricultores sobre sus necesidades y las posibles soluciones a sus problemas. Esto podría lograrse con la elaboración de diagnósticos, la participación de productores a través de investigaciones en sus propias fincas o la realización de transferencia por medio de entidades participativas como cooperativas, organizaciones gremiales y organismos no gubernamentales.

12. Alternativas que incorporan explícitamente los factores socioeconómicos, y sobre todo la rentabilidad de la nueva tecnología. Algunos posibilidades podrían encontrarse con la incoporación de científicos sociales a los equipos de investigación y transferencia o la capacitación de agrónomos en aspectos socioeconómicos.

V. Ocho Experiencias con nuevos enfoques para la transferencia de tecnología

A continuación se describe ocho experiencias recientes de transferencia de tecnología agropecuaria enmarcadas dentro de los nuevos enfoques. Los casos se presentan siguiendo el ordenamiento de las doce características planteadas arriba tanto para el análisis de la metodología tradicional de extensión como de las alternativas para una transferencia más eficaz.

EXPERIENCIA No. 1 - Investigación en finca
Transferencia para maíz y frijol en Caisán, Panamá (Saín y de Gracia, 1990)

a. Elementos básicos

En 1978 el Instituto de Investigación Agropecuaria de Panamá (IDIAP) y el Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) comenzaron un proyecto piloto en Caisán, Panamá para comprobar el uso de la metodología de investigación en finca, basada en un enfoque de sistema de producción restingido. Caisán fue la primera experiencia con esta metodología en Panamá. En el proyecto también participaron extensionistas del Ministerio de Desarrollo Agropecuario (MIDA).

Caisán está ubicado en el extremo centro occidental de Panamá. En 1970 tenía una población de 1.530 habitantes. Predomina el sistema de cultivos de maíz en rotación con frijol y anualmente se siembra aproximadamente 1.000 hectáreas de cada uno de estos cultivos. Allí prevalecen las explotaciones pequeñas en un área con un buen potencial tecnológico en razón de las condiciones agroecológicas.

En el proyecto trabajaron un ingeniero agrónomo y un agrónomo del IDIAP, un extensionista (agrónomo) del MIDA y un técnico del CIMMYT que coordinaba y supervisaba el proyecto en forma parcial a través de visitas.

b. Objetivos, campos de acción y clientela

Desde el inicio del proyecto se limitó el ámbito de acción sólo a la generación y difusión de información para producir maíz y frijol en Caisán.

Se trabajó con pequeños productores que no necesariamente debían ser productores "progresistas"

c. Aspectos Institucionales

El IDIAP controlaba las finanzas desde el nivel central, pero como se trataba de una institución relativamente pequeña con actividades concentradas en pocos lugares, la administración era más o menos ágil. El apoyo del CIMMYT permitió tener mayor flexibilidad.

Los recursos para gastos operativos fueron adecuados.

El carácter piloto del proyecto y la participación de un prestigioso centro de investigación internacional ayudó a motivar a los técnicos.

El extensionista del IDIAP que tuvo una participación directa, sólo tenía formación de agrónomo, pero recibió apoyo de los investigadores del CIMMYT y el IDIAP.

d. Metodología y fuentes de información

El CIMMYT y el IDIAP se preocuparon más por la necesidad de tener recomendaciones relevantes que por cuáles medios de transferencia de tecnología se usaban. Decían que "la mejor garantía para la adopción de la tecnología es asegurar que las circunstancias del productor estén incorporadas desde el inicio del proyecto en la estrategia experimental."

El proyecto planteaba la necesidad de una investigación adaptativa antes de comenzar a transferir tecnología. Los investigadores y extensionistas compartieron oficinas y trabajaron juntos en todos las etapas, salvo en el diseño de los ensayos, que era realizado por el IDIAP. El extensionista ayudaba seleccionar colaboradores, en la siembra y la cosecha de los experimentos y en la formulación de recomendaciones. A los productores participantes les pedían sus opiniones sobre las tecnologías que estaban siendo ensayadas en sus fincas.

Para determinar qué investigar, en el primer año se realizó un diagnóstico. Se realizó una encuesta para evaluar las prácticas usadas por los productores y sus principales factores limitantes y sus planteamientos respeto a los problemas existentes, y para definir posible dominios de recomendación. Por medio de la encuesta se detectaron 5 problemas prioritarios: malezas, arreglo espacial y densidad, eficiencia en uso de fertilizantes, acame y erosión. Para cada uno de estos problemas los investigadores analizaron las posibles causas y alternativas de solución, y diseñaron una estrategia de investigación.

En 1981 el proyecto ya estaba listo para establecer parcelas de validación y analizar la interacción entre los diferentes componentes bajo estudio. Con esta metodología se desarrollaron recomendaciones útiles en control químico de malezas, arreglo espacial y densidad de siembra, labranza cero y mínima y fertilización en un período de unos tres años. Las recomendaciones obtenidas fueron dirigidas a las condiciones específicas de los productores de maíz y frijol del área de Caisán, que era un grupo relativamente homogéneo.

La transferencia se realizó usando todos los métodos tradicionales: visitas, materiales escritos, demostraciones etc. También se organizaron visitas de productores a los ensayos. Como el dominio de recomendación era pequeño, las relaciones personales entre los investigadores, quienes vivían en la comunidad, los extensionistas y los agricultores influyeron significativamente en la transferencia de tecnología.

En todos las etapas se analizó la rentabilidad de las recomendaciones y no sólo los resultados físicos. El técnico del CIMMYT, con formación en economía, contribuía de manera significativa en esta área.

e. Impacto

Muchos productores adoptaron las recomendaciones más importantes en muy poco tiempo. La adopción de las recomendaciones de control químico en malezas pasó de 8% en 1978 a 61% en 1982; para arreglo espacial y densidad, del 21% al 63%; para labranza cero/mínima, del 0% al 23%; y para el no uso de fertilizantes, del 39% al 79%. Se encontró que el uso de fertilizantes en este caso no era rentable.

Después de haber realizado estos esfuerzos de transferencia, prácticamente todos los productores reportaron tener algún grado de conocimiento sobre la mayor parte de las recomendaciones y al mismo tiempo se registraron aumentos notables en rendimientos y rentabilidad.

EXPERIENCIA No.2 - Capacitación y Visita
Transferencia para cultivos varios y ganadería en Costa Rica (Bolaños, 1990)

a. Elementos básicos

El sistema de extensión "Capacitación y Visita" (C y V) fue diseñado por el Banco Mundial a mediados de los años setenta. En

Costa Rica se introdujo el sistema en el Pacífico Seco en 1979 con la asesoraría de la consultora israelí Tahal Consulting Engineers Ltd. En 1980 el Ministerio de Agricultura y Ganadería (MAG) decidió implementar este método de extensión en todo el país, con el apoyo de dos a cinco asesores a tiempo completo de Tahal y financiamiento del Banco Mundial.

Al inicio de la experiencia en C y V, Costa Rica ya contaba con un servicio de extensión tradicional, organizado en 8 Centros Agrícolas Regionales (CAR), 54 agencias y 7 oficinas de promoción. El servicio de extensión cubría todos los rubros de producción y se decía que atendía a un 15% de los productores.

b. Objetivos, campos de acción y clientela

Bajo la operación del sistema C y V el servicio limitó sus actividades a la difusión de información sobre recomendaciones específicas en un número reducido de rubros prioritarios.

Su clientela directa fueron unos 5.000 agricultores de "enlace", que tenían menos de 50 Has. cada uno. Se suponía que estos agricultores de enlace difundirían a sus vecinos los mensajes que recibían. Se puede decir que la mayoría de los agricultores de enlace eran productores "progresistas".

c. Aspectos Institucionales

Como actividad regular del Ministerio de Agricultura, el servicio de extensión no gozaba de autonomía, ni agilidad administrativa. En cierto sentido la introducción de C y V hizo el servicio de extensión mas rígido todavía, ya que el sistema procuraba uniformar todas las tareas, sin considerar las especificidades locales o los requerimentos de clientelas.

Adicionalmente las restricciones financieras dificultaban el transporte y algunas de las acciones operativas.

Un objetivo principal del nuevo sistema era aumentar el rendimiento de los extensionistas. Se buscó ordenar su trabajo y supervisarlo más. A cada extensionista se le asignaba un microzona de trabajo, dentro de la cual se definieron las rutas a recorrer y agricultores de enlace a visitar. Se estructuró el tiempo de los extensionista usando un calendario quincenal de actividades que se debía cumplir. Se creó un gran sistema de supervisión, con un supervisor por cada cuatro extensionistas.

Bajo C y V prevaleció la idea que la extensión directa debería ser realizada por agrónomos. Los ingenieros agrónomos fungían solamente como supervisores y especialistas, y casi no tenían contacto con los agricultores.

d. Metodología y fuentes de información

Para transferir tecnología se usó casi exclusivamente la visita individual, con apoyo en menor grado, de trabajos en parcelas demostrativas.

Se dio mucha importancia a la definición de mensajes específicos para transferir. Cada quincena los extensionistas recibían un día de capacitación de los especialistas donde se les transmitía los mensajes para ese período. Se prepararon manuales con recomendaciones oficiales para cada rubro, lo que permitía suplir la falta de conocimientos que pudieran tener los extensionistas sobre la tecnología que se estaba difundiendo.

Las recomendaciones que se hacían eran generales. No tomaban en cuenta las necesidades específicas de las diferentes zonas agroecológicas (a menos que se tratara de las regiones mas grandes) ni las necesidades de diferentes tipos de productores.

Se hicieron diagnósticos en ocho regiones del país, pero éstos fueron muy generales y no contaron con la participación de los productores. El método de C y V utilizó el mismo esquema de trabajo para productores medianos con un alto grado de tecnificación y para agricultores marginales en zonas aisladas.

La mayoría de los especialistas, a quienes les correspondía definir las recomendaciones, no eran especialistas en su campo, sino ingenieros agrónomos generalistas nombrados como especialistas.

C y V hizo poco para mejorar la relación entre los extensionistas y los investigadores, que fueron siempre limitadas.

Pocas de las recomendaciones contaron con el soporte de análisis económico que mostrara su rentabilidad.

e. Impacto

En 1983, después de tres años de funcionamiento, el Ministerio de Agricultura decidió abandonar el sistema de C y V. Nunca hubo una evaluación objetiva de su impacto. No obstante, una encuesta reciente realizada por Bolaños a 28 funcionarios que participaron en la experiencia permite conocer sus opiniones.

Los participantes opinaron que la especialización de C y V en pocos cultivos prioritarios era conveniente, igual que el mayor ordenamiento que impulsó el sistema y la preocupación por capacitar a los extensionistas. Ven como fallas del sistema que: no se tomaba en cuenta las necesidades específicas de productores heterogéneos; la atención se concentraba excesivamente en visitas individuales; las recomendaciones estaban poco articuladas con las fuentes de tecnología y suministro de crédito e insumos; se generaban recomendaciones demasiado uniformes; se utilizaba exclusivamente a peritos agronómos para el trabajo de campo. Esto constituía un error para el caso de trabajo con productores ya tecnificados. También se suponía erróneamente que los agricultores de enlace iban a producir un gran efecto multiplicador entre sus vecinos.

EXPERIENCIA No.3 - Grupos de Amistad y Trabajo
Transferencia para café en Comayagua, Honduras (Vejarano, 1990)

a. Elementos básicos

Desde 1978 el IICA dirige el proyecto PROMECAFE que constituye una red de investigación y transferencia de tecnología en café para Centroamérica, México y República Dominicana. Participan los Ministerios de Agricultura de los países, los institutos y asociaciones nacionales de café y varios organismos internacionales. Su financiamiento principal proviene de USAID-ROCAP, tiene su propio cuerpo técnico y también financia y asesora actividades en los diferentes países miembros.

PROMECAFE comenzó a transferir tecnología en Honduras en 1983, con un programa implementado por el Instituto Hondureño del Café (IHCAFE). Hasta hace poco tiempo, la transferencia concentró sus esfuerzos en una zona piloto de siete municipios en el departamento de Comayagua, donde se cultivan 15.289 mzs. de café, bajo la orientación de los llamados "Grupos de Amistad y Trabajo".

b. Objetivos, campos de acción y clientela

PROMECAFE fue establecido como un mecanismo de defensa ante la amenaza de la roya y la broca del café, que aparecieron en la región en los años setenta. Actualmente trabaja en varios temas específicos de investigación y en desarrollos metodológicos para la transferencia de tecnología del café.

IHCAFE es un organismo especializado en café. El trabajo de sus técnicos se restringe a la generación y tranferencia de nuevos conocimientos, aunque los técnicos coordinan sus actividades con los entidades crediticias.

La clientela del IHCAFE son los pequeños y medianos caficultores con menos de 50 Has en producción de café. El servicio atiende a la mitad de los 50.000 caficultores del país, aunque la atención real probablemente sea algo menor. La mayoría de los caficultores hondureños tienen niveles muy bajos de educación y usan prácticas rudimentarias de cultivos, aunque los extensionistas de IHCAFE tienden a atender a los productores más progresistas entre ellos. La clientela de los Grupos de Amistad y Trabajo estaba restringida hasta hace poco a la zona del proyecto en Comayagua.

c. Aspectos Institucionales

IHCAFE es una institución pública, autónoma, con una fuerte representación de las asociaciones de caficultores en sus instancias directivas. Su agilidad administrativa está en un punto intermedio entre la típica rigidez del sector público y la flexibilidad de una institución privada.

Goza de una situación financiera privilegiada y recibe fondos directamente, provinientes de un gravamen a la venta de café.

Los extensionistas de IHCAFE disponen de fondos para gastos operativos y han recibido financimiento de PROMECAFE para capacitación.

Los salarios de los extensionistas están por encima del promedio del sector público, y en general es personal motivado con una baja tasa de rotación. Seguramente la participación de este personal en un proyecto internacional como PROMECAFE ha sido un factor motivador adicional.

La mayoría de los extensionistas del IHCAFE son agrónomos, que trabajan bajo la supervisión de ingenieros agrónomos. Esto no ha sido un problema significativo debido a que los extensionistas han recibido capacitación especializada en el cultivo, tanto en aspectos técnicos como metodológicos, y porque los extensionistas ya contaban con experiencia empírica en café y el apoyo de técnicos de mayor nivel académico.

d. Metodología y fuentes de información

En su trabajo con IHCAFE, PROMECAFE ha enfatizado la necesidad de tener recomendaciones concretas. En cuanto a metodología de transferencia, el proyecto opera con los "Grupos de Amistad y Trabajo" y unidades demostrativas. Los grupos se constituyen con 10 a 20 caficultores, liderados por un guía seleccionado por el extensionista de IHCAFE, quien actúa como enlace entre el extensionista y el grupo. Estos extensionistas hacen un seguimiento permanente del área, producción y prácticas de cultivo de cada miembro del grupo.

El eje de los grupos son las unidades demostrativas, parcelas en las cuales los extensionistas hacen demostraciones y se prueban las opciones tecnológicas recomendadas. Antes de comenzar una prueba en la unidad demostrativa se reúne a todos los integrantes del mismo Grupo para elaborar un programa de manejo de esa unidad. Esto se complementa a su vez con cursos sobre caficultura, giras de observación a fincas tecnificadas, demostraciones de resultados, charlas, circulares y atención a consultas en oficina. Tanto en la parcela con la opción propuesta como en una parcela testigo se llevan registros económicos, cuyos resultados también son discutidos con el grupo.

Los extensionistas no sólo daban recomendaciones específicas para la zona donde trabaja el proyecto, sino que también hicieron recomendaciones distintas para productores medianos, con mayor capacidad económica y para pequeños productores, con menos acceso a capital.

Para definir las recomendaciones, en 1984 se elaboró un diagnóstico del sistema de producción del café en la zona de Comayagua, donde participaron investigadores y extensionistas. Como parte del diagnóstico se realizó una encuesta para caracterizar los sistemas de producción de los caficultores, que permitió identificar sus limitantes tecnológicas, socioeconómicas y de infraestructura. Luego se separaron los problemas encontrados entre los que requerían investigación y validación, y aquellos para los cuales ya había opciones tecnológicas que los productores podían implementar con sus propios recursos. Donde se encontró que faltaba investigación hubo coordinación entre investigadores y extensionistas, para apoyar la realización de ensayos.

Ninguna recomendación se ha hecho sin una evaluación previa de su rentabilidad.

d. Impacto

En 1987 había 91 Grupos de Amistad y Trabajo en Comayagua, con 2.000 miembros. Algunos cálculos iniciales basados en los registros del proyecto demostraron que las tecnologías recomendadas fueron mucho más rentables que las prácticas tradicionales que usualmente seguían los productores. Los resultados de la cosecha 87/88 dieron rendimientos muy por encima del promedio encontrado al inicio del proyecto.

EXPERIENCIA No.4 - Cultivos no tradicionales
Transferencia para macadamia en Costa Rica (Coles, 1990)

a. Elementos básicos

El cultivo de macadamia fue introducido en Costa Rica en la década del sesenta. En los años siguientes el CATIE, y la Universidad de Costa Rica (UCR) en colaboración con el Instituto Costaricense del Café (ICAFE) iniciaron investigaciones sobre este cultivo. Posteriormente una empresa privada, Macadamia de Costa Rica S.A., invertió sumas significativas en producción y procesamiento de macadamia.

Después de 1984 el área sembrada con macadamia creció varias veces, debido en parte a una política gubernamental de apoyo a los cultivos no tradicionales de exportación. Al mismo tiempo creció también la preocupación para generar y transferir tecnología para este cultivo; y en 1988 se creó el Programa Nacional de Macadamia.

Este Programa constituye un esfuerzo interinstitucional que incluye al Ministerio de Agricultura, ICAFE, la UCR, el Consejo Agropecuario Agroindustrial Privado (CAAP), la Cámara Nacional de Agricultura y Agroindustrias (CNAA) y tres asociaciones regionales de productores de macadamia. Actualmente el Programa tiene tres investigadores y dos ingenieros encargados de la transferencia de tecnología a tiempo completo, y el apoyo de otros transferidores de instituciones como la Oficina de Diversificación Agrícola de Turrialba y el Banco de Costa Rica. Aunque Macadamia de Costa Rica S.A. no pertenece formalmente al programa intercambia información y realiza sus propias actividades de transferencia.

En 1988 había un poco más de 500 productores de macadamia en Costa Rica, con un área sembrada de 5.500 Has. El 90% del área estaba concentrada en 8 municipios ubicados en el Norte y la costa atlántica del país. Los productores varían en tamaño, aunque la producción está concentrada en manos de productores medianos y grandes.

b. Objetivos, campos de acción y clientela

El programa busca promover la producción de macadamia. Realiza investigación adaptativa y transfiere tecnología.

La transferencia se hace usando todos los medios tradicionales. Los transferidores solo difunden información, pero tienen fuertes vinculos informales con el sistema de crédito e la información de mercadeo.

La clientela de la transferencia son prácticamente todos los productores de macadamia, quienes, por falta de experiencia en este cultivo tienen mucho interés en recibir asesoría.

c. Aspectos Institucionales

El programa tiene flexibilidad para sus operaciones. Utiliza personal, campos de experimentación y vehículos de diferentes instituciones, principalmente privadas y semiprivadas. De igual modo cuenta con recursos adecuados provinientes de las mismas fuentes.

Puede decirse que cuenta con personal motivado, bien pagado y muy dinámico, entre quienes están algunos de los técnicos que más conocen sobre macadamia en el país.

d. Metodología y fuentes de información

Por no haber una experiencia previa con macadamia en el país, todos los productores van aprendiendo con la práctica.

Los paquetes tecnológicos originales fueron importados de Hawai, pero se han ido modificando en muchos aspectos conforme a los resultados obtenidos.

Los investigadores muestran interés en aprender de las experiencias prácticas de los transferidores y los productores. Muchas veces los investigadores mismos realizan actividades de transferencia, y por su parte, los transferidores se muestran muy interesados e involucrados con los ensayos de investigación en las que participan. La información es muy fluída, incluyendo un intercambio importante con la empresa procesadora Macadamias de Costa Rica.

Se pone mucho hincapié en desarrollar recomendaciones específicas adaptadas a las condiciones locales. Hay una preocupación por la rentabilidad de las recomendaciones, aunque los analísis que se han hecho son generales y basado más en modelos teóricos que datos empíricos.

El programa actual de investigaciones y transferencia de tecnología está basado en un diagnóstico de la situación y necesidades de los productores. Los productores también participan directamente en la toma de decisiones a través de la participación de sus tres asociaciones regionales en la mesa directiva del Programa.

e. Impacto

Un gran porcentaje de los productores han sido atendidos por el programa, que poco a poco ha adaptado las tecnologías importadas a las condiciones locales. El área sembrada y la producción han aumentado significativamente, pero todavía es demasiado temprano para medir el impacto global del programa.

EXPERIENCIA No.5 - Tecnología Ganadera
Transferencia para la ganadería en Nueva Concepción, Guatemala (Iturbide, 1990)

a. Elementos básicos

En 1986 Guatemala inició el "Proyecto de Generación y Transferencia de Tecnología Agropecuaria y Producción de Semillas" (PROGETTAPS). En este proyecto participa el Instituto de Ciencia y Tecnología Agrícola (ICTA), las Direcciones Generales de Servicios Agrícolas (DIGFSA) y Pecuarios (DIGESEPE), los servicios de extensión, y el Banco de Desarrollo Agrícola (BANDESA). El proyecto recibe financiamiento externo del Banco Interamericano de Desarrollo (BID) y el Fondo Internacional de Desarrollo Agrícola (FIDA).

El PROGETTAPS incluye un subproyecto de Transferencia de Tecnología y Asistencia Técnica Pecuaria, coordinado por DIGESEPE. El supbproyecto tiene cuatro módulos, siendo el mas grande el de Nueva Concepción, al suroccidente del país. Cada módulo tiene un coordinador y un grupo de transferencistas, asistentes y personal de apoyo de otras instituciones vinculadas al subproyecto.

Nueva Concepción es una antigua área de colonización que tuvo su origen en un proyecto de reforma agraria. El municipio tiene 1.400 parcelas familiares, de alrededor de 20 Has cada una, con una superficie de 39.000 Has.

Más del 80% de los productores de Nueva Concepción se dedican parcial o completamente a la ganadería de doble propósito. El municipio produce el 7% de la leche a nivel nacional, con predominio de sistemas tradicionales con bajos niveles de productividad. Los productores tienen poco acceso a bienes de capital importados y se estima que antes del inicio de proyecto el 85 por ciento de los productores no recibían asistencia técnica.

b. Objetivos, campos de acción y clientela

El subproyecto de Transferencia de Tecnología y Asistencia Técnica Pecuaria del PROGETTAPS tiene por objetivo principal el incremento de la productividad ganadera, especialmente durante la época seca.

DIGESEPE se especializa en ganadería, y sus extensionistas se dedican sólo a este rubro.

La transferencia de tecnología en el proyecto tiene dos modalidades principales, que incluyen asistencia técnica directa y promoción y capacitación. Para la promoción y capacitación se utiliza metodologías tradicionales de extensión tales como charlas, demostraciones de métodos y resultados, distribución de material divulgativo y visitas. La capacitación se hace para representantes agrícolas, otros ganaderos y técnicos. Ultimamente también ha cobrado importancia la entrega de servicios directos como inseminación artificial y multiplicación y distribución de semillas forrajeras.

Originalmente los extensionistas del proyecto tenían labores de supervisión de crédito, pero a partir de 1988 se dedican solamente a difundir información sobre las recomendaciones prioritarias del proyecto y a algunas actividades de validación de tecnología.

La clientela del subproyecto ganadero en el Nueva Concepción son beneficiarios del reparto de tierra que tuvo origen en la reforma agraria, con fincas similares en tamaño.

c. Aspectos Institucionales

DIGESEPE es una institución pública con una tradicional rigidez y fuertes problemas financieros. Esto implica muchas veces salarios relativamente bajos y falta de recursos para realizar acciones oportunas. A menudo los recursos llegan con retraso y hay problemas con el transporte. No obstante, la existencia de una unidad ejecutora del subproyecto a nivel central y en cada uno de sus cuatro módulos, y el financimiento especial que ha recibido PROGETTAPS, han permitido cierta mejora en esta situación.

Con PROGETTAPS, los extensionistas de DIGESEPE han ganado motivación gracias a la introducción de una metodología y objetivos más claros, a la mayor interacción que han tenido con investigadores y gracias al prestigio y recursos que ha obtenido el proyecto. Todo el equipo técnico vive, comparte, enseña y se capacita en la comunidad. Aún así, se produce una salida de técnicos por falta de incentivos salariales.

Una de las innovaciones mas novedosas de PROGETTAPS ha sido el uso de "representantes agrícolas". Estos representantes son productores seleccionados por sus comunidades, quienes sirven de enlace entre el sector público agropecuario y sus comunidades. Informan a las instituciones públicas de la problemática local y difunden tecnología que reciben de estas instituciones; a cambio reciben una renumeración pequeña. Nueva Concepción tiene aproximadamente unos 25 representantes agrícolas.

La mayoría de los extensionistas de DIGESEPE no tienen formación universitaria, aunque el proyecto ha contribuido sustancialmente a mejorar la capacitación y supervisión técnica que reciben.

d. Metodología y fuentes de información

El proyecto ha desarrollado una relación estrecha entre extensionistas e investigadores. Cuenta con un plan operativo conjunto entre ICTA y DIGESEPE que incluye reuniones, encuentros técnicos interinstitucionales, trabajos en parcelas de prueba y de transferencia, y "confrontaciones técnicas" donde los investigadores y extensionistas discuten con un grupo selecto de productores las recomendaciones a divulgar.

Las recomendaciones que promueve el módulo de Nueva Concepción tienen su origen en gran medida en una investigación en sistemas de producción bovina de doble propósito que el ICTA y el CATIE realizaron la región entre 1978 y 1983. Esta investigación incluyó diagnósticos estáticos y dinámicos de los sistemas ganaderos y el uso de registros económicos para analizar la rentabilidad de diferentes alternativas. Se determinaron los limitantes principales de la producción y se definieron algunas soluciones posibles. El antecedente de este trabajo fue una de las razones para ubicar el módulo en Nueva Concepción. Antes de comenzar PROGETTAPS los resultados de estas investigaciones habían tenido poca difusión.

En 1986, cuando se inició el trabajo en el módulo de Nueva Concepción, los representantes agrícolas levantaron una encuesta sobre los sistemas de explotación ganadera utilizados y se realizó una confrontación técnica con los ganaderos para discutir posibles alternativas tecnológicas. De esta primera experiencia se definieron las tecnologías con que se iba a trabajar en investigación, validación, transferencia y el diseño de programas de capacitación. Se identifó el problema de la alimentación en época seca como el principal factor limitante y se decidió concentrar los esfuerzos del proyecto en las alternativas para conservación de pastos. También identificaron como áreas de acción prioritaria el combate de malezas, ordeño, sanidad animal y administración.

Para cada ganadero que recibe asistencia técnica directa se hace un diagnóstico de la finca y se elabora un programa de trabajo que preve la incorporación de varias de las recomendaciones prioritarias del programa.

Las recomendaciones que hace el proyecto son específicas a las condiciones locales, y están respaldadas con análisis económicos, usando, en parte, registros económicos que levanta con los ganaderos que reciben asistencia directa.

e. Impacto

El módulo ha dado asistencia técnica completa a unos 80 ganaderos (7% del total), pero sus actividades de promoción y capacitación han llegado a un porcentaje varias veces mayor.

La única evaluación objetiva que se ha hecho del impacto del proyecto incluye a productores que han recibido asistencia técnica directa. Una encuesta aleatoria a 34 de ellos mostró un mejoramiento notable en el conocimiento e incorporación de 15 tecnologías prioritarias promovidas por el proyecto. En promedio, el porcentaje de productores que conocían estas tecnologías pasó de 49% a 85% antes y después del proyecto, y entre los que ya conocían las tecnologías el nivel de conocimiento de ellas también se incrementó.

El promedio de adopción de las diferentes tecnologías pasó de 20% a 62%. Hubo cambios destacables en adopción de tecnologías relacionadas con pastos de corte, conservación de forrajes, levante de terneros, programación del uso de potreros, manejo del hato y uso de registros, en prevención de enfermedades y control de parásitos. También se ha notado un incremento marcado en el uso de pastos de corte y conservación de forrajes entre los ganaderos que no recibieron asistencia técnica directa.

Las principales dificultades en adoptar las tecnologías se dieron en aquellos casos donde la utilización de las mismas resultaba muy complejo o se requería de grandes cantidades de capital o de insumos.

<u>Experiencia No. 6 - Tecnología para el desarrollo comunitario</u>
Transferencia para cacao y cultivos perennes promisorios en Talamanca, Costa Rica (Carroll y Baitenmann, 1987; McLarney, 1989)

a. Elementos básicos

La Asociación ANAI es un organismo no gubernamental que opera en la región de Talamanca, cerca de Panamá en la costa atlántica de Costa Rica. Fue creada por dos ecológos norteamericanos en

1975. Tiene sus raíces en el movimiento ecologista de los Estados Unidos, y las preocupaciones de ese movimiento por desarrollar formas sostenibles de producción.

Talamanca tiene unas 25 pequeñas comunidades en un área de 2.500 kilómetros cuadrados. Es una zona pobre y aislada, con pocos servicios públicos y escasa tradición de organización comunitaria. Tiene una gran diversidad agroecológica y étnica. El cultivo principal es el cacao, pero este ha sido fuertamente atacado por la monilia desde 1979. La zona vive un proceso acelerado de deforestación.

ANAI ha recibido donaciones de AID, Catholic Relief Services, CINDE, el Inter-American Foundation, el gobierno holandés y varios individuos de los Estados Unidos. Hasta 1983 tenía apenas cinco empleados, pero en ese año recibió una donación de CINDE que le permitió aumentar su personal a 13. Actualmente tiene 25 empleados pagados y un gran número de voluntarios. Su personal incluye investigadores, extensionistas, un administrador de fincas, un organizador comunitario y un coordinador educacional.

b. Objetivos, campos de acción y clientela

Los principales objetivos del proyecto son: (a) la diversificación de las fuentes de ingreso, en sustitución al monocultivo del cacao, (b) un modelo sostenible de desarrollo comunitario, y (c) una mayor organización comunitaria.

Sus actividades tecnológicas se concentran en la introducción de variedades resistentes de cacao y nuevos cultivos para la diversificación (condimentos, plantas medicinales, frutas exóticas, raíces y tubérculos). Trabaja en investigación adaptativa, asistencia técnica y la organización de viveros. También tiene proyectos de: tenencia de la tierra, comercialización, agua potable, inversiones en porquerizas y acuacultura, refugios naturales y áreas silvestres.

Su clientela son productores pobres de Talamanca, que tradicionalmente han tenido poco acceso a servicios y mercados.

c. Aspectos Institucionales

Como ONG, ANIA es autónoma. Su limitado área de acción geográfica, pequeño tamaño y estatus jurídico le dan flexibilidad y permiten que la mayor parte de las decisiones se tomen informalmente.

El equipo de ANIA tiene una fuerte mística de trabajo, basado en una principios ecologistas y desarrollo comunitario. Los extranjeros que trabajan en la asociación podrían ganar más en otro lugar pero permanecen allí por su compromiso con el trabajo que realizan. Viven en comunidades en Talamanca, junto a los productores. La asociación tiene muchos voluntarios, tanto del exterior como agricultores locales que trabajan en los viveros comunitarios.

El nivel académico del personal es muy diverso; varía desde los que tienen doctorado a los que tienen sólo estudios secundarios.

d. Metodología y fuentes de información

El componente tecnológico de ANIA tiene un producto muy claro y específico: nuevas variedades resistentes de cacao y una media docena de nuevos cultivos. Para estos productos hace recomendaciones agronómicas y de mercadeo y ayuda a organizar viveros. Recibe materiales promisorios del CATIE y de contactos personales de los técnicos en diferentes lugares del mundo. Antes de difundir los materiales se hace ensayos de adaptación y validación, y las recomendaciones que emergen de estas experiencias son específicamente adaptadas a las condiciones locales y al nivel de recursos de los productores.

Los productores participan en todo el proceso. No se toma ninguna decisión importante en la organización sin consulta directa con ellos, manejan los viveros comunales y prueban los diferentes cultivares nuevos. ANIA sólo provee el material genético inicial, un equipo básico y asesoría en los aspectos técnicos y organizativos. Los viveros envían representantes a reuniones mensuales donde se discuten sus problemas con los técnicos de ANIA. ANIA también trabaja de cerca en su program de diversificación con una cooperativa regional (COOPETALAMANCA).

ANIA no hace estudios económicos formales, pero la información que reciben de los viveros y sus propias actividades de mercadeo les da una visión muy concreta de la rentabilidad de las alternativas que propone.

e. Impacto

El principal impacto tecnológico de la experiencia ha sido que unos 1.500 agricultores sembraran dos millones de árboles nuevos de cacao y otros productos para la diversificación, y que estén funcionando 25 viveros comunales. También ha promovido un proceso de experimentación por parte de los productores que junto a la organización comunitaria dará frutos en el futuro.

Experiencia No. 7 - Conservación de suelos y desarrollo integral Transferencia para maíz y frijoles en Guinope, Honduras (Bunch, 1987)

a. Elementos básicos

Entre 1976 y 1980 varios ingenieros agrónomos de la Secretaría de Recursos Naturales de Honduras visitaron los proyectos coordinados por Vecinos Mundiales en granos básicos y conservación de suelos en Guatemala. Como resultado, la Secretaría le pidió a Vecinos Mundiales abrir un proyecto similar en Honduras. En 1981 se firmó un convenio entre la Secretaría, Vecinos Mundiales y ACORDE, un ONG hondureño, para iniciar un proyecto en Guinope. Vecinos Mundiales proporcionó el personal, el financimiento y la metodología; la Secretaría contribuyó con apoyo logístico, y ACORDE con apoyo administrativo y tecnológico.

La zona del proyecto se ubica al sur-central del país, entre Tegucigalpa y la frontera con Nicaragua. Es una zona pobre, con monocultivo de maíz, suelos erosionados y fuerte deforestación. El proyecto comenzó en la comarca de Guinope y tres comarcas vecinas, pero en los años siguientes se ha expandido hasta cubrir 41 comarcas en los municipios de Guinope, San Lucas y San Antonio de Flores.

b. Objetivos, campos de acción y clientela

El componente agrícola del proyecto pretende: (a) aumentar los rendimientos de maíz y frijol, (b) promover la producción y comercialización de hortalizas, como fuente alternativa de ingresos, (c) mejorar la conservación de los suelos y el manejo de los recursos naturales, y (d) implementar un método de trabajo que pueda ser sostenido sin la participación de Vecinos Mundiales.

La base del proyecto es la realización de pequeños ensayos en fincas, demostraciones y charlas. Además promueve la venta de las hortalizas producidas por el proyecto y tiene un programa de salud y nutrición.

La clientela son productores pobres de granos básicos de la región, no productores "progresistas".

c. Aspectos Institucionales

El proyecto conducido por Vecinos Mundiales tiene mucha flexibilidad administrativa y programática. No tienen problemas de recursos para sus gastos operativos y el personal tiene un fuerte compromiso con su trabajo.

Todas las charlas y demonstraciones son hechas por "para-técnicos", campesinos del lugar contratadas por el proyecto como extensionistas. Estos paratécnicos tiene un bajo nivel de educación formal, pero están apoyados por un grupo de mucha experiencia y trabajan con técnicas sencillas, previamente validadas.

d. Metodología y fuentes de información

El enfoque de Vecinos Mundiales busca identificar técnicas sencillas, baratas para cultivos tradicionales que puedan tener un gran impacto sobre los rendimientos físicos. En el caso de Guinope diagnosticaron que el factor limitante para la producción era la baja fertilidad y conservación de los suelos, por tanto concentraton sus esfuerzos en promover pequeños canales de drenaje, el uso de gallinaza y fertilizantes y la siembra de abonos verdes. Luego comenzaron con la promoción de hortalizas una vez que el trabajo con maíz había alcanzado éxito.

Todas las tecnologías, menos el uso de abonos verdes, son adaptaciones de técnicas utilizadas en proyectos de Vecinos Mundiales en Guatemala, validadas en ensayos sencillos manejados por los propios productores en sus fincas. El proyecto no tiene un programa de investigación propiamente dicho.

Además de participar como extensionistas y en la realización de ensayos, los los productores están organizados en una asociación de productores de hortalizas y en unos 40 comités agrícolas locales que mantienen un diálogo constante con el proyecto.

No se hacen analísis formales de la rentabilidad de las técnicas, pero solo se trabajan con técnicas de muy bajo costo monetario.

e. Impacto

Un estudio realizado por Vecinos Mundiales en 1987 encontró que unos 1200 productores aumentaron significativamente sus rendimientos de maíz y/o frijol como resultado del proyecto. La capacitación que dieron a unos 400 agricultores sobre hortalizas y su trabajo de mercadeo hizo que la zona sea productora significativa de estos productos. Para 1987 tenía unos 60 campesinos entrenados como extensionistas, y muchos más con experiencia en realizar ensayos y organización comunitaria.

Experiencia No. 8 - Asistencia Técnica Dirigida en Granos Básicos Transferencia por la Dirección General de Reforma Agraria en el Pacífico Sur de Nicaragua (Dulcire y Hocde, 1988)

a. Elementos básicos

En 1983 se formó un equipo interinstitutional de investigadores de la Universidad (ISCA) y el Ministerio de Agricultura (MIDINRA) y técnicos de la dirección de reforma agraria del Ministerio (DGRA) para generar, validar y transferir tecnología para granos básicos en tres regiones de Nicaragua. Durante dos años el equipo hizo ensayos en maíz y frijol, sin mayores resultados.

En 1985 la oficina regional de la DGRA en el Pacífico Sur (Región IV) retomó la idea original y creó el Programa de Asistencia Técnica Dirigida (PADT) que funcionó de lleno a partir de 1987. En el programa participaron unos 50 técnicos ubicado en siete oficinas zonales, con apoyo de la oficina regional en Masaya y del ISCA y MIDINRA en Managua.

La región IV de Nicaragua tiene 600,000 habitantes y una superficie de 4,700 KMs2. Es una región muy heterogenea, tanto agro-ecologica somo socialmente, con un importante sector cooperativizado y también con pequeños y medianos productores privados.

b. Objetivos, campos de acción y clientela

El PADT buscaba aumentar los rendimientos regionales de maíz, frijol y sorgo.

Como programa estaba limitado a la generación de transferencia de tecnología, aunque muchos de los técnicos participantes también tenían tareas administrativas, de organización cooperativa y supervisión de crédito.

Su clientela básica eran las cooperativas de crédito y servicios (CCS) y las cooperativas de producción (CAS), aunque también participaron agricultores individuales.

c. Aspectos Institucionales

La DGRA formaba parte del aparato central del Ministerio de Agricultura, con todas las trabas administrativas y financieras y de inestabilidad que esto implica. Recibía algún apoyo, menor, de la cooperación francesa. No obstante, contaba con un grupo de técnicos muy motivados, con diversos niveles de formación académica.

d. **Metodología y fuentes de información**

El PADT dio casi igual énfasis a las metodologías de investigación y transferencia de tecnología como a las recomendaciones tecnológicas mismas. Trabajó con varias técnicas sencillas para granos básicos, pero tuvo mayor impacto con las recomendaciones sobre nuevas variedades de maíz y control de plagas.

Las recomendaciones que se hicieron fueron resultado de un proceso que incluía diagnósticos; levantamiento de registros económicos y agronómicos de un grupo selecto de productores; ensayos experimentales y de validación realizados en fincas de productores; análisis de visitas hechas por técnicos; y talleres regionales y zonales con técnicos y productores. Estas recomendaciones se recopilaron en "cartas tecnológicas" por cultivo, que servían de referencia para la transferencia y se revisaban todos los años. Las recomendaciones eran generales, y no diferenciaban entre diferentes zonas agro-ecológicas o tipos de productores. Se trató de usar los registros económicos para determinar la rentabilidad de las recomendaciones, aunque no siempre con éxito. Debido a la participación limitada de investigadores capacitados, no siempre tenían un fuerte respaldo científico.

Los campesinos tuvieron una participación muy activa en el PADT por multiples vías. Unos 400 productores participaron en los talleres zonales donde se discutían los temas de los ensayos, las recomendaciones técnicas y las evaluaciones del trabajo realizado. Los técnicos organizaban reuniones, generalmente alrededor de ensayos o parcelas demostrativas donde se promovía un intercambio de experiencias con los productores. Los productores manejaban los ensayos en sus fincas y discutían los resultados de los diagnósticos y registros en reuniones con los técnicos.

e. **Impacto**

El porcentaje del área sembrada de maíz en variedades mejoradas aumentó de 50% en 1983 a 90% en 1987, de frijol del 0% al 30%. El uso de insumos químicos aumentó, y se hizo más eficiente. Por ejemplo, las cooperativas crearon un grupo de "plagueros", quienes aprendieron metodologías para estimar el daño de las plagas y decidar cuando se justificaba económicamente el uso de plaguicidas.

Entre 1985 y 1987 los rendimientos de maíz de los productores que participaron en el PADT aumentaron de 2500 a 4020 kilos por hectárea, mientras los de los restantes productores crecieron muy poco. El proyecto ofreció pocas recomendaciones muy nuevas para sorgo y frijol y por razones climáticas los rendimientos de estos cultivos cayeron fuertamente entre 1985 y 1987, tanto para los participantes del PADT como para los restantes productores.

VI. Conclusiones

a. Tendencias Generales

La experiencia de los ochos casos presentados muestra ciertas tendencias generales entre los nuevos enfoques de transferencia de tecnología en la región:

Primero, los proyectos concentraron sus actividades sobre un número reducido de rubros y regiones. Sólo los casos de Capacitación y Visita y los esfuerzos de diversificación de ANAI y Vecinos Mundiales trabajaron con más de tres rubros; e incluso estos tres proyectos buscaron intencionalmente limitar el número de rubros.

En todos los casos excepto en Capacitación y Visita (el caso cuyo impacto fue menos claro), el trabajo se limitó a unas pocas zonas o regiones geográficas. Esto plantea inquietudes importantes, que todavía no tienen respuesta:

- ¿Esto se debe a las características de la tecnología transferida, que tiene que ser adaptada a condiciones locales, o a aspectos institucionales?

- ¿Cuando se trata de programas con cobertura nacional se vuelven demasiado grandes y burocráticos?

- Aún si se concluye que los esfuerzos localizados son más efectivos, ¿serán necesariamente más eficientes, o se estará invertiendo recursos cuantiosos para dominios de recomendación muy pequeños?

- ¿Que impacto pueden representar los proyectos locales en los parámetros macroeconómicos del sector agropecuario?

Segundo, la flexibilidad administrativa, la motivación de los técnicos y la disponibilidad de fondos operativos son condiciones necesarias para una transferencia efectiva. Las experiencias de transferencia muestran que ésta puede ser exitosa en la medida que incorpore nuevas metodologías. Pero esas metodologías no sólo deben ser adecuadas sino que también deben estar acompañadas del financiamiento que permita desarrollarlas.

Para Vecinos Mundiales, ANAI y el Programa Nacional de Macadamia la participación preponderante del sector privado facilitó la flexibilidad de operaciones. En los casos en que el sector público tuvo particpación directa hubo trabas burocráticas, pero éstas fueron parcialmente superadas cuando intervenía el financimiento externo.

Todos los casos contaron con recursos adecuados para cubrir los gastos operativos, provenientes en gran medida del financiamiento externo. En tres de las experiencias, lideradas por el sector público, se observó que los recursos operativos en algunos momentos parecieron ser insuficientes para realizar todos los esfuerzos de transferencia programados. Pero aún en estos casos los proyectos contaban con mayores recursos para gastos operativos que las disponibilidades promedio que asignaba el sector público.

En las condiciones actuales, parece claro que los presupuestos fiscales no habrán de aumentar significativamente en los próximos años como para fortalecer las actividades de transferencia. Los países habrán de reducir la carga salarial para disponer de recursos operativos o solamente se podrá financiar gastos operativos si se mantiene la ayuda externa. Las actividades de transferencia se realizarán unicamente conforme a la disponibilidad de recursos externos.

Varios factores ayudaron a la motivación de los técnicos. Entre ellos se cuenta que se tenía una metodología definida y también términos de referencia claros para el trabajo de los transferidores. Otro aspecto fue contar con objetivos claros, que representaban en alguna medida las prioridades nacionales sobre producción agropecuaria o desarrollo del sector.

Al mismo tiempo, los proyectos piloto, con reconocimiento nacional e internacional, ayudaron a motivar a los técnicos en seis de los casos. En Capacitación y Visita la clave fue la supervisión y la definición actualizada del trabajo a realizar; en el Programa Nacional de Macadamia e IHCAFE, fueron los salarios relativamente altos; en PROGETTAPS, Vecinos Mundiales y ANAI, fue el empleo de paratécnicos altamente motivados; y en PADT en Nicaragua, Vecinos Mundiales y ANAI, las motivaciones ideológicas fuertes.

Tercero, el éxito de la transferencia depende del <u>número reducido de recomendaciones concretas, que: (a) respondan a las necesidades sentidas de los productores, (b) surjan directamente del trabajo de generación y adaptación de tecnología, y (c) sean rentables y adaptadas a las condiciones específicas de los productores a quienes van dirigidas</u>.

En todos los casos se hacía recomendaciones bien definidas, que generalmente no pasaron de 10 por rubro. En ningún caso los transferidores recetaban recomendaciones en base a su experiencia acumulada o lo que aprendieron en su educación formal.

En general las recomendaciones estaban adaptadas a las condiciones específicas del lugar y al nivel de recursos de los productores. Donde no fue así, con el sistema de Capacitación y Visita en Costa Rica y el Programa de Asistencia Técnica Dirigida en Nicaragua, esto fue mencionado como problema y los resultados fueron menos exitosos.

En los resultados de la transferencia ha sido clave el vínculo establecido con las fuentes de la tecnología. En cinco casos se formaron equipos conjuntos entre investigadores y transferidores, y en dos más los transferidores tenían la responsabilidad principal de conducir la investigación adaptativa. Vecinos Mundiales y ANAI en importaron tecnología de afuera y validarla localmente. Sólo el sistema de Capacitación y Visita en Costa Rica tenía una relación débil entre generación e importación de tecnologías.

Los productores alimentaron y retroalimentaron el proceso de desarrollo tecnológico por tres vías participativas diferentes:

- en cinco casos los productores proveyeron información sobre sus sistemas de producción y sus problemas para los diagnósticos formales,
- en siete casos participaron en investigaciones realizadas en sus fincas, ya sea como comentaristas o como participantes en el diseño y analísis, y
- en cinco casos (IHCAFE, el Programa Nacional de Macadamia, ANAI, Vecinos Mundiales y los técnicos de reforma agraria en Nicaragua) los proyectos participaron directamente en la formación de grupos o asociaciones de productores que podían servir de interlocutores en las discusiones tecnológicas; y en los primeros tres de estos casos los productores participaron además, en la junta directiva de la organización.

En la mayoría de los casos hubo una clara preocupación por la rentabilidad de las recomendaciones y la capacidad de los productores para implementarlas. En cuatro casos esta preocupación tomó la forma de análisis económicos formales, y en otros tres, aunque no se realizó análisis económicos formales, los proyectos mostraron una gran sensibilidad a este tipo de problema.

b. Por un pluralismo de opciones

Si bien se observaron ciertas tendencias generales entre las experiencias recientes de transferencia efectiva, también se nota una fuerte diversidad entre ellas. Los objetivos se cumplieron siguiendo diferentes mecanismos, que en esencia significaban ajustes en los diseños institucionales y metodológicos, conforme lo requería cada grupo ó área identificado como clientela del proyecto.

La agricultura centroamericana y las demandas tecnológicas que reciben las instituciones son cada día más complejas. Además de la tradicional preocupación por aumentar rendimientos y el nivel de vida del productor han tomado importancia la sostenibilidad y la conservación de suelos (ANAI, Vecinos Mundiales), la diversificación de los fuentes de ingreso (Programa Nacional de Macadamia, ANAI, Vecinos Mundiales), problemas fitosanitarios (IHCAFE) y el desarrollo comunitario para los productores marginales (ANAI, Vecinos Mundiales). Estas preocupaciones diferentes requieren estrategias de transferencia de tecnología necesariamente diferenciadas.

Los diferentes actores de los procesos de transferencia parecen enfocar clientelas diferenciadas. Los organismos no gubernamentales, y en menor grado, los proyectos de investigación en finca-transferencia del sector público, han procurado atender grupos de productores tradicionalmente poco servidos por los servicios del Estado. Por otro lado, grupos privados o semi-privados de transferencia (como el Programa Nacional de Macadamia) tienen como clientela a productores empresarios, aunque demandan una atención mucho más personalizada.

Según las circunstancias, resulta indispensable contar con transferidores con un alto nivel académico. En otros casos, parece ser suficiente el uso de investigadores y personal con mayor nivel académico de apoyo a los transferidores, sobre todo cuando éstos tienen un nivel bajo de educación formal.

En términos generales, se observa una tendencia a concentrar los esfuerzos del transferidor en proveer sólo información. La coordinación con entes crediticios se realiza en ocasiones, pero no los proyectos de buscan participar directamente en estas actividades. No obstante, para los sectores marginados, como los que atiende ANAI y Vecinos Mundiales, parece que ha sido indispensable combinar la difusión de información tecnológica con otras actividades como las de desarrollo comunitario. También hubo casos donde resultó indispensable promover directamente la producción y distribución de material genético (PROGETTAPS, ANAI).

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SEMINAR "Mobilizing Agricultural Technology to

Meet Central American Challenges"

THE AGRICULTURAL TECHNOLOGY SYSTEM: A CONCEPTUAL FRAMEWORK

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ABSTRACT

Development, exchange and utilisation of agricultural technology is increasingly seen as a crucial ingredient in the 'mix' of essentials for agricultural development. Increasingly, therefore, international financial agencies, donor agencies, governments, commercial companies and farmers, invest in the institutions and processes involved. IICA's Technology Development and Transfer Programme is no exception.

Investment decisions are guided by theories, which often remain implicit. In the case of technology development, exchange and utilisation, these theories differ a great deal between economists, physical and biological scientist, sociologists and others. And practical men who say to have no patience with theories whatsoever are guided by the theories of yesteryear, as J.M. Keynes pointedly observed.

In recognition of these facts, IICA was mandated to contract a paper on the conceptual framework underpinning decision making about technology development, exchange and utilisation in agriculture. This paper is not a stand-alone output, but rather an input into the March 1990 conference which is to mark the beginning of IICA's programme.

The present paper takes a systems perspective and builds on the knowledge utilisation research tradition established by such as people as Herbert Lionberger, Everett Rogers, Ronald Havelock, Robert Rich, William Dunn, George Beal, Paolo Freire, Anne van den Ban, Uwe Jens Nagel, Jean Darré, Burt Swanson and others. The paper builds further on the work done when the authors were involved in the Research/Technology Transfer Linkages study of ISNAR, the Hague (Kaimowitz, 1989).

The paper looks first at the different implicit or explicit metaphors which are used to think about technology processes. It then sets out to develop an alternative perspective for which much empirical support and reflective practice is available. The perspective is based on a systems approach. Hence the paper considers the agricultural technology system or ATS. The ATS is:

> the set of organisations and/or persons, and the links and interactions between them, which are engaged in, or managing, such processes as the generation, transformation,

transmission, storage, retrieval, integration, diffusion and utilisation of agricultural knowledge and information, with the purpose of working synergically to support decision making, problem solving, and innovation in a given country's agriculture, or a domain thereof. To all intents and purposes, the ATS is synonymous with the Agricultural Knowledge and Information System or AKIS

The paper systematically considers key aspects of the ATS, such as its the structure, processes, prime movers, performance and environment. This analysis takes up the bulk of the paper. It is necessary knowledge for understanding in order to formulate knowledge for action.

With respect to knowledge for action, a crucial factor input for knowledge managers and policy makers, the paper considers

1. major disorders of ATSs, based on international reflective practice;
2. vital qualities of ATSs, based on analysis of high performance systems;
3. leverage points for intervention;
4. a 'soft systems' process methodology for shared learning, analysis and decision making.

The last part of the paper focuses on this methodology as a basis for concrete action in the different countries in Central America. It ends by recommending that IICA set up some machinery for accumulating, integrating and consolidating the experience gained during the implementation of its programme.

IICA AND ITS PROGRAMME II

IICA (the Inter-American Institute for Cooperation on Agriculture), based at San José, Costa Rica, and more specifically its Programme II (the Technology Generation and Transfer Programme), coordinates the implementation of a major donor-supported effort to improve technology utilisation in Central America. IICA has been mandated to develop a conceptual framework using a systems perspective for thinking about existing and improved processes of technology development and utilisation. The present paper seeks to underpin that conceptual framework. It was prepared for the Conference on the Transfer and Utilisation of Agricultural Technology in Central America(????) to be organised in San José, Costa Rica, March 12-16, 1990.

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ABOUT THE AUTHORS

Source credibility has two major dimensions: trust and expertise (Berlo et al, 1966). That is, the source of a message is considered credible by its receiver if that source can be trusted and is considered to have expertise with respect to the subject concerned. How credible are the authors of the present paper? In terms of trust, we probably do not need to worry: we share the concern of Programme II: the need to increase the effectiveness and efficiency of the development, exchange and utilisation of agricultural technology for the mass of small farmers in Central America as a road to both, improving the livelihoods of those small farmers and reaching such national objectives as food security, a sustainable use of natural resources, a greater role of women in the national economy, and a higher demand for industrial products.

We are citizens of the Netherlands, a fairly harmless country since about 1700. It is smaller than Costa Rica.

Our claim to expertise in the subject area is not as straightforward, as can be expected. Both of us have been involved in studies, development projects and missions focussing on the improvement of agricultural technology systems for a good many years (e.g. Rogers et al (1970); Ascroft et al, 1973; Röling et al, 1976; Haverkort and Engel, 1986; Röling, 1986,a and 1988, Röling and Engel, 1989, Röling, 1989; Engel in prep.), the second author with experience in system management and participatory technology development in Chili, Peru and Colombia (e.g. Engel, 1989,a).

Both of us have a good knowledge of, and experience in, the Dutch agricultural technology system (Holland is the third largest agricultural exporter by value after the US and France although it is small (33.6 thousand square kilometers) and heavily populated (375 persons/km^2)). Both of us are involved in ISNAR's Agricultural Research/ Technology Transfer Linkage (RTTL) study (Kaimowitz, 1989) and in the MSc course 'Management of Agricultural Knowledge Systems' (MAKS) of the Agricultural University in Wageningen, and have for many years provided intellectual leadership in the International Course on Rural Extension (ICRE) which is held every year at the International Agricultural Center in Wageningen. One of us has also been involved from its inception in the International Course for Development Relevant Research in Agriculture (ICRA) organised annually by European donors.

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The authors want to express their gratitude to IICA for the opportunity provided them to participate in the exciting work it is undertaking. They want to acknowledge the critical comments and editorial suggestions of Eduardo Lindarte and David Kaimowitz, both of IICA. Cees Leeuwis formulated fundamental criticism, based on his own work (Leeuwis, in prep.) which has hopefully been utilised by the authors in a way which makes the paper more theoretically consistent. Janice Jiggins has made substantive contributions based on her wide-ranging experience with international institutional development and has been kind enough to edit a substantial part of the paper.

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THE AGRICULTURAL TECHNOLOGY SYSTEM
A CONCEPTUAL FRAMEWORK

1. INTRODUCTION

1.1 To start off: An illuminating story

One of our favourite stories features two men on a dark night. The one is hurrying along the pavement when he sees the other searching for a lost object in the light of a street lantern. He stops and asks what the other has lost. Can he help? The man is looking for his car keys. Says he: 'I dropped them near my car but out there it is too dark for me to see anything'.

The story is a favourite because it so admirably shows how scientists and professionals, including ourselves, often behave. When we have to solve a problem we necessarily look for the solution *using the concepts and theories we know*. They shed light, but not necessarily where it is required. Our behaviour is unhelpful when new problems arise, particularly when we are required also to undertake action to solve the problem.
The story is germane to our discourse, as we shall see.

1.2 The area of discourse

Our area of discourse is the agricultural technology system.

> The *Agricultural Technology System* (ATS) is the set of organisations and/or persons, and the links and interactions between them, which are engaged in, or managing, such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of agricultural knowledge and information, with the purpose of working synergically to support decision making, problem solving, and innovation in a given country's agriculture, or a domain thereof. To all intents and purposes, the ATS is synonymous with the Agricultural Knowledge and Information System or AKIS (Röling, 1989).

This area of discourse is new in the sense that the concerted effort to understand and manage the ATS in order to improve existing systems and design better ones, is relatively recent. To our knowledge, the first efforts in this area were Havelock's (1969, 1986 a,b) and Lionberger and Chang's (1970). Notwithstanding their contributions, agricultural developers, planners and policy makers have continued to be inclined, partly for reasons of institutional politics, to consider farming systems, extension, agricultural technology development, research and policy making as separate spheres, each with its own sets of issues, managed by groups of researchers and professionals who overlap only marginally.

It is only recently that the emphasis has shifted to *linkage*. Interest in linkage between Research and Extension (R&E) (e.g., Kaimowitz, 1989) and between farmers and research (e.g., Merrill-Sands and McAllister, 1989) was preceded by increasing practical recognition that the elements of the ATS should be more closely integrated and coordinated operationally if they are to realise their synergetic potential. Thus Farming Systems Research (FSR) seeks to provide information from and about farmers to technology developers to improve the goodness-of-fit between agricultural technology, on the one hand, and the motivation, knowledge and capacity of farmers, on the other. Increasingly, the need for linkage between Farming Systems Development (FSD) and extension is seen as an essential ingredient in successful research utilisation (Friedrichs, 1989). The Training and Visit (T&V) system of extension has sought to operationalise a strong and regular link between R and E (Hayward, 1989).

There is a historical as well as conceptual progression from looking at various institutions and practices, such as FSD, Extension, and Research, in isolation, to considering the linkages between pairs of these elements, and now to looking at all the elements as an agricultural technology *system*. We need to advance along this path because the needs of policy and management dictate it. We cannot effectively provide answers in today's rapidly changing rural and commercial environment unless we consider the entire technology system.

In taking this perspective in agriculture, we are considerably strengthened by the fact that multi-national industrial companies, public service institutions and others provide comparative experience which supports the systems approach and the notion that knowledge processes can be effectively managed by using such an approach.

1.3 The objective of the paper

Although many agricultural institutions continue to be managed as if they are kingdoms on their own and although the situation in some countries is far from ripe for systems coordination and policy making, the advantages of a systems approach to supporting innovation in agriculture have become too obvious to be ignored. Sufficient instruments for nudging reluctant institutions to coordinate and synergise their activities seem to be available, principally to farmers organisations, national policy makers and managers, and external donors.

IICA has been mandated to develop a systems perspective for thinking about existing and improved processes of agricultural technology development in Central America. The perspective has implications for the conceptual framework and normative assumptions which tend to govern daily practice as well as strategic thinking. As Keynes put it: people who describe themselves as practical men, proud to be uncontaminated by any kind of theory, always turn out to be intellectual prisoners of the theoreticians of yesteryear (quoted by Checkland, 1985).

It is here that the little story with which we started comes into its own. Each of us is inclined to look at technology systems from the perspective of our own 'reality world' (Cantril, 1965). Thus the agricultural economist might consider information as a commodity and implicitly introduce various assumptions based on that metaphor. The agronomist might look at the technology system as a physical or 'hard' system and ignore the intentionality and strategic behaviour of the actors in it. The sociologist might take an inductive approach to the analysis of power and institutional conflict and be reluctant to use a systems framework to guide decisions about how to improve existing technology development and innovation.

The authors have been asked to provide a background paper on an alternative conceptual framework. It seeks to underpin the analysis of, and decision making about, agricultural technology systems in Central America. A paper can never replace the living concepts which are shared and used by those involved in IICA's Programme II.

What the paper can do is to create awareness of some of the issues involved and of some of the alternative ways of looking at them. The paper is, therefore, not so much a 'stand alone output' as an input. It has been written as an input into two processes: (1) the workshop elaborating Programme II (March 1990) and (2) collective decision making in different countries to improve technology systems. Because of this 'input' focus, the paper is not only analytical, but also considers the technology system as a basis for a 'soft systems' approach to shared learning and decision making.

1.4 Outline of the paper

Technology is only one element in the mix of necessary ingredients for agricultural development and technology only plays an important role when the conditions are suitable. We assume in the paper that conditions in Central America call for renewed attention to technology development, exchange and utilisation. Chapter 5 discusses agricultural technology systems in a variety of contextual conditions.

The paper starts off with *analysis of the metaphors* we use when discussing agricultural technology. The dominant metaphor views technology as a commodity, which is produced by research and transferred or delivered by technology transfer institutions. If these fail in their job, technology is seen to accumulate 'on the shelf'. If only transfer and delivery bottlenecks could be removed, adequate technologies would be available for most of the problems agriculture faces today. We deal at length with this metaphor because it introduces various hidden assumptions which seem unhelpful. Because the metaphor is so widespread, we need to tackle it at the start to clear the way for alternative concepts.

The paper subsequently briefly considers what it means to use a *systems approach*. It reiterates some of the approach's strengths and weaknesses. It then describes the soft systems methodology developed by Checkland (1981). 'Hard' systems are physical systems for goal seeking, for which unambiguous objectives can be defined. *Soft systems* deal with 'human activity systems' as the setting for joint learning and decision making. Soft systems are sets of human activities which have been deliberately defined as systems, but often do not have unambiguous goals. In fact, their goals are the outcome of joint decision making and bargaining and might change over time. Relationship maintaining, rather than goal seeking, might be the appropriate characterisation of soft systems

(Checkland, 1985). The soft systems *methodology* provides a path along which those concerned can define their human activity system, decide on what it should achieve, evaluate its present functioning and agree on necessary improvements.

The major part of the paper describes the *agricultural technology system* or ATS. It systematically considers the *major aspects of systems*:

- -Structure (actors, linkages and configurations);
- -Process (knowledge and information processes);
- -Prime movers (what makes the system 'tick'?);
- -Performance and system states;
- -Environment and context.

This part of the paper allows us to draw attention to major variables and generalisations about agricultural technology systems, including some major disorders. These are the basis of some important **DOs** and **DON'Ts** for interventions.

The last part of the paper deals with knowledge management and technology policy.

> *Knowledge management* is the conscious activity aiming to enhance the societal, organisational or individual benefits of knowledge and information, by means of interventions in the technology system; *Technology Policy* creates of the conditions for the effective functioning of the technology system, and for its optimal contribution to overall policy goals.

We move, therefore, to the concerns of practitioners looking for the best ways to intervene to improve matters. Based on a soft systems methodology (developed for knowledge systems by Engel and Seegers (1989) and Van Beek (1989)), we elaborate an iterative process of analysis and choice as an operational guide to the improvement of national ATSs in Central America.

2. COMMON ASSUMPTIONS ABOUT TECHNOLOGY DEVELOPMENT AND DELIVERY[1]

2.1 The commodity metaphor

One of the problems is dealing with technology systems is that we lack adequate language to talk about them. We are usually forced to use metaphors (Dunn, 1986). Technology is most often seen as a commodity which can be 'transferred', 'delivered' to 'users', 'stay on the shelf' and so on. A widely shared scenario has researchers at IARCs and NARs develop the technology, extension services, or preferably 'technology transfer agencies', including media, agricultural education and agri-business, transfer or deliver it, and farmers use it. Technology development is usually seen as so far advanced that if only the existing technology could be applied by farmers in developing countries, many of agriculture's problems could be solved. The fact that many results of research remain on the shelf is seen as caused by bottlenecks in the delivery system, starting with the links between agricultural research and 'technology transfer'.

This scenario has positive spin-offs to be sure, if only because it provokes investigation of R/E and other linkages between components of the technology system. This investigation in turn contributes to our understanding of the processes taking place in technology systems. Thus a different perspective has emerged (e.g. Kaimowitz, 1989), but the lingo lingers .... and with it, the danger that unspoken assumptions enter the discourse. Below, we attempt to make explicit some of these assumptions as a pre-requisite for discussing technology development and use from a systems perspective.

The Commodity Metaphor

Technology is produced by Research, transferred or delivered by Extension and used by farmers. A malfunctioning linkage

[1]) This chapter is based on N.Röling (1989), Why farmers matter: the role of user participation in technology development and delivery, Paper presented at the International Workshop 'Making the Link between Agricultural Research and Technology Use', The Hague, ISNAR, November 19-25, 1989.

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mechanism between R and E leads to accumulation of unused technology on the shelf.

Major implicit assumptions are: (1) farmers are users; (2) a ready-made product is delivered; (3) upstream flows are irrelevant; and (4) technology is a uniform product.

2.2 Assumptions implicit in the commodity metaphor

1. **Farmers are users.** Farmers are seen as 'users' of technology developed by those outside farming reality, instead of as active problem solvers who develop most of the technology they use themselves. Instead of speaking of links between two types of researchers, farmers and agronomists, we speak of linkages between researchers and users or 'consumers', a completely different paradigm. We are not denying that many research-based innovations are adopted by farmers just as Sony Walkmans have been adopted by consumers (Rogers, 1985). But to look at farmers solely as users, analogous to consumers in a market economy, is unhelpful for understanding many aspects of technology development and utilisation.

2. **Delivery of a ready-made product.** Research results in a technology 'product' which sits on the shelf, ready for delivery by transfer agents. This conceptualisation denies the more likely event, that is, that the technology is transformed as it is transferred. Transformation has been shown to continue even during the technology's diffusion among farmers (Basant, 1988). The active role of adaptive researchers, subject matter specialists, extension workers, commercial agents, farmers and other 'actors,' in developing, transforming, consolidating, packaging and integrating technology is ignored in this assumption. But these functions, continuously and iteratively carried out by a multitude of actors, are crucial for successful utilisation in farmers' fields.

The word 'transformation' still suggests that it is the same product which left the researchers' hands that takes on different shapes as it is transferred. But actors on the theory/practice continuum integrate knowledge from numerous sources into new products. The technology that is finally utilised in farmers' fields often bears only a distant resemblance to the technology released by the research station. Language which more nearly captures these processes is that of **integration** of researchers' products into others' dynamic knowledge (Engel, 1989,b).

3. Upstream flows are irrelevant. The perception of technology as a commodity emphasises the flow of information and products 'downstream'. Flows 'upstream' and the transformations of information from and about farmers, are neglected. At best, a commodity is seen to require feedforward for targeting, and feedback for adjustment. But technology development requires a great deal of information from and about farmers, and usually involves active exertion of influence by farmer interests, and frequently the active role of farmers as technology developers in their own right. Instead of a downstream flow under researchers' control, the process in reality involves bargaining, lobbying and other interactive transactions. It is a multi-faceted process. The nature of the process has far-reaching consequences for the performance of the technology system, e.g. its bias to resource-rich farmers. A preponderance of one-way 'downstream' flows can be considered a serious disorder of a technology system.

4. **A uniform product**. When technology is viewed as a commodity, it is implicitly considered a uniform product to be consumed by a large homogeneous mass of consumers. We do not need to explain that especially resource poor farmers on rain-fed land hardly comprise a large homogeneous mass in terms of their technology needs. What's more, the commodity metaphor suggests an emphasis on technology in the form of only one type of product, 'hardware', such as seeds, insecticides. It de-emphasises technology as software in the form of practices, recommendations, ideas, and services. It is one thing to consider only the pesticide in its packet, quite another to take into account the dilution introduced by the farmer, the spraying equipment to which he has access, the role of his wife in carrying the water for the sprayer, the access of his children to the poison, etc.

In brief, the commodity metaphor is specifically wrong in that it misrepresents actual practice and broadly unhelpful in its simplemindedness.

2.3 The marketing paradigm

It is perhaps useful briefly to discuss another paradigm which views technology development from a marketing perspective. In the marketing paradigm, the technology developer seeks to influence farmer behaviour, inducing farmers voluntarily to exchange existing practice by designing and offering products and services the farmer will choose to acquire (Kotler, 1982). A great advantage of the marketing paradigm is that it introduces deliberate client orientation into technology development. If a purchase or the adoption of a technology is a *voluntary* act, inducing that act requires a strong orientation of what the client wants, knows and is capable of (Röling, 1988). Commercial and industrial marketing practice *operationalise a client orientation* as follows:

. segment the potential market into target categories, for whom the product can be considered relevant,
. analysis of consumer characteristics and preferences within a category,
. product testing with intended customers,
. close attention to sales figures as a form of feedback.

On-farm research and farming systems research can be viewed as efforts to introduce such common and proven marketing practices into ATSs. But they typically remain isolated activities, which are not integrated into the total research 'production' process. The operationalisation of a client-orientation has not accepted as necessary in agricultural technology development.

It is interesting to speculate on the reasons for this state of affairs. One likely cause is the widely held assumption that agricultural research is capable of producing useful agricultural technologies (commodities) without recourse to 'market research'. A second likely cause is that the tenets of 'diffusion of innovations' research have become widespread. This has led to the expectation that a technology developed by research will trickle down in a social system. That *stringent conditions* must apply for this to happen is often conveniently forgotten. Everett Rogers (1976) himself has spoken of diffusion of innovations research in terms of a 'passing paradigm' as early as 1976 has, but unfortunately his cautioning has not diffused very widely.

2.4 Other paradigms

In industrial countries, farmers increasingly are seen as business managers, who call in consultants for a fee to solve problems they themselves have identified or to provide specific services. In this view, the problem is defined by the farmer, the initiative is with the farmer and the researcher is there to provide scarce and specialist knowledge and skills to supplement the farmer's problem solving capacities. The farmer becomes the central figure in an elaborate system of knowledge management.

One could even go further and emphasise that the farmer is a technology developer in his or her own right, who needs assistance in how best to develop, test and integrate technology for solving problems, how best to use external knowledge, how best to use resources for innovation, etc.

> An example is a Dutch project to assist medium or small industrial enterprises to develop their capacity to experiment and innovate (Buijs, 1987). In this project, the emphasis was not so much on the delivery of technology from outside, but on teaching businesses how to innovate themselves. Only part of the learning process focussed on using external information. More emphasis was placed on 'human resource development', i.e., on training and capacitating the business itself to define strategies for innovation, to use creative techniques for decision making, and to organise itself so that innovation was given due consideration, in a financially competitive setting.

This approach bears close resemblance to the 'five element model' of rural development often used by Non-Government Organisations (NGOs) (Röling and de Zeeuw, 1983, Röling, 1986; 1989). This paradigm recognises that resource-poor farmers need more than the 'delivery' of agricultural technology from outside. Study of projects which are effective in uplifting the position of resource-poor farmers (Freire, 1973; Morss, et al, 1976; Colin, 1978, Jiggins, 1983) has shown that a combination of the five elements is required, with the fifth element ensuring that the right mix of elements is present at the right time, and that the system is protected from political interference. The *five elements* in the essential *mix for uplifting resource poor farmers* are:

1. organisation;
2. mobilisation;
3. training;
4. concrete opportunities;
5. system management.

The paradigms discussed are germane to our argument. Since many resource-poor farmers in rain-fed ecological niches are unlikely in the near future to benefit from elaborate 'official' agricultural research services, serious consideration is already being given to strengthening the usually already strong tendency of such farmers (e.g. Brouwers, in prep.) to engage in technology development on their own (Chambers and Jiggins, 1986; ILEIA, 1989; Farrington and Martin, 1987; Röling and Engel, 1989).

The above discussion hopefully demonstrates that the paradigm one uses when considering technology development and delivery, determines to a large extent the roles one sees the actors playing in the process. A conceptual systems must take into account the context within which a paradigm might prove appropriate, including the possibility that, in some situations, science-based technology can be seen fruitfully as a commodity.

3. THE SYSTEMS PERSPECTIVE

3.1 What is so special about a systems perspective?

We propose a systems perspective for purposes of analysis, management, simulation and improvement of existing systems and the design of better ones. Our perspective needs explanation, not because readers would be unfamiliar with systems approaches, but because they are likely to be familiar to them in different ways.

> A *system* is a construct created and imposed on phenomena by an observer for a purpose. This construct emphasises that:
> (1) the set of components (e.g., actors) the observer calls a system forms a whole with a boundary, an environment, relationships between the components and a 'mission', or 'performance' which we attribute to the set of components;
> (2) the set of components as a whole has certain system states, such as a degree of entropy or disorder, or a degree of synergy. *Synergy* means that the combined contribution of the components to the 'mission' of the system is greater than the sum of the individual contributions (simply, the total is more than the sum of the parts);
> (3) the set of components has structure and process. In the absence of
> (4), prime movers, the system is likely to move from a state of synergy and high performance towards a state of entropy and low performance. Synergy is not a sufficient condition for high performance. Other necessary conditions include the nature of the resource input, the nature of the environment, the capacity of the system.

A systems perspective is useful because, compared to a Cartesian reductionist approach, it stimulates a global view, emphasises model building, is suited to the analysis of complex phenomena and can be expected to provide tools for policy, management and operation (Hurthubise, 1984). Although the elements of the system can be looked at separately in a reductionist fashion, some essential *'emergent properties'* (Checkland, 1981) become apparent at the systems level which cannot be seen by reductionist analysis. A car is more than a heap of spare parts.

A systems approach is complementary to reductionist analysis and makes a claim to a contribution of its own. But this does not negate the contribution of reductionist analysis. Systems thinking can be expected to stimulate deductive reasoning. It needs to build upon painstaking inductive reasoning.

Our approach can be classified as *'soft systems thinking'* (Checkland, 1981 and 1985; Holt and Schoorl, 1989).

> Instead of dealing with concrete systems in the real world, which can be engineered, simulated and otherwise manipulated through powerful techniques for goal seeking, we emphasise a complex world which can be explored by using system models which are intellectual constructs shared among professional practitioners. A major goal is learning and analysis. Such shared analysis and learning lead to ideas which guide decision making by those involved, in order to improve or design the real world events they have agreed to call a system. Comparative analyses in widely differing circumstances can be helpful in developing and accumulating such ideas.

Our systems perspective, and the expectation that greater synergy is a necessary condition for improved system performance, made us aware of the need for *system management*, i.e.,

> the need to coordinate the activities of the components of the system, to create linkage mechanisms at crucial interfaces between components, to create components to fill gaps, to manipulate prime movers to avoid disintegration, etc. Such system management implies (i) a working model of the empirical system in question, (ii) a system management information system and tools of analysis, (iii) instruments for intervention, and (iv) some idea of the desired direction of change of the system.

At this point, we must clearly distinguish between *empirical* and *normative* uses of systems. The systems perspective is, first of all, a tool to look at empirical phenomena. If models are built as a result of such empirical research, they contribute to knowledge for understanding. However, where the attributed mission of a system is usually an outcome of a human purposeful activity, increased understanding of factors that affect the performance of the system leads to knowledge for action. We acquire diagnostic, strategic, operational, instrumental and evaluative information. Hence the body of knowledge soon takes on normative, practically useful, properties. It is from this perspective that we can speak of system management. A system manager would typically utilise knowledge for action provided through system research.

The term 'system management' easily suggests a single management or directorate which controls all the actors in the technology system. In a commercial corporation, for instance, the central research laboratories, the various R&D departments in the different production companies, production itself and marketing, all fall under central management. Central management ultimately controls the incentive and disciplinary structures throughout the corporation.

This is by no means the case in most ATSs. Typically, various ministry departments, university laboratories, commercial agencies, farmers organisations and other actors at different levels have little reason to work together or coordinate their activities. We do not argue for a single central system coordinator of national ATSs. But we do contend that ATSs, to be effective, do need coordinated, integrated and consistent action. They need to build a deliberate balance of powers between various actors. They need a shared philosophy in which all actors recognise their own and mutually complementary positions, and they need to develop a shared set of objectives.

3.2 Agricultural Technology Systems

The systems approach to trying to understand and affect the complex phenomena associated with knowledge and information in agriculture, has grown upon us slowly over a number of years (Haverkort en Engel, 1986; Röling, 1986,b;1988). Extension science used to focus on two interfaces: farmer/farmer communication (diffusion of innovations) and farmer/extension communication. We analysed them by using models relating dependent and independent variables. We focussed especially on communication methods in an effort to help technically trained field workers become more effective, adding 'people knowledge' to their existing 'farm knowledge'.

Our interest in the inequitable effects of untargeted extension and autonomous diffusion (Röling et al, 1976) led us to look for ways to direct extension efforts towards resource poor farmers. At that point, our focus on communication methods failed us. We had to take into consideration the technology development process and farmers' countervailing power ('user control'), in order to understand the implementation and impact of targeting.

We now had to consider three elements and their interfaces: farmers, extension and research. We were no longer talking about transfer of technology through clever use of extension methods. We had realised that flows 'up' the system were as important as flows 'down' the system. Extension came to be viewed as a highly strategic and anticipatory activity. We learned much from marketing.

It is at this point that we began to develop a systems approach. Research, extension, education and farmers could be seen as components of a system with a 'mission'. The shared mission, knowledge utilisation, required a high degree of synergy between the components for its achievement. It became clear that a comparative study of knowledge systems in agriculture, industry, health, and other sectors would enable us to build guidelines and tools for policy and management. We began to speak of a generalised model of a knowledge system, borrowing heavily from people such as Herbert Lionberger (1986), Ronald Havelock (1969), Robert Rich (1981), Everett Rogers (1985; 1986), Burt Swanson (1986), Hugh Bunting (1986), George Beal et al (1986), Anne Van den Ban (1988), Uwe Jens Nagel (1981), Paolo Freire (1973), Jean Darré (1985) and others who preceded us. Soon our initially crude conceptualisation began to develop and grow. Figure 1 illustrates our first, rather simplistic, model of the ATS:

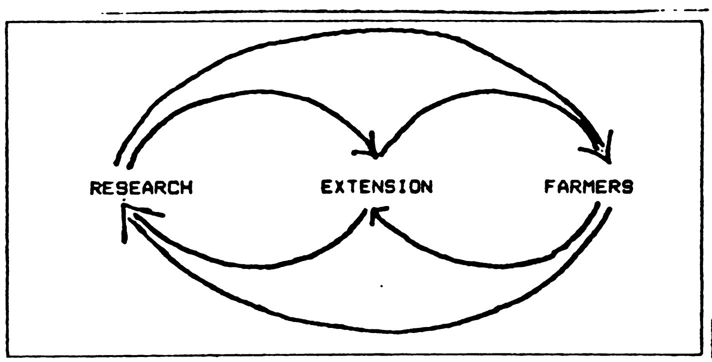

FIGURE 1: AN EARLY, SIMPLE MODEL OF THE ATS

We now distinguish the following aspects of technology systems:

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1. structure: the system's actors, the interfaces and linkages between them, the patterns in which they are arranged. The system's resources and other attributes which affect how interactions between components take place. The segmentation into domains such as political entities (e.g. provinces), sectors (e.g. livestock), commodities (e.g. mushrooms), or farmer groups, for which (semi-)autonomous (sub-)systems operate.

2. process: basic knowledge and information processes, such as generation, transformation, storage, retrieval, dissemination, integration, diffusion and utilisation and the functional differentiation and integration between actors as they engage in these processes. When dealing with process, we shall see that we lack terminology to discuss 'upward' knowledge and information processes, although we know that information and influence from and about farmers are vital in effective technology systems.

3. prime movers: management, policy, user control and other prime movers create the necessary conditions for coordinating the components and increasing the synergy of the system. The focus on prime movers ensures attention to the political, economic and other forces which make the system 'tick'. Without prime movers, the system tends towards entropy. We shall explicitly consider the following *prime movers*:

- Farmers organisations;
- Policy makers;
- Managers;
- Commercial companies;
- Foreign donors;
- Non-Government Organisations

4. performance: It a characteristic of soft systems that their objectives are the result of a decision and not an inherent property of the system. Performance is often not easy to measure. What's more, the performance of the ATS can not be understood in isolation from its economic context. The term 'induced innovation' introduced by Ruttan and Binswanger (1978) emphasises the powerful role of external conditions. But performance is closely linked also to system states, such as synergy and entropy. In some of the studies in which we have participated (e.g. Kaimowitz et al, 1989, the World Bank's effort to write a policy document for extension,

e.g. Hayward, 1989) the following *performance criteria* have been used:

(1) availability of new technology;
(2) relevance of the new technology to various categories of users;
(3) the ATS's adaptability in changing conditions;
(4) the ATS's situation specificity; and
(5) the ATS's economic and institutional sustainability.
Performance measures must be sensitive to unintended consequences such as the squeezing of resource-poor farmers and ecological threats).

5. environment: the system belongs to a larger whole, the agrarian system or economic system, from which it receives inputs and to which it contributes outputs (its performance). It is extremely important to consider the ATS in its environment. Changes in economic incentives strongly affect the processes in the ATS. Trying to explain their functioning only by their internal dynamics would not get us very far (Van der Meer, 1989). System/environment interactions, all have important repercussions for the technology system.

4. THE ANALYSIS OF TECHNOLOGY SYSTEMS

4.1 Introduction

In the section below, we shall examine some of the 'conceptual highlights' of ATSs, following the general systems aspects discussed above: structure, process, prime movers, performance and environment.

4.2 Structure: actors

One of the main questions one can ask with respect to any technology system is: Who are the actors? The actors determine the boundary and nature of the system. There are a number of important observations to be made about the actors in technology systems.

To begin with, we must emphasise that the elements which make up the technology system are actors. We are not, for example, describing cognitive systems in which the elements are ideas, beliefs, etc., as would cognitive anthropologists or knowledge sociologists (e.g. Arce and Long, 1987). Nor are we discussing pure information systems in which the main elements are information carriers, information nodes, etc., as would management information specialists (e.g. Davis and Olson, 1985). We deal with systems in which the elements are actors, i.e., people as individuals and institutional actors capable of self-consciousness, intentional behaviour, strategic anticipation, symbolic communication and other behaviours which usually defy prediction and generalisation.

The earlier efforts to study ATSs implicitly assumed that we are dealing with systems of which the components are institutions such research, extension and so forth. In other words, we always spoke of institutional systems. Engel (1990) has suggested that such institutional knowledge systems are a special case of a general phenomenon. Individuals are single knowledge systems. Knowledge is a factor input, i.e., it continues to exist even though it is used. But it is continuously transformed as people acquire new knowledge, re-integrate knowledge, etc.

Individuals are often part of knowledge networks. Multiple knowledge systems are collectivities in which not all actors are connected directly. Some multiple knowledge systems can be called institutional systems, when the system is clearly segmented and when each of the segments has relative autonomy. This way of looking at knowledge systems has considerably broadened the viewpoint. It allows, for example, for the analysis of farmers and their technology development, exchange and utilisation activities as 'indigenous knowledge systems', which are relatively isolated from government research and extension institutions (e.g., Brouwers, in prep.). In the present paper, we shall especially consider institutional knowledge systems.

But we are running ahead of developments. The first efforts to describe technology systems not only focussed on institutional knowledge systems, they also focussed on only three institutions: agricultural research, extension and education. Farmers were left out altogether. In the Netherlands, for example, where the members of the structures supporting agriculture have always been aware of the important role of Research, Extension and Education, it is customary to speak of the 'REE triptych' as the key explanation of Holland's efficient farming industry.

Havelock (1986,b) also leaves out farmers when he describes the American ATS:

> The oldest, most elaborate, most ambitious, and arguably most successful effort to develop a structured macrosystem for knowledge development and use has been going on in agriculture in the United States over the past 100 years. The Land Grant universities, their experiment stations, and the Cooperative Extension Service together comprise a coherent and well-coordinated system for the generation, transmission, transformation and utilisation of scientific knowledge about agriculture, home economics, and to some extent, community development and youth development. These truly amazing feats of knowledge production and use are realised through an elaborate sequence of institutions and mechanisms, partly consecutive in mission, partly redundant. It includes some unique institutions and roles such as the extension specialist and the county agent who act as linkers and boundary spanners between the worlds of research and development and the world of routine everyday practice.

Notice that Havelock, although speaking of 'use' as a function of the system, does not include farmers as actors in it. Yet his 1969 'linkage model' based on a study of some 4000 publications about knowledge utilisation, does feature 'the user community' (see Figure 2).

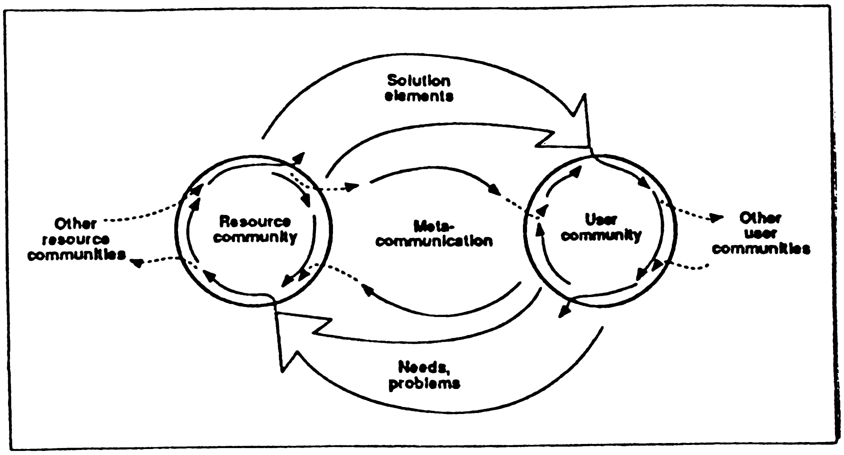

FIGURE 2: HAVELOCK's LINKAGE MODEL (Havelock 1969)

The linkage model integrates three different traditions of the study and theoretical formulation of knowledge utilisation:

(1) the diffusion of innovations,
(2) R&D in industry and
(3) human problem solving.

It was the third tradition which contributed the 'user', described as an active problem solver, to Havelock's linkage model (Havelock, 1969). The linkage model became the basis for new ideas about knowledge utilisation. Also our work builds on it. The basic model posits a certain relationship between the actors in the model: it is not a one-way flow or transfer but a two-way, interactive relationship. Both flows are essential for the performance of the system.

Uwe Nagel of Berlin's Technical University (1980) was one of the first explicitly to develop a theory of the agricultural institutional knowledge system. His work is based on Havelock's linkage model. He does include farmers as actors. But with the benefit of hindsight, his model can be said to be rather simplistic. Researchers are said to generate technology, extensionists to transfer it and farmers to use it.

It took time to realise that Research also utilises and transfers, that Extension also generates and utilises, and that farmers do not only utilise technology generated and transferred by R and E. In fact, all agricultural technology used by farmers before, say 1850, was mainly farmer generated, as is most technology used by farmers today. Farmers are also actively involved in transfer (e.g. in the diffusion of innovations developed by themselves as well as by researchers and others).

> A good *example* is the 'Green Revolution in Africa', as Hugh Bunting from Reading University (1990) likes to call it. Maize, cassava, beans, tobacco, potatoes, tomatoes, and chilies, which now are central to the 'traditional farming systems' of most African countries, spread autonomously, i.e., without government research and extension services, after their introduction from Latin America by the Portuguese, Arabs and Spaniards from the 15th century onwards. It is one of the most dramatic examples of farmers' roles as adaptive researchers and transfer agents.

In other words, we realised (Engel, 1989,b) that all actors in the system engage in all the basic technology processes. We shall come back to this issue when we discuss process in the next section. Suffice it here that our new ideas about functional differentiation between the actors in the system cleared the way for recognising that a great many different actors can play important roles in it. Thus NGOs can be crucial in empowering people to 'pull down' government services. Commercial agents can play vital roles in transferring hardware. Farmer organisations can be indispensable when it comes to advocacy of farmers technology needs in research programming. And so forth.

A special role is played by policy. Is policy a part of the technology system or not? It is possibly helpful to borrow a leaf from experience in industrial production. It is customary for large multi-national companies to assess the R&D implications of business strategy, as a vital input to research programming. The industrial technology development path has been described as follows (Bruin and Okkerse, 1989):

- assess R&D implications of business strategy;
- formulate the research programme;

- the actual R&D process;
- transfer of R&D output to companies.

According to this view, the technology development process does not 'start' with research, but much earlier, when policy decisions are being made about the technology implications of general policy, when strategic investment into research, extension and other infrastructure is being decided, and when research programmes are being formulated. It seems to us, that, put this way, policy makers are crucial actors in the technology system.

The large number of possible actors in the technology system implies that it is impossible to generalise about the composition of institutional knowledge systems across widely differing situations. In some conditions, few institutions might exist, which engage entirely or partly in technology processes. In other situations, one can speak of institutional complexity. Further, the inclusion or exclusion, of actors in the system is, to a large extent, a matter of agreement (soft system approach) among the actors themselves. It means that **the technology system must be locally defined** (Van Beek, 1989).

4.3 Structure: linkage and interface

The essence of a system is that it is not just an arbitrary collection of floating actors. The essence is that they are integrated into a whole which is capable of a performance which none of the actors is capable of alone. As Engel likes to put it (Engel, in prep.): diversity and integration together make strength for synergy. It is therefore crucial to consider the *linkages and interfaces* in a technology system.

> A *linkage mechanism* is a concrete procedure, a regular event, arrangement, device or channel which bridges the gap between components of a system and allows communication between them. Although in computer terminology, "interface" is used for a "device linking two systems" (Hurthubise, 1984), it is preferred here to use "*interface*" for the relational "force field" between two institutions. The linkage mechanism is the device which operationalises the interface.

In some countries, the research institute's annual report -often published late or not published at all- is still virtually the only official linkage mechanism between Research and Extension. In others, much has been done in recent years to increase the number of linkage mechanisms and improve their effectiveness. Generally speaking, the greater the number of linkage mechanisms, and the greater their span within the administrative hierarchy, the better the chances that effective linkage occurs. A typical example of a structure with multiple (and partly redundant) linkage mechanisms is the Ghana Grains Development Project:

1. *A survey carried out jointly by research and extension staff*: at the beginning of every cropping season, a team of breeders, economists, agronomists and extension staff pay informal visits to farms and ask questions about farmers' problems. The answers are used to draft a questionnaire and, on the basis of the results of the questionnaire, research projects are formulated for that year.

2. *Quarterly meetings of the members of the on-farm, economic and extension programmes*: discussion at these meetings centers on current trials and surveys and on the plans for the following quarter.

3. *Annual Reports*: published quarterly, annual reports describe the various research programmes and their results. These reports are intended mainly for a scientific audience.

4. *An annual workshop*: at this workshop all the year's research and extension activities are presented to a large audience. It is attended by members of the technology system from all parts of the country and by representatives from foreign research institutes.

5. *A pre-workshop meeting*: before the annual workshop all senior officers of the project meet in order to transform research findings into recommendations. A committee is charged with the responsibility of turning the recommendations into comprehensible language for use by extension officers and literate farmers. The result is a booklet entitled *Maize and Cowpea Guide*. The booklet is updated before every workshop, to keep abreast of current findings.

6. *Training programmes*: research officers of the project explain in detail the latest recommendations on the crop to field agents, who are organised in groups according to

agroclimatic zones. Issues encountered in the field are raised by the field agents.

7. *Field days*: these are organised three times during a planting season. Research officers normally participate, thus gaining first hand experience from both the farmers and the field extension workers (Annor-Frempong, 1988).

In a country such as the Netherlands, where the agricultural technology system is said to function effectively, linkages are often highly redundant. The same actors reappear in different roles, there are a great many cross-linkages, and meetings, various farm journals and other mechanisms disseminate consistent information. In this system, informal communication plays as important a role as formal communication. In all, one can say that such a system is characterised by redundant, multiple formal and informal networks, with a shared culture, a perceived commonality of objectives, and a 'corporate' ideology with respect to the functioning of the technology system. These cultural aspects are actively promoted by management and policy makers.

Wilful imposition of a specific linkage mechanism, say a research/extension liaison committee, is no guarantee that effective linkage occurs. Status differences, unspannable gaps in education, different professional perspectives between research and extension, conflicting incentive systems, institutional conflict and many other factors can make a ritual out of centrally imposed formal linkage mechanisms. Such mechanisms must be appropriate to the characteristics of the interface.

It is our experience, backed up by careful field research both in industrial (Wagemans, 1987) and in developing countries (Blok and Seegers, 1988, Wijeratne, 1988), that it is often difficult for management to know what is actually happening in the field. the implementation of decisions taken at the top often flounders in the morass of strategic 'survival' behaviour of field workers (e.g. Leonard, 1985). For instance, a T&V system, existent on paper and officially adopted by policy and management, might not exist if one looks at the field level where it ought to be implemented.

An example: In Sri Lanka, the T&V system had been adopted formally for some time. A component of the system is the regular (fortnightly) transmission of information from

> research to extension, to be used in the following fortnight by village level workers in their contacts with paddy farmers. In practice, farmers are engaged in different operations at different times. They are not all working on the same problem within a given fortnight. Some of the information is not useful for some of the farmers. As a result, the village level worker becomes an active information processor, selectively storing what he considers useful for later use, discarding what he cannot use, and telling farmers what he feels necessary, exactly as he has done in the past. Instead of the intended simple task of transferring fortnightly chunks of ready-made information, extension work continues to be a highly decentralised activity. The effect is determined largely by the motivation and the inventiveness of the VLW. Since this process is not recognised in the formal T&V system, there is no effort to help VLWs, for example, to store and retrieve information (Wijeratne, 1988).

Most of the processes which are relevant for a technology system occur at the interfaces between actors. It is for this reason that it has been said that the management of complex phenomena boils down to interface management. Annor-Frempong (1988) and Van Beek (1989) have used this idea in developing the **interface matrix** as a tool for knowledge management. The coordinates of this matrix feature the actors in the local technology system.

	1 PRODs	2 FACTs	3 AGBUs	4 TEACH	5 AI+HR	6 LIBRA	7 SPECI	8 HIERA	9 RESEA	10 EXEEN
1 PRODs	X	1a	1a	3c	2b	3c	2a	1a	2a	1a
2 FACTs	1a	X	2c	3d	2d	3c	2a	2a	2a	1a
3 AGBUs	1a	3d	X	2b	2b	2c	2a	2b	2c	2a
4 TEACH	2b	3d	2b	X	2b	3c	2a	2b	2b	2b
5 AI+HR	1a	1a	2b	3b	X	3c	1a	1a	2b	1a
6 LIBRA	3b	3c	3c	3a	3c	X	2a	2c	2a	3a
7 SPECI	1a	1a	2b	2c	1a	2a	X	2b	1a	1a
8 HIERA	2a	2a	2b	3b	1a	2c	1a	X	1a	2a
9 RESEA	2a	2a	2a	2a	2a	1a	1a	2a	X	1a
10 EXTEN	1a	1a	2a	2b	1a	3c	1a	1a	1a	X

The actors are: producers (PRODs), dairy factories (FACTs), Agri-businesses (AGBUs), teaching and educationists (TEACH), Artificial Insemination and Herd Recording Section (AI+HR), libraries (LIBRA), specialists (SPECI), the hierarchy (HIERA), research (RESEA) and extension (EXTEN).

The X refers to internal structure of the actor and to processes within it.

The figures in the cells refer to frequency of use: 1 = frequently used, 2 = occasionally used, 3 = not used.

Letters in the cells refer to degree of importance: a = very important, b = some importance, c = potentially important, d = not important.

The creation of a matrix can be used as a tool in a soft systems approach: the definition of the actors and the evaluation of the each cell in terms of importance, frequency of use, ease of control by the manager and so forth, is done together with those involved.

FIGURE 3: THE QUEENSLAND DAIRY ATS (Van Beek, 1989:58)

Each of the cells in the matrix therefore represents an interface between two actors in the system. This simple matrix helps in the systematic assessment of each interface in terms of importance to system performance, benefit/cost, required management attention, etc. Figure 3 provides an example of the matrix for the Queensland Dairy Technology System.

The creation of a matrix can be used as a tool in a soft systems approach: the definition of the actors and the evaluation of the each cell in terms of importance, frequency of use, ease of control by the manager and so forth, is done together with those involved.

But an interface matrix is a poor representation of the configuration, or network of the actors in the technology system. A classic in our field is the study of the Taiwan ATS by Lionberger and Chang (1970). They wrote of the 'institutional calibration' of the science\practice continuum. Instead of simply distinguishing Research, Extension and Farmers as the three main actors, they write of a continuum along which different actors, such as research institutes, experiment stations, adaptive research farms, specialists, extension workers, and different types of farmers,each play their roles. If technology is to flow smoothly from one part of the technology system to another, this continuum must be finely calibrated. The simple sequence, research-extension-farmers, is too course. It leaves unbridgeable institutional gaps. It does not allow for the 'scaling down' required to bridge the gaps between institutions.

The scaling down can be compared to the transmission of a car. To be driveable, a car needs several gears, representing different speeds which must be used in sequence. The gear cogs are designed to allow smooth transmission from one speed to the next, but linkage mechanisms (synchronisation, double clutching) are required to bridge the speed gaps between the cogs (Röling, 1989). The institutional calibration of the continuum requires both 'cogs', i.e., intermediate institutions, and 'linkages', i.e., mechanisms to facilitate interaction and communication between these institutions.

4.4 Structure: Domains

A question which quickly pops up when trying to define the local technology system is: what is the domain we are talking about? Is it the national system, the system in a province, or in a certain sector or sub-sector, or even in a branch? It is impossible to answer that question unequivocally.

> We define *knowledge domain* as an area of concern in a technology system, e.g. 'edible oils and fats' in a major multi-national food processing company, 'mushroom production' in a capital intensive horticultural industry, soil erosion, or farming on the Adja Plateau. Technology system components, e.g. disciplinary research institutes, branch organisations, specialists and farmers, are clustered around such a domain. Domain segmentation, organisation and coordination are vital aspects of technology system management. In a domain, the capacity to generate, transform, integrate, exchange and utilise knowledge is organised to serve a certain industry, a certain category of producers or a certain product. This description holds especially at the 'downstream' end of the science-practice continuum where farmers, specialists, extension workers, specialised journals, adaptive and applied research often cluster in 'self-aware' wholes with elaborate linkage mechanisms and informal networks. At the 'upstream' end of the continuum, domains might be defined in terms of branches (e.g. arable crop production) or even disciplines (e.g. phytopathology).

In other words, the way in which the technology system is carved up into organisational clusters varies as one moves 'down' the continuum, from discipline, to branch, to industry, category of producers or product. At the interfaces between these clusters linkage problems can occur. Thus the same discipline can serve different branches, and one branch can serve different industries, types of farmers or products.

Usually, high value export crops constitute specialised domains, served by an elaborate cluster of knowledge institutions. Food crop production often has to do with much less, unless considerations of food security have led to heavy (often temporary) investment in specialised technology systems. Partly because it is difficult to collect levies on food crops, food crop production often lacks adequate institutional elaboration of the technology system. This holds especially for non-grain crops.
It often proves difficult to shift resources between domains, even if diminishing returns begin to characterise investment in the well-endowed domain, and investment in a less well-endowed domain promises high pay-off.

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The manner in which domains are segmented is arbitrary and varies enormously per country. There is not one optimal solution. Instead, different arrangements can produce equally satisfactory results. Yet typical problems recur.

One example is provided by the Turkey ATS some years back. A T&V type extension system was organised on a geographical basis, served by a research system organised on a commodity basis. Thus a provincial research institution focussed on a specific commodity, and was not able to backstop subject matter specialists in the range of the problems and industries which are typical of the province.

Another example is provided by Queensland, Australia, where the technology system is divided into domains consisting of branches, such as the Beef Cattle Production Branch, the Pasture Improvement Branch, the Veterinary Services Branch and the Economics Branch. In this case, the fracture occurs at the farm level. A beef producer might require the services of all the three Branches mentioned. Special linkage mechanisms, such as 'Industry Groups' and 'Regional Extension Leaders' are required for coordination between branches (Röling, Jiggins, and Carrigan, 1987).

4.5 Process: actors' activities

Process here refers to the activities of actors with respect to knowledge and information. Usually, such processes as information generation, transfer, diffusion and utilisation come to mind. But, as we have seen, we consider transformation, integration, storage and retrieval, selection, consolidation and others equally, if not more important. The extent to which the emphasis on 'transfer' and 'adoption' have predominated at the expense of other processes, is in fact, remarkable and damaging. We have, for example, no agreed definition of the transformation processes which take place, as research findings are 'translated' into recommendations, and from these into extension messages (Röling, 1988).

Many authors have tried to define the required sequence of cogs on the science-practice continuum in linear terms, describing the 'functions' or 'steps' or 'stages' which must be performed (e.g. Beal and Meehan, 1986; Havelock, 1986a,b; Lionberger, 1986, Rothman, 1986). In most cases, they have described only downstream sequences, using terms such as: 'basic research', 'technology generation', 'technology testing', 'technology adaptation', 'technology integration', 'dissemination', 'diffusion' and 'adoption' (McDermott, 1987, see Figure 4). McDermott, however, clearly distinguishes between these processes and the actors, the existing institutions for Research and Extension. He claims that the formal responsibilities conventionally assigned to existing Research and Extension organisations may leave a 'fatal gap':

> In even the best of cases, research often stops midway through the testing process. Testing is not finished until it is done in the system in which the technology is expected to perform. At the other end of the continuum, extension does not expect to start until the dissemination function. The seriousness of the gap is apparent.

The presumed gap is often exists in reality. A typical Ministry may recognise three basic policy instruments: Research, Extension and Regulation. The Research Division focusses on publications as their main product. It is for these publications that Research is rewarded. However, scientific publications do little to promote technology transfer. Extension provides services and disseminates innovations. The gap here is obvious: there is no institution or actor assigned to the 'development' function, i.e., which transforms research results into recommendations which farmers can use. The lack of the development function might be clearly felt in the field, but this lack does not automatically translate into budgets and facilities to support it, let alone that staff is rewarded for carrying it out.

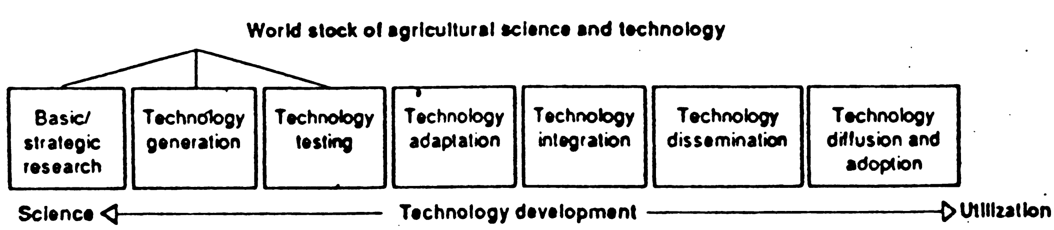

FIGURE 4: McDERMOTT's ATS FUNCTIONS (McDermott, 1987)

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McDermott continues:

> "Farming systems research is providing an exceptionally effective means by which research can move into that gap from its end of the process and effect the interaction with farmers. As of now, extension has not made a significant move into the gap from its end of the process".

Various types of institutional go-betweens, such as subject-matter specialists, or technical liaison officers and supporting staff, are currently developing to bridge the gap. The job descriptions of these go-betweens are still evolving. Their main functions are: to maintain liaison with research so as to keep abreast of new technical development and help translate field problems into researchable questions; to establish links with suppliers as so to improve chances that inputs are available; and to provide technical support to field staff and pick up field problems from them. Important functions of technical liaison are adaptive research, training, developing reference materials and training aids, trouble shooting and responding to requests for help from extension agents.

If any thought has gone into function and functional differentiation, it is usually focused on what happens as one moves 'downstream' from research to farmer. But no attempt has been made to name the functions to be performed in transforming the needs of farmers into research questions and in bringing farmer influence to bear on research programming. Clearly we have little insight as yet into bottom-up flows of information. This state of affairs reflects current practice. It is often difficult to get even minimal funds and time allocated to the process of learning from farmers who might positively influence the priorities and programmes of experiment stations (Biggs, 1983 and 1989).

4.6 Process: data, information and knowledge

Clearly there is a relationship between structure and process, in the sense that certain crucial processes, or bundles of activity ('roles'), require certain actors if they are to be performed. These actors typically play bridging roles.
However, a focus on actors playing roles and performing activities would over-emphasise process as a function of actors, while, for many processes, it is more useful to consider process as a function of an interface between actors. To explain this further, we must

go right back to the essence and look at data, information and knowledge as the basic ingredients in technology systems.

Data is input from the environment via sensory organs. *Information* is data that have been processed into a pattern which is meaningful to the recipient and is of real or perceived value in current or prospective actions or decisions (Davis and Olson, 1985). Information, therefore, has a subjective nature: it anticipates its receiver. Data can, of course, be deliberately patterned to be informative for a receiver by a sender.

Knowledge exists within people ('between the ears') and cannot be transmitted. Knowledge is the 'personal reservoir' through which meaning is assigned to information. Knowledge can be encoded into information, and information can be decoded into knowledge.

Engel (1989,b) has made the following distinction between the three basic ingredients and the processes associated with each:

data	information	knowledge
collection	production	generation
storage	gathering	acquisition
retrieval	selection	validation
transfer	storage	integration
destruction	retrieval	consolidation
processing	exchange	utilisation
elimination	processing	encoding
	diffusion	
	decoding	

In other words, some processes refer to knowledge and can, therefore, be expected to take place within an actor. Others typically refer to data or information and can, therefore, be expected to occur at interfaces between actors.

4.7 Prime movers

A systems perspective can easily lead to emphasis on 'squares and arrows', structure and mechanics, without consideration of the dynamics, which make the system 'tick'. Sims and Leonard (1989) have pointed out that strong incentives exist in technology systems which lead them to be unresponsive to needs of farmers, especially resource-poor farmers.

Why should research institutions and extension services collaborate? Why would any autonomous institution coordinate its activities with that of another for that matter, and lose freedom of manoeuvre? Why would Research and Extension choose to be client-oriented and target their work on the needs of farmers, who have little to offer them, while the power to reward them is more usually in the hands of their peers and superiors?

Most human service organisations are typically characterised by sharp fracture lines between service personnel, management and policy makers (Kouzes and Mico, 1979), often leading to rituals which are intended to maintain freedom of manoeuvre of service staff while perpetuating myths and erroneous beliefs at the top about what is happening in the field (Wagemans, 1987). It is not uncommon for technology systems to show complete lack of correspondence between what the system is formally said to do and what is actually happening in the field. This gap is only made more serious by the weakness of Management Information Systems in ATSs. In South and South East Asia, for example, information can only come from someone with a higher status, which means that information from the field has a hard time to flow up the system (Blok and Seegers, 1988).

> The anecdote about the decision by President Suharto to adopt Integrated Pest Management as the national policy for plant protection in rice in Indonesia, is illustrative of the situation. He did not hear about the alarming destruction caused by resistant Brown Plant Hoppers from his Ministry of Agriculture. In fact, the officials had only reported that all was well. He heard about it informally by the fact that the rice crop in his native village was a complete failure as a result of the infestation.

With such a plethora of chances for an ATS not to gel, not to move towards synergy, it is small wonder that Sims and Leonard speak of '*default*'. It calls to mind the computer science meaning of this term: unless you do something, the default value will pertain. The technology system will not function as a system, unless special forces, prime movers, create pressure for the system to function as a system. As such, Sims and Leonard mention farmers' organisations, management, policy, commercial companies and foreign donors. We add Non-Government Organisations (NGOs).

We consider these very important contributions. All too often, AKSs are described in terms of their formal linkages and functions without any consideration for the essential dynamics which can explain their functioning. All too often people have mechanistically tried to copy successful systems elsewhere without regard to the political and other operant forces that are essential for explaining the success of the system copied.

An example of reasoning which does take prime movers into account is provided in the following anecdote (Wagemans, pers. comm.): when asked whether farming systems research should become part of an expensive technical assistance project to China's agricultural technology system, the expert replied:

> There are three reasons why I believe FSR would not work in China: (1) decision making is highly centralised, hardly a situation for situation-specific reactions required in response to farming systems information; (2) the technology system is highly segmented into bureaucratic domains, hardly conducive to the inter-disciplinary action required to understand and develop farming systems, and (3) policy aims at national food security in rice and therefore provides no incentives for attention to the diverse industries and livelihood patterns typical for most farming systems'.

Kaimowitz (1989) emphasises that external forces are required to make institutions in the ATS perform. Left to themselves, they cannot come together for synergetic activity:

> Institutions in technology systems must receive strong and focussed external pressure to function synergetically over sustained periods. Without such pressure, institutions and personnel act to fulfill their own social and political needs more than those of their clients, and their effectiveness is invariably reduced.

The point is that prime movers countervail the tendency of bureaucratic institutions to become entangled in their own (re)organisation, to lose focus and purpose and become self-indulgent and propelled by self-interest and bureaucratic convenience, unless pressured from outside, which is crucial to the argument. 'External' therefore refers to forces external to the individual institutions which are to perform synergic functions in the technology system and which are by nature not exposed to market pressures.

It is our conviction, borne out by some evidence (e.g. Rogers, 1986; Blum, in press), that an effective technology system, which has the 'mission' to support innovation in farming and related industry, is best pressurised by *demand and political influence from those who use the technology produced.* But it is difficult to make technology systems operate fully commercially. Especially in developing nations, public services continue to play crucial roles. Hence other than commercial pressures must be sought to provide essential countervailing power.

> Our conviction has led us to proclaim that the quickest route to developing ATSs in developing countries is to mobilise (small) farmers' countervailing power over such systems, for example by giving control over part of the government budget for extension and research to small farmers' organisations, as is current practice in France, Denmark and the Netherlands. However, making that suggestion at a recent (1989) 'Global Consultation on Extension' organised by FAO showed how far most countries still are from taking such a suggestion seriously. Apparently, farmers can not be trusted to intelligently pursue their self-interest and are incapable of realising that research and extension have anything to offer them. All good is expected to come from well-intentioned and benign civil services.

In most developing nations, empowering small farmers to 'pull down' the technology they require seems, therefore, for the time being, to remain the sole responsibility of NGOs which focus on mobilising, organising and training members of small groups of rural people, thus allowing them to make use of opportunities provided. In contrast, most 'official' institutions which form part of technology systems focus almost exclusively on providing external opportunities, they do not develop the capacity of people to use those opportunities. As we shall see when we speak of performance, this leads to one of the great unsolved problems with respect to technology systems.

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NGOs, such as BRAC in Bangladesh, AWARE in India and others which empower very large numbers of resource-poor rural people and help them to play roles in existing technology systems, can be considered as prime movers in their own right. They play key roles in determining whom the system serves and in mediating the influence farmers bring to bear on the system. Where NGOs do not play such roles, it is normally only the more well-endowed farmers who control farmers' organisations, who can influence the technology system. It has been remarked that such influence is better, also for small farmers, than no farmer influence at all. There are some who even claim that the benefits for small farmers of the influence of large farmers outweighs the disadvantages in terms of the inequities introduced into the system by such biased influence. We believe that the outcome depends on the nature of the system and on the time frame one takes. As we shall see when we speak about performance, technology propelled development can rapidly squeeze large proportions of small farmers out of business.

In addition to farmers' organisations and NGOs, other prime movers can also play important roles, although that statement requires some caution. Thus Kaimowitz (1989) observes that *national policy makers* often react to political contingencies (disasters, consumer pressures, food riots, etc) and seldom provide sustained countervailing pressure. International donors can prove very effective in making national institutions gel into a system, but the problem often is that the effort is not sustained and that the withdrawal of donor pressure and resources quickly leads to disintegration. Thus, in Turkey, the only permanent part of the budget of the Ministry of Agriculture is the salary component. All other recurrent expenditures come on the basis of projects. Thus the externally funded effort to introduce the T&V system and related improvements in research are considered as a project to be left when funding stops, and not a structural improvement of the system (B. Wake, pers. comm).

An important category of prime movers are *knowledge managers*. They are most equivocally part of the system itself. They obviously must use other potential prime movers to their advantage, balancing positive and negative aspects of user control, NGOs, foreign donors, policy makers and commercial interests.

But they are also prime movers themselves. By dexterous use of management pressures, they can provide incentives which nudge system components to coordinate their activities. They can create a 'corporate ideology' among a system's actors which emphasises the role each plays in the technology system. Managers have a major influence on the delineation of system domains, and the institutional calibration of the science/practice continuum. Finally, management can, as is the case in commercial companies, greatly affect the extent to which actors in a system are client-oriented. We shall come back to some of these points when discussing knowledge management in a later chapter.

4.8 Performance

> *Technology* is the software and hardware available for controlling the environment for human purposes. The software consists of strategies, procedures, methods and skills. The hardware consists of physical objects such as tools, equipment and genetic material. Technology development can be based on the advance of science and hence on the application of research findings. However, these are by no means the only sources of technology development. Technology is continuously developed on farms, in kitchens, in backyards or in shops and offices, by farmers, tinkers, managers, housewives and businessmen and women. Technology is by no means limited to physics or biology, but includes organisation and management. In fact, we increasingly require technology to deal with human intentionality and organisation. Whatever form it may take, technology is the way by which inputs are transformed into outputs (Fresco, 1986). This very paper can, therefore, be considered an attempt to develop technology for technology transformation and utilisation.

Man's main survival strategy is the utilisation of knowledge. In addition to institutional differentiation and integration, and to improvements in human rights, equity and mutual accountability, the very essence of development is knowledge utilisation and technical innovation. These are supposed to lead to greater control over the environment and hence to efficiency, health, productivity, income, and organisation.

> The *mission* of an ATS is to enable a domain of human activity to optimally benefit from knowledge utilisation and innovation.

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But these desirable outcomes cannot be the direct effect of an ATS. The economic context, such as prices, market opportunities, infrastructure, and resource and capital availability, as well as other factors such as political stability, policy measures, the equity of access to resources, and the level of general education, all directly affect knowledge utilisation and innovation. Therefore, we must specify the contribution of the ATS (Kaimowitz et al, 1989).

The ATS makes available new technologies for use in agriculture. So one important performance criterion is availability. A continuous flow of new technologies is one of the 8 key attributes of an effective ATS identified by Rogers et al (1976).
But the available technology must also be relevant to the various categories of those who use it. This is often a problem when the ATS largely makes available technology which is not relevant to the mass of small farmers in a country. Hence relevance is an important performance criterion.

In turn, availability and relevance can be considered as outcomes of attributes of the system itself which are directly associated with performance. We consider the ATS's adaptability, its situation specificity, its economic and institutional sustainability and its synergy.

We consider *adaptability* largely determined by the extent to which farmers and other prime beneficiaries can exert pressure on the system. But such pressure has to be tempered by the influence of policy which takes the interests of the entire body politic into account. Farmers might, for example, not be highly motivated voluntarily to engage in long-term conservation measures.

Situation specificity is enhanced by decentralisation and domain articulation and clustering at the downstream end of the science/practice continuum.

Sustainability is a crucial issue, especially where donors are concerned. Given the difficulties of measuring the rate of return to investment in ATSs, and especially in attributing growth in agricultural production to research and extension, and in generalising from areas where the rate of return has been measured (say the Punjaab) to other areas with different marketing contexts, (Evenson, 1986), it is difficult to determine the required level of investment in a specific ATS. Other considerations are the extent to which a government can recover foreign loans for ATS improvements through taxes or levies, and the time perspective within which investment in the ATS will pay off. One issue which is often overlooked is that investment in an ATS might lead to increases in production which reduce product prices to a point where previous rate of return calculations no longer hold.

Notwithstanding these difficulties, governments and donors are often inclined to invest in the ATS regardless because of considerations of food security, political stability, or of maintaining the competitiveness of agricultural products in foreign markets.

A special consideration with respect to performance and sustainability is the *carrying capacity* of the domain served. It is one thing to design an ATS for irrigated paddy in South East Asia, quite another to create a capacity to generate appropriate technologies for the highly variable farming systems in rainfed conditions. These farming systems often occupy relative small ecological niches and do not generate large surpluses. In these environments the ATS therefore has to deal simultaneously with both, diversity and low carrying capacity for elaborate institutions supporting technology development. It is for these situations that completely new approaches, such as helping farmers to become better experimental technology developers themselves, have been suggested (e.g. ILEIA, 1989).

Synergy, finally, has been discussed at length before. It is a system state in which the different components of the system gel so that the system acquires emergent properties and the whole becomes more than the sum of the parts. Synergy simultaneously requires, not only functional differentiation and integration, but also balance between actors in terms of influence and power. If researchers have more status and power than extensionists, it is difficult to make them work together. If farmers do not have countervailing clout, chances are the system will not be responsive to their needs, leading to low performance.

By way of summary, we depict the discussion of performance in figure 5.

KNOWLEDGE UTILISATION
AND INNOVATION

AVAILABILITY OF RELEVANT TECHNOLOGY

ADAPTABILITY
SITUATION SPECIFICITY
ECONOMIC AND INSTITUTIONAL SUSTAINABILITY
SYNERGY

FIGURE 5: PERFORMANCE CRITERIA OF THE ATS

An important additional issue to consider is the ATS's tendency to make available technology especially to the top 20% or so of the farmers. In situations, like those often encountered in Latin America, where land distribution is very skewed with, say 10% of the farmers holding 80% of the land, the ATS tends to be pressured by the larger landowners to provide for their technology needs. Such ATSs then produce technologies which are usually not very relevant to the 90% of the farmers who hold the remaining 10% of the land. We shall not discuss here whether this is desirable or not. Many governments believe that national goals are served if 80% of the land is managed efficiently, others opt for serving the 90% of the farmers, for example, because of the costs in terms of loss at elections, poverty, urban migration, political unrest and so on.

Serving both, the mass of small farmers and the major part of the land, requires very careful and strategic design of the ATS. The usual claim that the ATS serves the farmers reflects an ostrich policy. It is the default option leading to an ATS serving resource-rich farmers. Serving also the resource-poor requires a great deal of strategic effort. Such effort involves

(1) providing *opportunities* to resource-poor farmers, for example by careful targeting of technology on various categories of such farmers, and
(2) *empowering* resource-poor farmers to make claims on the ATS, for example by encouraging NGOs to mobilise, organise and train rural people.

It is obvious that such dual policies need to be carefully crafted and strongly defended because, in a highly inequitable situation, the resource-rich farmers are unlikely to allow resource allocation to resource-poor farmers without a fight.

A special mechanism which must be understood when considering the performance of the ATS is *technology propelled development* (Röling,1987).

> When conditions, such as market opportunities, infrastructure, access to credit and inputs, and other elements of the agricultural development mix are favourable, and farmers have unequal access to land, capital, education and so forth, as is usually the case, technology can begin to play a key role in squeezing the relatively resource-poor. The mechanism is largely responsible for the very rapid reduction in numbers of farmers in the European Community in past two decades.
>
> The mechanism is based on the fact that a large number of firms all produce the same product without each individually being able to affect the price of the product. In these conditions it is beneficial for a farmer to produce as much of the product as efficiently as possible. New technology increases efficiency. Larger farmers usually benefit from the technology first because they tend to be the first to adopt. They benefit enormously and reap a pioneer profit because the can produce more, more efficiently at the given price. Soon others also adopt the innovation. As a result, total production increases and prices begin to drop. Farmers ho have not adopted the new technology yet are now compelled to do so, to prevent loss of income. But investing in the technology no longer pays as much as it did the innovators. At the end of the scale, small farmers who cannot adopt the new technology move another notch in the direction of being squeezed out of farming.

This mechanism can be considered beneficial if the aim of policy is an efficient agriculture for purposes of national food security, or competitiveness in the world market. If a country depends on agricultural exports, like the Netherlands does, such competitiveness might even be a condition for maintaining high employment in agriculture. But if a country is faced with large numbers of poor farmers and landless, can offer few employment opportunities outside agriculture for the time being, or has large tracts of vulnerable eco-systems which are threatened by agricultural practices or need to be maintained by local farmers (e.g. mountainous areas), the mechanism of technology propelled development is not so beneficial.

Dealing with this problem is one of the great challenges facing agricultural administrators in many industrial countries, such as France, Switzerland, and Germany, today. The most likely solution lies in creating part-time off-farm employment in rural areas, income supports and other measures outside the purview of knowledge managers and policy makers. Of course, knowledge managers and policy makers can help matters by carefully targeting technology development also at categories of resource-poor farmers but it is doubtful whether such measures can be sufficient in themselves.

4.9 Environment

A crucial aspect of the ATS is its environment. The two extremes of looking at a system are

> (1) to consider the technology system a black box and to be mainly interested in how properties of the economic environment affect the performance of the system, and
> (2) to focus on the internal dynamics and become so carried away that one forgets about the environment altogether. We intend to adopt neither extreme.

A useful way of dealing with the ATS's environment is illustrated in Figure 6 (Elliot (1987):

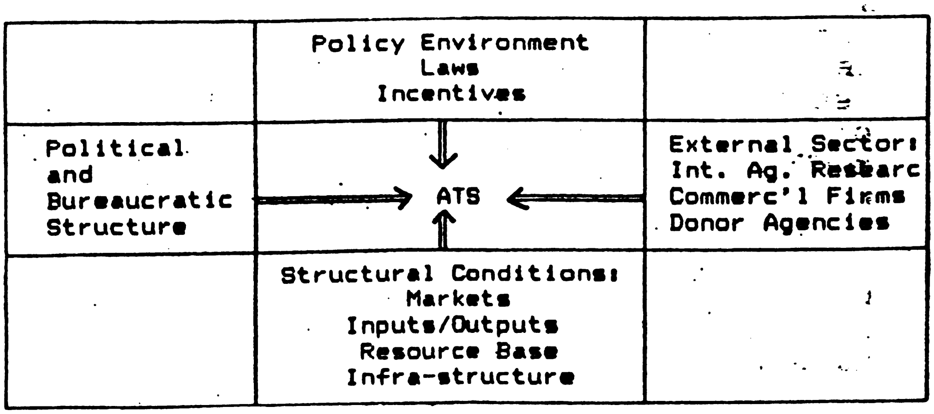

FIGURE 6: THE ATS AS PART OF A LARGER SYSTEM (Elliott, 1987)

The ATS in a particular domain must be examined against the backdrop of:

1. The *policy environment*, which formulates the laws, regulations and incentives that create conditions for ATS functioning and performance;

2. *Structural conditions*, such as markets, inputs, the resource base, infra-structure, the structure of farming, and institutional diversity (e.g. the existence of farmers unions);

3. The *political and bureaucratic structure* through which various groups influence the system, the extent of equity in the system, the power of the farm lobby, etc.;

4. The *external sector*, comprising donor agencies, international agricultural research centers, commercial firms and international NGOs.

As we have seen, policy plays an important role in that it can be considered a prime mover. Policy makers play important roles in creating the conditions within which the ATS can gel and contribute to national goals. This requires that policy makers have some understanding of the role of technology utilisation in agricultural development, i.e., know the technology implications of national development policy. It also requires that they have some idea of the working of an AKS so as to be able to identify points of leverage for steering the system. We shall try to come back to this point in the conclusion to this chapter. It should have become obvious from earlier points that a laissez faire policy with respect to technology opts implicitly for default options, such as the ATS serving resource-rich farmers and squeezing out the mass of resource-poor ones with consequences which run counter to national policy.

Likewise, *structural conditions* play an important role. Variability in the production environment and among the farmers who use it has tremendous implications for the design and management of the ATS. Technology development and utilisation must be coordinated with other elements in the mix of conditions necessary for agricultural development, such a seed and input distribution, credit, building infra-structure, and so forth. This, in turn, requires horizontal links between the institutions comprising the ATS and institutions outside it.

Structural conditions make themselves felt especially in terms of the structure of the agriculture and the domain which the ATS serves. The composition of the farming population, the commercial development and the extent to which farming is served by various private and commercial organisations, the nature of the crops and animals grown, the nature of ownership, the extent of centralisation or decentralisation, all these have a tremendous influence on the nature of the ATS, affecting the type of actors it comprises, the relationships between them, the carrying capacity of the system and other crucial aspects.

The bureaucratic and political structure is mentioned separately by Elliott (1987) for good reasons. In many situations, especially where few alternative institutions to Government have emerged, the bureaucratic structure is a prime determinant of the ATS, often limiting the extent to which users can influence the system, the client orientation of the system, the extent of decentralisation and coordination. We consider a bureaucratic structure and procedures basically enemical to an effective ATS. We might phrase it differently, saying that, in a bureaucratic environment, the options for ATS design and system management are severely reduced. In an earlier chapter, we gave an example when we quoted reasons why farming systems research might not be an option in present-day China.

The political structure is also of great importance. What political power to farmers have? Which farmers? How important is the urban versus the rural vote? What are the mechanisms through which informal power is exerted? What is the position of international companies who process agricultural produce or own plantations? These and other questions must be considered if one wants to understand the conditions within which the local ATS must or can work.

The external sector contains another prime mover (donor agencies) and acts as a source of information and technology for the ATS in a certain domain. Any local or national ATS serving a particular domain is part of the mainstream of scientific and technological development. No ATS can afford not to keep abreast of external developments. It must avail of specific linkage mechanisms to be able to pick up what is happening outside. Favourite mechanisms are training abroad, subscriptions to foreign journals, excursions, sabbaticals, etc. These work particularly well with respect to scientific development. When it comes to specific technologies, such mechanisms might not suffice. In fact, fear of competition might severely restrict the flow of information.

If we take into consideration all the points raised above, it becomes all the more obvious why it is impossible to create the optimal normative model for ATSs in Central America or anywhere else. All one can do is raise the central issues, provide information about critical attributes and leverage points, and provide process methodologies and tools. The specific ATS must be locally designed to serve local wishes, knowledge and capacity.

4.10 Conclusions

We have considered the various aspects of the ATS in some detail. In past two or three years, we have come a long way in conceptualising the ATS. But that is easily said, looking at the point of departure. A different picture emerges when we look at the mission ahead. A great deal is still unclear and much comparative research and reflective practice is still required if we are to provide hands-on guidelines for technology policy, knowledge management and user lobbies. We still cannot provide many answers to questions in such crucial areas as:

- Leverage points for management, especially with respect to the control of the 'mix' of prime movers which can make the ATS gel at a higher system level and acquire emergent properties through synergy;

- Criteria for the design of ATSs in different conditions with respect to level of development, agricultural diversity, carrying capacity, etc. We do not have enough information on rates of return to investment in the ATS under these different conditions for policy to provide for the appropriate ATS.

- Viable alternatives to the tendency of the ATS to serve mainly resource-rich farmers and to squeeze the resource-poor out of farming.

- Balancing top-down and bottom-up flows of information and influence in the ATS.

We are, therefore, rather modest in our claims. Our main claim is that the ATS perspective we provide in the present paper is a necessary condition for advancing our understanding. In this respect, we hope that the experience to be gained in Central America as a result of the work in the Technology Generation and Transfer Programme will be accumulated into the existing body of knowledge about the ATS.

We want to conclude this chapter by discussing three issues which have received some attention in the past, and which seem to be particularly relevant as products of our quest for understanding the ATS:

1. *ATS Disorders*. Since we are dealing with systems, the malfunctioning of any part of the system affects all the other parts, and reduces the synergy of the system. Considering the comparative experience with ATSs today, we can pinpoint a number of specific common disorders. Knowing about them might be helpful to policy and management.

2. *Vital qualities for ATS performance*. It is easy to drown in the mass of aspects mentioned. It is, therefore, essential to identify key aspects which explain performance. Some work has been done in this area.

3. *Key leverage points.* It is one thing to know the symptomatic patterns of disorders, and even to know the vital qualities, quite another to know the points of leverage for management and policy. Typically, it is this area where only very few conclusions have been reached. Since we are dealing with soft systems, and can, therefore, not apply powerful goal-seeking techniques, we must rely on (a) following the soft systems methodology (Chapter 5) and (b) accumulation of experience through reflective practice and research.

4.10.1 ATS disorders

ATS disorders provide an exciting area of study. We have begun to identify a number of them (Röling, 1989) which we identify below. We expect that many more will emerge, but also that, as knowledge management comes into its own, some of them will be permanently banished and become extinct. The sources for the disorders mentioned can be found in the paper or in the reference list. Exceptions are H. van Dissel, the late manager of the International Course in Rural Extension in Wageningen, and S. Mansholt, a former socialist Dutch minister.

1. Engel's wrong plugs: the lack-of-fit between the domains used by different actors (for example, a commodity research institute is used to backstop extension servicing a multi-crop farming system);

2. McDermott's fatal gap: a functional gap which cannot be bridged by linkage mechanisms because of insufficient calibration of the science-practice continuum (for example the non-existence of adaptive research because applied research is satisfied with producing scientific publications, while extension starts with recommendations);

3. Bigg's mis-anticipation: the lack-of-fit between the conditions anticipated during technology development and those in which technology is used (for example the formulation of a fertiliser recommendation on the basis of crop responsiveness under unrepresentative research station conditions);

4. Van den Ban's **cross-purpose disability**: reward systems and incentives which encourage ATS actors to reduce the systems synergy (for example, rewarding members of the Research Division for scientific publications and not for producing innovations for farmers);

5. Wageman's **vertical flow blocks**: lack of effective linkage mechanisms for bottom-up and top-down information flows (for example when lower levels in the ATS are strongly farmer-oriented and higher levels government-oriented, especially when the goals of farmers and government conflict);

6. Mosher's **mix insufficiency**: the lack of provision of one or more of the conditions essential for technology utilisation (for example, research-based recommendations for farmer behaviour, while the required inputs are not available);

7. Ascroft's **equity syndrome**: progressive farmer control over the ATS, biasing technology development and transfer in favour of a minority of farmers;

8. Van Dissel's **policy folly**: the use of extension as if it were a policy instrument with compulsive power, especially if coupled with disregard for the fact that farmers have to live by the results of their technology;

9. Rogers' **heterophily gaps**: interfaces between actors which differ so greatly that linkage mechanisms cannot span them;

10. **No juice**: blaming the ATS when the problem is agricultural prices;

11. Mansholt's **small farm squeeze**: setting in motion technology-driven agricultural development in high-potential areas for resource-rich farmers without regard to the employment and livelihood effects on small scale farmers and those in less well-endowed areas;

12. Jiggins' **Out-a-synch**: giving priority to ATS development when the majority of farmers have not gained sufficient control over their production environment to use a regular flow of knowledge;

13. Sims and Leonard's **default incentives**: the tendency of ATS actors to act in ways which are detrimental to the synergy of the ATS as a result of feebleness of prime movers;

14. Röling's **economist myopia**: managing and/or designing the ATS as a black box completely determined by the economic context, especially if combined with the belief that technology is a commodity.

15. **Benor's syndrome**: investing large amounts of borrowed money in the extension sub-system even when the availability of new technology to feed it is uncertain, or when the carrying capacity of the agriculture in question seems incapable of sustaining the sub-system in the long run.

Hopefully, our compendium of ATS disorders will inspire reflective practitioners in Central America to identify some syndromes of their own.

4.10.2 Vital qualities

Different authors (e.g. Rogers et al, 1976 and Blum, in press) have attempted to identify the vital qualities of successful ATSs with a view to providing guidelines for designing ATSs elsewhere or in other sectors. Rogers et al (1976) started with the question why efforts to transplant the successful US agricultural technology development and cooperative extension model, based on the Land Grant system, had been so unsuccessful both, in developing countries and in other sectors, such as health promotion. They concluded that the transplantation efforts has not taken into account crucial aspects of the successful ATS, and only copied structural externalities. They then tried to identify these *crucial elements or essentials*:

1. a critical mass of new technology;
2. a research sub-system oriented to utilisation;
3. a high degree of user control over the research utilisation process;
4. structural linkages between the ATS's actors;
5. a high degree of client contact by extension and other linking sub-systems;
6. a 'spannable' social distance across each interface between actors of the ATS;

7. evolution as a complete system;
8. a high degree of control by the system over its environment.

The reader will recognise most of these points from our earlier discussions. Rogers et al (1976) are indeed a classic in the field. The two crucial elements we have not mentioned so far are the last two.

Stressing *evolution as a complete system* refers to the fact that the components in a successful ATSs, such as the US system, did not evolve in isolation from each other, but formed part of a system from the start, stronger, were designed to operate as a system from the start. Thus adepts of the US Land Grant system has always presented unified education, research and extension functions as a key ingredient in the success formula.

Control of the system over its environment refers to a situation where ATS policy makers and managers, including leaders of farmer associations and other stake holders, have relative political and economic power so that they are not at the whim of politicians and others who have no vested interest or understanding of the system.

> A typical example is provided by Margaret Thatcher's Britain, where the ideology of lean government and an strong drive towards privatisation have led to cuts in vital aspects of the British ATS without regard or understanding of the synergetic nature of the system. Activities of the ATS which were considered 'close-to-market' where severely cut from one day to the next. The need of ADAS staff to earn 50% of their keep and their charging for services is said by some to have led to a sharp drop in farms served, especially the smaller ones (Engel et al, 1989; Coutts, 1990).

Other authors have attempted to build on the work of Rogers et al (1976). Blum (in press), who carried out a comparative study of the Netherlands and Israel, observed, not only that the eight elements identified by Rogers et al. were indeed conspicuous in Israel and Holland also, but that a number of other vital qualities could be identified as well. These are:

9. Technology policy is an important actor in the ATS;

10. Transfer sub-systems include more than extension, with media (e.g., farm journals), agricultural education, and farmer organisations playing key, and often redundant, roles;
11. Informal linkages are as important as formal ones;
12. The actors are independent from other actors and government, in that they can follow their own professional judgement;
13. Serving a small geographical domain is beneficial for the quality of linkage between the components of the ATS;
14. Farmers' cooperatives and other associations play key roles in strengthening user control and client orientation in the ATS.

Our Wageningen group considers the study of vital qualities of extreme, if for the time being especially heuristic importance. Vital qualities must, first of all, be linked to a desired performance and to the environment. It is one thing to determine the vital qualities of an ATS that supports technology-propelled development in industrial agriculture, without regard to the consequences for resource-poor farmers, quite another the vital qualities of a system which can support low external input and sustainable subsistence agriculture. The vital qualities are, therefore, dependent upon goals and environment.

Nevertheless, a number of vital qualities which seem to be relevant across the board can be tentatively mentioned. These refer especially to (a) user control and user-orientation, (b) functional differentiation between actors' activities and (c) synergy between actors' activities.

With respect to user control and orientation, vital qualities seem to be:

1. Ability to make available relevant technologies;
2. Adaptability to changing conditions;
3. Situation specificity;
4. Economic and institutional sustainability.

With respect to functional differentiation, we can consider such vital qualities as (Engel, in prep.):

5. Multiplicity;
6. Diversity;
7. Redundancy.

Where synergy is concerned, it seems that we must consider the system's

8. Formal and informal integration;
9. Functional adjustment and convergence;
10. Cognitive adjustment and convergence;
11. A shared 'corporate' ideology;
12. Coordination through management and policy measures.

4.10.3 Leverage points

The following 10 *areas of management endeavour* seem to stand out in requiring knowledge about leverage points and tools for manipulating them:

1. co-ordination of the activities of actors;
2. institutional development;
3. ATS corporate ideology development;
4. management information systems;
5. interface process management (e.g. such tools as the interface matrix);
6. client-orientation and its operationalisation;
7. generation of pressure from prime movers and avoiding disabling conflicts between them (e.g. between policy and users);
8. protection against interference from non-germane short-term political interests;
9. development of resource feedback loops sustaining the ATS;
10. shared analysis, learning and decision making by those involved in the ATS.

We are not dealing with hard systems for which we can develop blueprints, but with human activity systems or soft systems. Instead of on blueprints, we must, therefore, focus on process (Sweet and Weisel, 1979). It is only when much experience has been gained and knowledge about knowledge management has accumulated and shared, that we can hope to formulate statements which go beyond the process to be followed.

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In the next chapter, we shall elaborate the methodology which allows shared learning, analysis and decision making about the ATS. In other words, we shall only elaborate on the last of the 10 areas of concern enumerated above.

5. TOWARDS A METHODOLOGY

5.1 The Soft Systems Methodology

Peter Checkland and his colleagues in Lancaster have, since 1969, developed a methodology 'for rational intervention in human affairs' from practical experience. The Soft Systems Methodology (SSM) was developed because systems engineering, based on defining goals and objectives, simply did not work when applied to 'messy, ill-structured, real world problems'.

MSc students, academic supervisors and interested parties belonging to various human activity systems, such as commercial firms, departments and service agencies, have collaborated to develop SSM as a tool for shared learning, analysis and decision making. The 1981 book, now (1990) in its sixth reprint, reports on this experience and consolidates it into a methodology. A later article (Checkland 1985) provides further clarification.

SSM represents a 'path' or process. These words are misleading, however, since the methodology is not a series of 'steps' which can be sequentially followed. In fact, following the path involves backtracking and iteration, while one does not have to start at the beginning. One could speak of a checklist or a menu.

SSM contains two kinds of activities: 'real world' activities necessarily involving people in the problem situation, and 'systems thinking' activities, which may or may not involve those in the problem situation. Figure 7 shows the different kinds of activities which constitute SSM (Checkland, 1985). It allows us to understand the methodology before we apply it to agricultural technology systems.

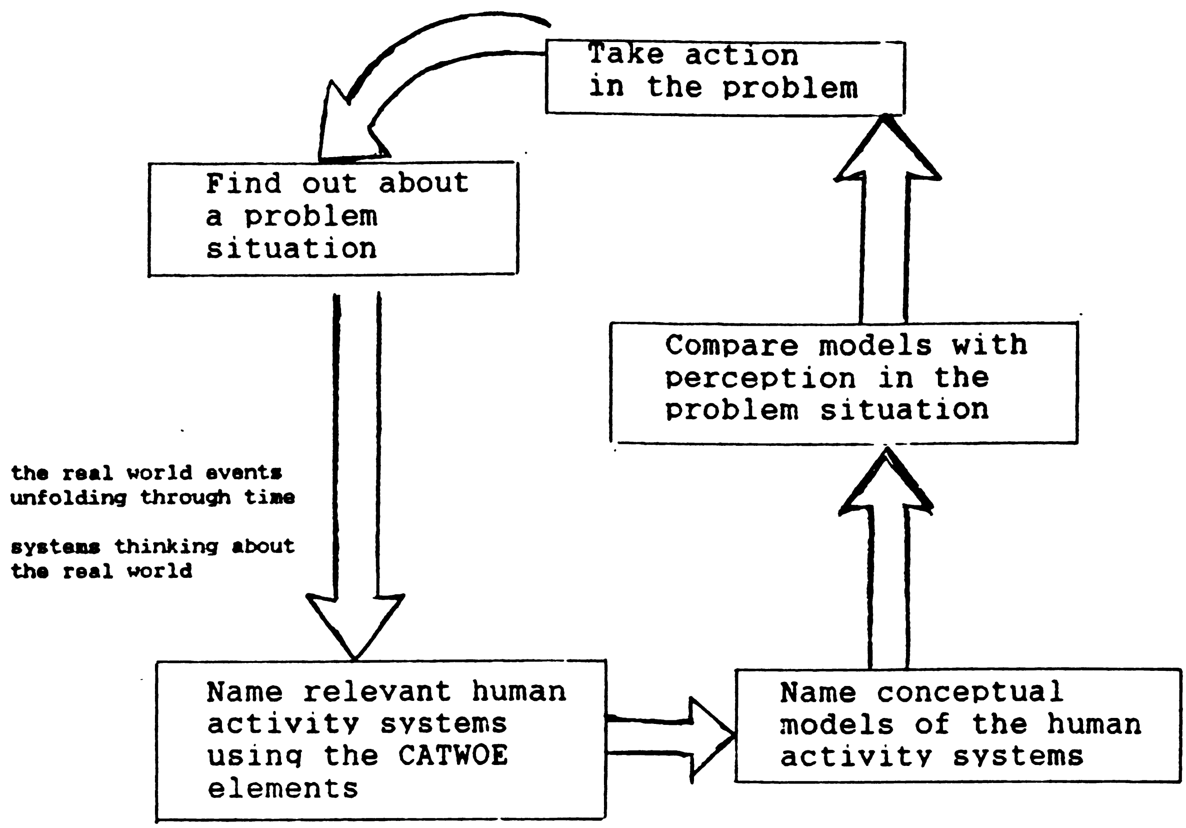

FIGURE 7: THE SOFT SYSTEMS METHODOLOGY IN SUMMARY (After Checkland, 1985)

CATWOE:

C: 'C ustomers'. Who would be victims or beneficiaries if this system were to exist?
A: 'Actors'. Who would carry out the activities of this system?
T: 'Transformation process'. What input is transformed into what output by this system?
W: 'Weltanschauung'. What image of the world makes this system meaningful?
O: 'Owner'. Who could abolish this system?
E: 'Environmental constraints'. What external constraints does this system take as given?

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Checkland (1985) gives the following characterisation of SSM:

> The methodology moves from finding out about a problem situation to taking action in the situation. It does so by using systems thinking.
>
> The first stage is the definition of the *problem situation.*
>
> Once the problem situation has been defined, some *human activity systems* relevant to exploring the problem situation are named, using the CATWOE elements.
>
> *Conceptual models* of the human activity systems are then built. They are models of the purposeful activity considered relevant to debate and argument about the problem situation. They are not at this stage thought of as designs.
>
> The debate about the situation is structured by *comparing models with perceptions of the real world.* The aim of the debate is to find some possible changes which meet two criteria: they are systematically desirable and culturally feasible in the particular situation.
>
> Definition of *desirable and feasible changes* gives a new problem situation (how to implement) and the cycle can begin again.
>
> SSM seeks accommodation among conflicting interests. It is doubly systematic: it is itself a cyclic learning process and it uses systems models in that process.

SSM seems eminently applicable to shared learning, analysis and decision making about the ATS at regional, national and local levels of analysis. By applying the knowledge which is accumulating about agricultural technology systems through comparative analysis and reflective practice of managers, consultants, and others, SSM can grow into a powerful tool for ATS development.

1. FIND OUT ABOUT A PROBLEM SITUATION	- What are the 'gets and wants' (symptoms and definition of the problem)? - To what extent is it a technology problem? - What are the conditions to be met for tech. development and utilisation to make a contribution?
IF TECHNOLOGY IS SIGNIFICANT PROBLEM:	
2. NAME RELEVANT HUMAN ACTIVITY SYSTEM USING - Clients - Actors - Transformations - Weltanschauung - Owners - Environmental constraints	- What ATS are we talking about (domain, components, linkages, environment)? - Who does what in the system? (functional analysis) - To what development in agriculture is the system supposed to contribute (performance)? - What outputs does the system produce? - What is the perception of the system by those involved? - What are the environmental conditions for the expected performance? (e.g. economics, infrastructure, etc.)
3. NAME CONCEPTUAL MODEL OF THE HUMAN ACTIVITY SYSTEM (not yet a design)	Use ATS conceptual framework for modelling the local ATS described above with respect to: - functional differentiation (structure and process); - coordination (prime movers); - integration (synergy); - performance; using hypotheses about vital qualities, ATS disorders and points of leverage.
4. COMPARE MODEL WITH PERCEPTION OF THE PROBLEM SITUATION	- Who can act to change the situation? - What are the concrete points of leverage? - What can be done in terms of knowledge management and intervention?
5. TAKE ACTION	joint decision making about implementation

FIGURE 8: FIELDS OF ANALYSIS RESULTING FROM APPLYING THE SSM TO ATS DEVELOPMENT

(Adapted from Checkland, 1985; and Engel and Seegers, 1989)

5.2 Applying SSM to Agricultural Technology Systems

In applying SSM to ATS development, we shall make use of the guidelines for 'Rapid Appraisal of Agricultural Knowledge System and Networks' (RAAK S/N), developed by Engel and Seegers (1989). RAAK S/N is currently being tested in case studies in the Netherlands and abroad. Though developed before we had come to know about SSM -a contribution of P. Van Beek and others who are using SSM to develop ATSs in Queensland- the guidelines can be said to follow SSM, using the theoretical perspective developed in Chapter 4. Of course, exposure to SSM has made us adapt the guidelines.

Figure 8 provides a 'hybridisation' of SSM and the RAAK S/N guidelines. Basically, the hybridisation applies the ATS concepts in an SSM framework. In all, Figure 8 provides fairly concrete fields of analysis for ATS development which, to the best of our knowledge, make use of the present-day state-of-the-art of ATS analysis and development. An advantage of the set of fields of analysis suggested in Figure 8 is that new theoretical insights into the factors that determine ATS performance, and the accumulation of experience with interventions to improve the ATS, can be fed into the analysis of a concrete ATS. This occurs in the form of (1) hypothetical answers to the questions asked at each 'step' and (2) parameters for the major variables involved. The fields of analysis follow a clear problem solving logic (Figure 9).

Applying the SSM to ATS development involves the following operational phases, for which a certain amount of time can be allocated (Engel and Seegers, 1989 and Röling, 1974):

1. Policy decisions;
2. Formulating mandate and TOR for core team;
3. Selecting core team;
4. Becoming acquainted;
5. Preparatory workshop;
6. Information gathering;
7. Team information processing;
8. Presentation and discussion of preliminary results;
9. Formulation and presentation report.

Policy decisions are a necessary prerequisite for setting the process in motion. Such decisions must be taken with respect to the desirability of investigating the (national or local) ATS and of making suggestions for improving it. In other words, these policy decisions reflect the political will to improve the ATS and make available resources for it. To influence such decisions, high level advocacy (e.g. by IICA staff) or national workshops involving policy makers might be required.

Once the required policy decisions have been taken, the team can be selected and mandates and TOR must be formulated for it. The core team is assigned with the responsibility of taking those involved in the national or local ATS through the SSM.

In the RAAK S/M procedure, the core *'team'* consists of one or 2 'consultants', who know the methodology and the conceptual framework and one or more staff of the ATS concerned. At various stages, larger groups of participants in the ATS, or its directorate, need to be involved. It is very difficult to give a blueprint on who should be involved when. Suffice it here to say that the aim of the methodology is not so much to find the 'right answer', but to share learning and decision making, so as to set a process of sustained ATS development in motion. It is obvious that various categories of stakeholders are to be involved at appropriate moments.

Becoming acquainted allows the team to familiarise and become acquainted with the methodology. Tasks are divided and a workplan is made. An important element is the initial definition of key informants, largely by the team members belonging to the ATS. This also includes those 'owners' who need to be involved and kept informed. Important are also decisions about instruments to be used, and a common understanding of the approach to be used.

PROBLEM (LEVEL 1)
Describe agricultural system in terms of key elements, processes, symptoms and gets/wants.

DIAGNOSIS (LEVEL 1)
Key causes of problem in terms of elements of the agricultural development mix.

↓

is technology an important cause? → NO → other framework

↓

YES

↓

PROBLEM (LEVEL 2)
Describe local ATS in terms of key elements, processes, symptoms and gets/wants.

DIAGNOSIS (LEVEL 2)
Analyse local ATS in terms of functional differentiation, integration, coordination, and performance, focussing on leverage points, vital qualities and disorders.

IDENTIFY ALTERNATIVES
Identify possible courses of action to develop the ATS, and actors who could act.

DECIDE ON ACTION

EVALUATE

FIGURE 9: THE BASIC LOGIC OF THE SSM TO ATS DEVELOPMENT

The preparatory **workshop** introduces the core team, the concepts and the procedure to key decision makers. During the workshop, both the SSM and the ATS conceptual framework are introduced and discussed. Working procedures and involvement of key actors are agreed upon. A certain amount of commitment from key actors is solicited.

During **information gathering** the core team collects information on the local ATS, wherever necessary involving stake holders and other participants in the exercise. During **team information processing**, the team not only processes the information collected, but also develops the model of the local ATS.

The **presentation and discussion of preliminary results** is a crucial moment. It is at this stage that the team feeds back the information it has collected, as well as its preliminary suggestions for action. It is at this stage also that collective decisions are taken with respect to actual interventions to develop the ATS. These are laid down during **formulation and presentation of the final report**.

Figure 10 brings together the problem solving logic of the SSM applied to ATS development and the operational phases.

In all, the SSM applied to ATS development consist of the following components (Engel and Seegers, 1989):

1. The **chronology of activities**, a phased work plan for the appraisal team. It requires a certain period of time which is to be decided taking into account the local situation, time constraints, and the required amount of work. In the case studies carried out so far, about 4 weeks were required.

2. The **fields of analysis** represent the main fields of interest considered during the whole exercised. They are defined in Figure 8. The questions and points of consideration mentioned in Figure 8 represent a checklist of those bits of information which are

PROBLEM (LEVEL 1) DIAGNOSIS (LEVEL 1) DECISION: IS TECHNOLOGY IMPORTANT?	Policy decisions
	Mandate and TOR Becoming acquainted Preparatory Workshop
PROBLEM (LEVEL 2) DIAGNOSIS (LEVEL 2)	Information gathering Team information processing
IDENTIFY ALTERNATIVES EVALUATE	Preparation and discussion of preliminary results Formulate and present report

FIGURE 10: OPERATIONAL STEPS AND SSM LOGIC

considered important, given the present state of the art of ATS theory and reflective practice.

3. The instruments are analytical tools permitting the analist to address certain fields of analysis, or one particular field, efficiently and effectively. We are in the process of identifying and developing these analytical tools. In the present paper, no attention has been given to instruments which could be used for collecting information.

4. Communication approaches are the strategies, procedures and methods for participatory ATS development using SSM. These approaches depend a great deal on local culture, on bureaucratic custom and other established practice. However, it is essential to elaborate a communication plan which allows for shared learning and decision by those involved.

5. Parameters relate to important variables identified in ATS research and guarantee a minimum of consistency within and across fields of analysis.

6. Hypothetical statements refer to one or more specific fields of analysis and may be rejected or confirmed, depending the analysis of the local ATS. The hypotheses are formulated on the basis of accumulated results of comparative ATS research and reflective practice.The hypothetical statements and the parameters allow feeding the slowly growing body of knowledge about ATS development into concrete ATS improvement activities.

These ingredients together constitute the methodology.

6. CONCLUSIONS AND RECOMMENDATIONS

Knowledge and information, and their consolidation in software and hardware, can be seen as an important production factor in agriculture. Together with inputs, markets, prices, infrastructure, credit, land development and reform, technology forms part of the 'mix' of essential ingredients for agricultural development. The better the other ingredients are catered for, and the greater the control farmers have over production conditions, the greater the role of technology in agricultural development (Jiggins, 1986). It is likely that conditions exist, also in Central America, where investment in agricultural technology development is a waste of money, simply because removal of other bottlenecks could lead to substantial improvement in the increase and distribution of agricultural output with existing technology. We therefore emphasise the need to establish the potential contribution of agricultural technology development, before investmest in the ATS.

Given an established need for ATS development, two important tools for intervention can be identified:

1. The **Soft Systems Methodology (SSM)**, a well-established procedure for shared learning and decision making about human activity systems and their improvement; and
2. The **conceptual framework** for analysis, improvement, design and simulation of **Agricultural Technology Systems (ATS)**.

Bringing these together leads to a powerful methodology for ATS development which is based on the participation of those who are stakeholders in the local ATSs being developed.

Application of this methodology makes explicit the concepts which are being used, prevents imposition of ready-made solutions which have worked elsewhere but might not be applicable in Central America, and emphasises shared learning and decision making. The methodology has the advantage that it can 'learn': experience gained during application of the methodology can be fed back into it to improve its effectiveness and efficiency in Central American conditions.

Given these conclusions, we make the following recommendations for the international workshop:

1. IICA is mandated to adopt the methodology as the basis for national ATS development during its Technology Development and Transfer Programme;

2. IICA is mandated to adapt the methodology to Central American conditions.

3. IICA is mandated to advocate the methodology with top policy makers of member countries so as to gain acceptance and political support for actual field work.

4. IICA is mandated to organise a training programme for members of core teams who can operate in the respective Central American countries. They consist of individuals from these countries who can act as international consultants and national experts.

5. IICA is mandated to form a clearing house for 'learning'. Experience gained in using the methodology for national ATS development is collected, evaluated and consolidated by IICA and fed back into national efforts through training and other methods.

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