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IMPROVED TECHNOLOGIES FOR LATIN AMERICA'S NEW ECONOMIC REALITY RICE-PASTURES SYSTEMS FOR THE ACID SAVANNAS

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Introduction

Current agricultural development policies focus on how production can be increased or maintained without deteriorating the resource base while, at the same time, narrowing social and economic disparaties This means new technologies designed to improve resource management must have a long-term perspective where sustainability issues are thoroughly explored

Although last century's Malthusian predictions have not beeen fulfilled (Hanssen, 1939), and per capita food availability in the world has steadily increased, more people are now at food risk than 20 years ago (World Bank, 1986) However, they represent a lower percentage of the total population In 1970, 520 million people were at 80% or less of FAO's daily recommended calorie intake By 1980 this number had grown to 535 million people

There is growing awareness that the impressive growth in gross domestic product (GDP) in many developing countries, made possible by major food production increases, masks serious exploitation of nonrenewable resources In the wake of the revolution in high yielding varieties and high input agriculture, have come soil degradation, chemical abuse, and water misuse, which now threaten the environment's quality To curb and even reverse these trends, policymakers and designers of agricultural technologies have to understand how inappropriate farming practices contribute to loss of sustainability While development literature tends to focus on biological and climatic factors for environmental degradation, and technology design can address these issues, the importance of socio-economic and political interventions (White, 1987) is receiving increasing attention

This paper looks at economic trends and policies over the last 30 years in Latin America that led to exploitation of the continent's tropical savannas and rainforests and the ensuing environmental degradation and deforestation that occurred Current preoccupation with these issues has resulted in increased demand for technological solutions in the agricultural sector that rely less on area expansion than in the past, and enhance productivity while contributing to a sustainable agricultural or land-use system Crop and legume-based pastures systems, in particular, the rice-pastures system

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developed at CIAT (Centro Internacional de Agricultura Tropical) for Latin America's acid savannas, is an example of such a technology Several agronomic and economic advantages of the system are presented here

Latin America Towards the 21st Century

The 1980s constituted a decade of poor economic performance for Latin American countries, characterized by high debt burden, hyperinflation, low and even negative economic growth, net exports of capital associated with high interest payments and reduced foreign investment, more unemployment and under employment, and accute fiscal deficits (CEPAL, 1989) (Table 1)

This performance contrasts markedly with the rapid growth and modernization of the 1960s and 1970s In those years, almost all countries registered impressive per capita GDP growth rates Agriculture's share in contributing to GDP and employment generation decreased from 20% and 30%, respectively, in the 1950s, to about 11% and 20% in the 1980s The region went from being rural-based (51% of the population lived in the countryside in 1950) to being essentially urban based (75% lived in the cities in the 1980s

Policies Inducing Frontier Expansion and Deforestation

Agricultural growth was characterized by an aggressive area expansion In tropical South America, subsidies and important infrastructure and agroindustry developments accelerated colonization of frontier lands, namely the savannas and tropical humid forests Rapid environmental degradation resulted (Gallopin, 1989) Environmental issues in Latin America are complex The region hosts 23% of world forests and, with some 240 million ha, 57% of all tropical humid forests (CEPAL, 1990) Deforestation of the Amazons is an important factor in the extinction of unique flora and fauna and of the destruction of the ozone layer

Expansion into the savannas

The Latin American savannas, characterized by low nutrient content and high acidity, have about 130 million mechanizable hectares (at less than 8% slope), mostly privately owned Despite the limitations of soil fertility, the savannas constitute a valuable land resource in Brazil, Colombia, and Venezuela These three countries, in turn, control most of South America's rainforests

Savanna exploitation has been a policy objective in Brazil and, to a lesser extent, in Venezuela for 30 years In Brazil, the savannas have been rapidly colonized, raising questions about the deterioration of that ecosystem Savannas exhibit a variable erosion

potential given the relatively frail soils Inappropriate cultural practices exacerbate this problem, especially on slopes

Infrastructure development and high subsidies, linked to a high input agriculture (mainly lime and fertilizers), have supported this system Agroindustrial development in the Brazilian Cerrado (the largest of the three savanna areas) and in Venezuela has been a driving force for agricultural production increases In Brazil, for example, the Cerrado now provides a significant share of the country's grain and livestock production (Table 2) About one third of Brazilian cattle population is located in Goias and Mato Grosso, in the Cerrado Soybeans, rice and maize are also important in the region (Table 2)

In Venezuela, where oil constitutes the basis of the economy, representing over 75% of government revenues and 90% of export earnings, agriculture accounts for less than 7% of GDP The sector grew 4% annually from 1960 to 1990 Infrastructure development and high subsidies for agricultural inputs and products have been the norm Of the 1 2 million ha of coarse grains planted in 1988, more than half were in the acid savannas of Portuguesa, Guarico, Monagas and Anzoategui They have excellent infrastructure, but are highly dependent on cheap lime and fertilizer to alter poor soils

In Colombia, the savannas have received less attention, although current trends indicate agriculture is growing rapidly in the zone Table 3 shows recent expansion of cultivated areas (mainly favoring upland rice, soybeans and palm oil) in the Meta department in the eastern savannas of the country

One of the effects of colonization has been displacement of cattle herds from fertile to more marginal lands Relocation of cattle from southern Brazil to the acid savannas of the Cerrados is representative of this process (CIAT, 1988) As cattle ranching moved to less fertile lands, its productivity declined The best lands were used for more intensive agricultural activities Thus, growth in the cattle industy was based on increasing the number of hectares under exploitation, to compensate for lower productivity From 1966 to 1988, beef production in Latin America grew 2 1% a year Cattle herd expansion represented 2 6% per year of this total, while productivity, expressed in meat production per head in stock, showed a -0 5% growth rate Similar trends, less marked, are observed for milk production (Table 4)

Deforestation of the Amazon basin

The direct and indirect policies that contributed to accelerated deforestation of the Amazon basin are numerous Binswanger (1989) lists six types of policies that directly encouraged the Amazon's deforestation in Brazil (1) taxes on agricultural income, (2) rules of land allocation, (3) land taxes, (4) capital gains and commodity taxes, (5) regional and sectorial taxes, and (6) provisions for credit (Binswanger, 1989) These policies, coupled with growing scarcity of arable land, promoted land purchases for speculative purposes, and migration into the Amazon basin

The most prevalent policies accelerating deforestation, though, are indirect These include fiscal deficits associated with high inflation, lack of agrarian reform, distorted financial markets favoring investment in real estate over productive activities, and strong market pressures with high prices for food Many current macro-economic and trade policies place a high rate of discount on capital, which implies a preference for current versus future revenues, and have predatory effects on natural resources The current debt burden also places adverse pressures on the environment "Debt-for-nature" swaps are now being negotiated with developing countries (Potier, 1990)

Infrastructure plays a key role as well Governments provide infrastructure that, coupled with other socio-economic factors, encourage farmers to settle the frontiers In Brazil, soybean production was extended deep into the Cerrados and is now reaching the Amazon, because of export promotion policies and rapid growth in agroindustry INDA (National Institute for Agrarian Development) has been ineffective in relieving pressure on many areas of the country where land prices are already high (south) or where there are sharp socio-economic inequities (as in the northeast)

In Colombia, instability (extortion, kidnappings, guerrilla activities) in many in-land areas push settlers towards the Amazons Coca plantations are also a disruptive factor Illegal drug activities are linked to booming real estate prices because of "hot" money in the economy Thus, farmers investing in land as a hedge against inflation, are pushed towards the lower-priced lands in the frontier areas

In Ecuador, where oil companies have built roads to the jungle, the infrastructure, along with inflation and land pressure in the highlands and on the coast, attracts settlers to the Amazon In Peru, the government's offer of input and output subsidies actively promote colonization of the jungle

In all of these countries, deforestation has been linked to the acquisition of land titles and the need to demonstrate creditworthiness Farmers must provide proof of farming activity, and land clearing is the most basic task Moreover, uncleared land is subject to encroachment (Ramirez and Sere, 1990)

Although economic policies encouraged colonization of the savannas and tropical humid forests, there has been an accompanying lack of appropriate technologies and understanding of the fragile environments being used, and disregard for the productivity of systems being introduced This is especially the case for the tropical humid forest and, and to a lesser extent, for the savannas The result has been a number of cattle projects in the region characterized by low productivity and high social costs, in terms of lost natural resources and environmental degradation (Schipulle, 1989) (Table 5)

Checking inflation and reducing fiscal deficits will be the immediate policy framework among Latin American countries The region will face severe budget restrictions Thus, introducing agricultural production into new areas that require heavy

investments in infrastructure is unlikely However, demographic pressures, scarcity of arable lands, and the need to generate foreign exchange and employment, and reactivate economic activity, in which agriculture is expected to play a fundamental role (Mellor, 1987), will demand new approaches for more efficient use of resources In Latin America, both the livestock and timber-using industries that prevail in the frontier lands, are land-extensive (Laarman, 1988) For this reason, the forestry sector is a prime target for many reform proposals (Repetto, 1988) Research to improve pastures and the efficiency of cattle systems is another step towards more intensive land use

Increasing Productivity Through Crop-Pastures Associations in the Savannas

One of CIAT's main areas of research interest has been development of cassava, rice, and legume-based pastures that are well adapted to the low input, acid savanna conditions CIAT's current work in crop-pastures rotations for the savannas offers technologies that constitute financially attractive alternatives while, at the same time, increasing productivity and sustainability of the savanna ecosystem in the long term It is expected that this research will lead to intensified agriculture in savannas adjacent to the Amazon forests, therefore relieving pressure on the rain forest

Legume-grass pasture systems

The Brazilian Cerrado currently has about 30 million ha of improved pastures (mostly Brachiaria spp) in a total of about 100 million ha under pastures To make these extensive savannas more productive, CIAT developed legume-based pastures, using germplasm that was well adapted to the harsh conditions of acidity, water stress, and aluminum saturation

Legume-grass pastures have been shown to be profitable options in the Cerrado (Saez, 1990) Perhaps, relatively high initial cash requirements in the first two years make those systems less attractive than alternatives with better cash flows Presently only a few cultivars with limited adaptability are available These tend to be materials, such as Leucaena leucocephala, that require higher levels of fertility than generally found in the Cerrado, or that are of low palatability (Calopogonium muconoides) to cattle Research under way at EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria) and CIAT is expanding this range of options toward more acid and drought-prone soils

Integrating crops with these pastures into systems of intermediate intensity has compelling agronomic and economic arguments Pastures and crops can be combined to use resources in a complementary fashion crops tend to cover the ground rapidly and achieve maturity in 100 to 120 days Pastures are slower to start, but then take up the space and nutrients available after the crop is harvested This results in more efficient land preparation and fertilization, and reduces erosion and nutrient leaching Competition for light and nutrients differs for different combinations of crops and

pastures and can be influenced by agronomic practices (seeding and fertilization rates, timing of seeding, and acidification)

In financial terms, crops can dramatically improve the cash flow of pasture improvement by providing substantial revenues within the year of establishment Improving the cash flow of pasture establishment, particularly if combined with agronomically superior crops which yield well in association, can shorten the number of years a pasture is used This means more crop years and thus, less dependency on the persistence of the pasture This shift makes management of the legume-grass pastures less critical In other words, financial returns to the system will be less sensitive to accidents such as loss of the legume or deterioration of the pasture On the other hand, the system requires crop production expertise either from the grazier or through contract arrangements These have been the rule in regions where pastures have been established in this way

An agronomic disadvantage of legume-based pastures in the long run is that soil acidity tends to increase over time, partly as a result of the loss of nitrate ions and accompanying cations However, in rotations with annual crops, this effect can be ameliorated by the uptake of nitrate by plants, thereby minimizing soil nitrate accumulation and leaching of nitrogen and other basic cations

Crop-pastures rotations are currently practiced in the Brazilian Cerrados, but they are not common, despite the fact that most of the Brachiaria pastures are degraded (Table 6) and should be renewed Profitability of those rotations is not attractive enough to renovate the pasture Farmers opt instead to replace native grasses with more productive grasses rather than legume cultivars

Nevertheless, they use crops as a way to finance this initial transition from native Cerrado to pasture A EMBRAPA/CIAT survey of the diffusion of the grass Andropogon gayanus undertaken in the region around Brasilia in 1985 revealed that in 59% of the cases the pasture was sown after one or more cycles of crops (CIAT Pasture Program Annual Report, 1987)

Potential of rice-pastures systems

Upland rice has traditionally been the pioneer crop in the Brazilian Cerrado (Teixeira and Sanint, 1988), After clearing the land, high amounts of lime (3 to 5 tons/ha) are incorporated to adjust soil acidity Lime is abundant and cheap (US$10/ton) in the area Rice is frequently followed by other crops (soybeans, maize) or by pastures (natural or improved) Rice in rotations after other crops is limited Rice followed by rice represents a high percentage of the 2 0 million ha of this cereal in the Cerrado The tall rice varieties that exist in Brazil, lodge when rotated after soybeans and other legumes, because of nitrogen fixed in the soil (Teixeira et al , 1989)

New savanna rice lines developed over the past six years at CIAT are showing impressive results (Sarkarung and Zeigler, 1989) These semidwarf lines have strong root systems and, therefore, tolerate acidity, aluminum saturation, and water stress much better than their predecessors Aluminum toxicity affects the normal development of root meristems (the growing points of the roots) As a result, roots are deformed and not fully developed The new rice cultivars contribute to lower levels of nutrient leaching, since aluminum tolerant plants are able to develop root systems that are effective in tapping soil moisture and nutrients, preventing their loss from the soil profile

An important characteristic of these rice cultivars is that, although they were developed to tolerate low input conditions, they respond well to fertilizers, particularly nitrogen This is a key factor in rotations with legume-based pastures or in rice-legume rotations, such as soybeans The new rice lines do not lodge On the contrary, they assimilate the nitrogen, have higher yield stability and produce more Paddy yields of 3 0 to 4 0 tons/ha under commercial conditions, compared with an average rice yield of 1 2 tons/ha for the Cerrado, are common

The new savanna rice cultivars, besides improving productivity in the 2 0 million ha where the cereal is currently produced in the Cerrados, can provide a significant share of future Brazilian rice needs if pastures renovation based on rice planting gets under way For example, if by the year 2025 there are 50 million ha of improved pastures in the Cerrado (up from 30 million ha currently), and if half of the area is renovated every six years, this practice might generate 4 2 million ha of additional rice area. At a yield of 1 8 tons/ha (about half the yields being obtained in semicommercial trials), this represents 8 0 million tons more rice This would meet half of the additional rice needs of the country by 2025, when total consumption will reach 28 0 million tons (up from 12 0 million tons, currently) In Colombia and Venezuela, savanna rice is not yet cultivated The new varieties would open a vast area for rice cultivation in rotation with pastures or other crops This might relieve pressure to grow rice on the best lands of these countries, where higher value crops could be grown instead, in order to meet increased food needs

Partial Budgeting of Some Rice-Pastures Alternatives

Two final aspects are analyzed in this section profitability of six alternative systems and distribution of cash flow over the investment's planning horizon

The analysis compares six alternatives for savanna pastures exploitation Current use of native pastures to raise cattle is the basis for comparing the improved cattle systems Both grass- and legume-based pasture systems are analyzed in each case Five of the systems assume that the pasture is for beef production, while one assumes the farm produces both milk and beef Three types of options are examined (1) native savannas (as a control), (2) direct pasture establishment and (3) pasture establishment with the use of rice The six pastures systems are

1 Native savanna beef production
2 Grass pasture establishment for beef production
3 Grass and legume-based pasture establishment for beef production
4 Grass and legume-based pasture established with rice for beef production, pasture renovation and refertilization in the fifth year
5 Grass and legume-based pasture established with rice for beef and milk production
6 Same as alternative four, but pasture is renovated with the use of rice in the fifth year

The partial equilibrium model evaluates the alternatives assuming a nine-year time frame Rice yields are conservatively estimated at 2 5 tons/ha, some 33% lower than yields obtained by CIAT in semicommercial rice-pastures trials in the Colombian Llanos (CIAT, 1990)

Figure 1 shows the relative profitability of the six systems, as measured by the Internal Rate of Return (IRR) Activities where pastures were established jointly with rice are clearly superior, in terms of economic returns, to those where pastures are established without the crop Native savannas provide the lowest returns

An important factor in the profitability of the rice-pastures systems is the nature of the cash flow Receipts from rice sales are sizable during the first year, in the rice-pastures option (Figure 2) This not only increases profitability but, in a setting where high preference for liquidity may be an important objective in the farmer's risk management options, it means that rice-based pastures are much more attractive and viable than traditional direct pasture establishment (Botero et al , 1990)

Results of this financial analysis constitute a first approximation of the higher profitability of the rice-grass pasture system But the viability of the system depends on many other factors exogenous to the farm, such as resource availability, farm location and size, type of land tenancy, machinery, and other activities to be included in the system As pasture renovation is shortened to seven, six or fewer years, the profitability of the system increases In fact, rice monoculture appears to be more profitable than rice-pastures establishment in the eight-year time horizon Yet, rice after rice in monoculture is not a sustainable activity in the acid savannas

Conclusions

Rice and legume-grass pasture farming systems for the acid savannas of tropical Latin America seem to be a real possibility supported by semicommercial trials and initial economic analyses

The high expected profitability and cash flow profile suggest that diffusion of this technology would not require large amounts of credit However, profitability is just one

condition for the adoption of these sustainable systems In fact, a rice monoculture appears, in the mid-term, to be more profitable than rice-pastures systems Yet, it is not sustainable Well adapted rice germplasm opens important new alternatives for the acid savannas, but there is an urgent need to explore management alternatives within the savanna ecosystem with a wider set of more suitable germplasm, to achieve truly sustainable crop-crop and crop-pastures rotation systems

Policies undoubtedly play a key role in preventing unsustainable systems from being widely adopted, but such a task will be easier if researchers can offer a wide spectrum of viable sustainable technologies attractive to local investors Better soil management practices and natural resource conservation together with new crop and pasture rotation alternatives respond to the growing need to replace monocultures and establish or renovate pastures in the acid savannas of Latin America

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Table 1 Economic indicators for Latin America and selected countries for the 1980s

Region and country	Per capita GDP growth 1981 89a	Inflation rate 1989	Urban unemployment 1989	Foreign Debt Balance 1989 Total (US$ billions)	Foreign Debt Balance 1989 Per capita (US$)	Trade balance 1989 (US$ billions)[b]	Central govt's deficit as percentage of GDP 1988
LATIN AMERICA	8 3	994 2[c]	n d	415 9	945 8	28 0	-
Brazil	0 4	1476 1	3 6	111 1	754 1	16 0	11 7[d]
Mexico	9 2	18 2	3 0	99 9	1148 2	0 2	14 2[e]
Colombia	13 9	27 1	9 8	16 5	543 1	0 8	1 4
Venezuela	24 9	90 0	9 7	34 8	1810 0	5 0	2 9
Argentina	23 5	3731 0	8 0	61 1	3477 8	5 4	1 7

a Accumulated variation, 1980 89
b Exports minus imports of goods and services
c Average, weighted by total population
d 1985
e 1987

SOURCES CEPAL (1989) and IDB (1989)

Table 2 Relative participation of the Cerrado in Brazil's agricultural production

	Cerrado as % Brazil Area	Cerrado as % Brazil Prod	Brazil Ha (millions)	Brazil Tons (millions)	Cerrado Ha (millions)	Cerrado Tons (millions)
Rice	36 6	27 8	5 8	12 0	2 0	3 5
Soybean	31 1	34 6	10 5	18 1	3 0	6 0
Maize	12 8	16 5	13 1	24 0	1 5	2 0

SOURCE Teixeira and Sanint (1988)

Table 3 Recent evolution in crop area and production in Meta, Colombia's eastern savannas

Crop	1985 Production 000 tons	1985 Area 000 ha	1988 Production 000 tons	1988 Area 000 ha
Sorghum	35 2	14 4	25 4	10 6
Soybean	9 6	0 7	22 5	15 0
Rice	273 8	61 5	441 5	103 0
Cotton	5 3	3 8	4 0	5 2
Palm oil	11 8	7 9	56 4	18 8

SOURCE URPA (1989)

Table 4 Evolution of cattle production and productivity in Latin America 1966 88

Region	BEEF Annual Growth Rates (percent) Production	Stock	Production/ per head inventory	MILK Annual Growth Rates (percent) Production	Stock of milking Cows	Production/ milking cow
Tropical Latin America[a]	2 2	2 7	0 5	3 2	2 2	1 0
Temperate Latin America	0 7	0 4	0 3	1 4	0 9	0 5
Total Latin America	1 6	2 1	0 5	2 7	2 1	0 6

a Total Latin America excluding Argentina Chile and Uruguay

SOURCE Authors calculations based on FAO data

Table 5 Deforestation of the Amazon Basin, Brazil 1978 88

State or Territory	Total area (km^2)	Area Deforested (km^2)			Percent of area in state or territory		
		1978	1980	1988	1978	1980	1988
Acre	152 589	2,464 5	4 626 8	19,500 0	1 6	3 0	12 8
Amapa	140 276	170 5	183 7	571,5	0 1	0 1	0 4
Amazonas	1 567 125	1,785 8	3,102 2	105 790 0	0 1	0 2	6 8
Goias	285 793	10 288 5	11 458 5	33,120 0	3 6	4 0	11 6
Maranhao	257,451	7 334 0	10 671 1	50 670 0	2 8	4 1	19 7
Mato Grosso	881 001	28,355 0	53,299 3	208,000 0	3 2	6 1	23 6
Para	1 248 042	22,445 3	33,913 8	120 000 0	0 8	2 7	9 6
Rondonia	243 044	4 184 5	7 579 3	58 000 0	1 7	3 1	23 7
Roraima	230 104	143 8	273 1	3,270 0	0 1	0 1	1 4
Total	5 005 425	77 171 8	125 107 8	598 921 5	1 5	2 5	12 0

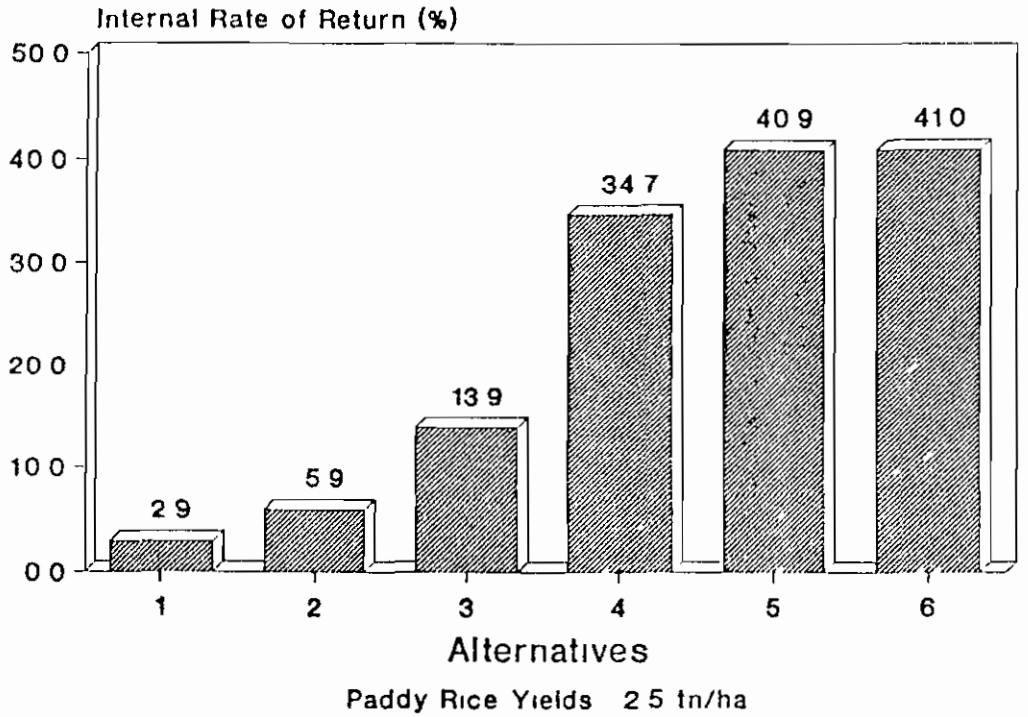
SOURCE Gester (1989)

Table 6 Mato Grosso use of crop rotation in alternative production systems, 1987-88

Crop Rotation with	Rice	Soybeans	Maize
After Cerrado	45 3	7 4	3 9
After pasture	4 6	4 6	2 0
After rice	28 1	35 2	11 8
After soybeans	14 1	38 0	62 7
After maize	1 6	1 8	5 9

SOURCE Teixeira et al 1989

Figure 1 RICE PASTURES ALTERNATIVES
Comparative I R R



Paddy Rice Yields 2 5 tn/ha

Figure 2 NET MARGINAL CASH FLOW
legume-based pasture vs
rice & legume-based pasture