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LOCAL INNOVATIVE SOCIAL DECISION SUPPORT SYSTEM: A PROPOSAL FOR TRANSITION TO COMPETITIVE ECO-DEVELOPMENT IN TROPICAL FRONTIER AREAS

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to
Gladys, Juliana
and Santiago
for their
courageous
support and patience

and to
the Little Prince,
wherever he maybe,
for his
inspiring courage.

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A C K N O W L E D G M E N T S

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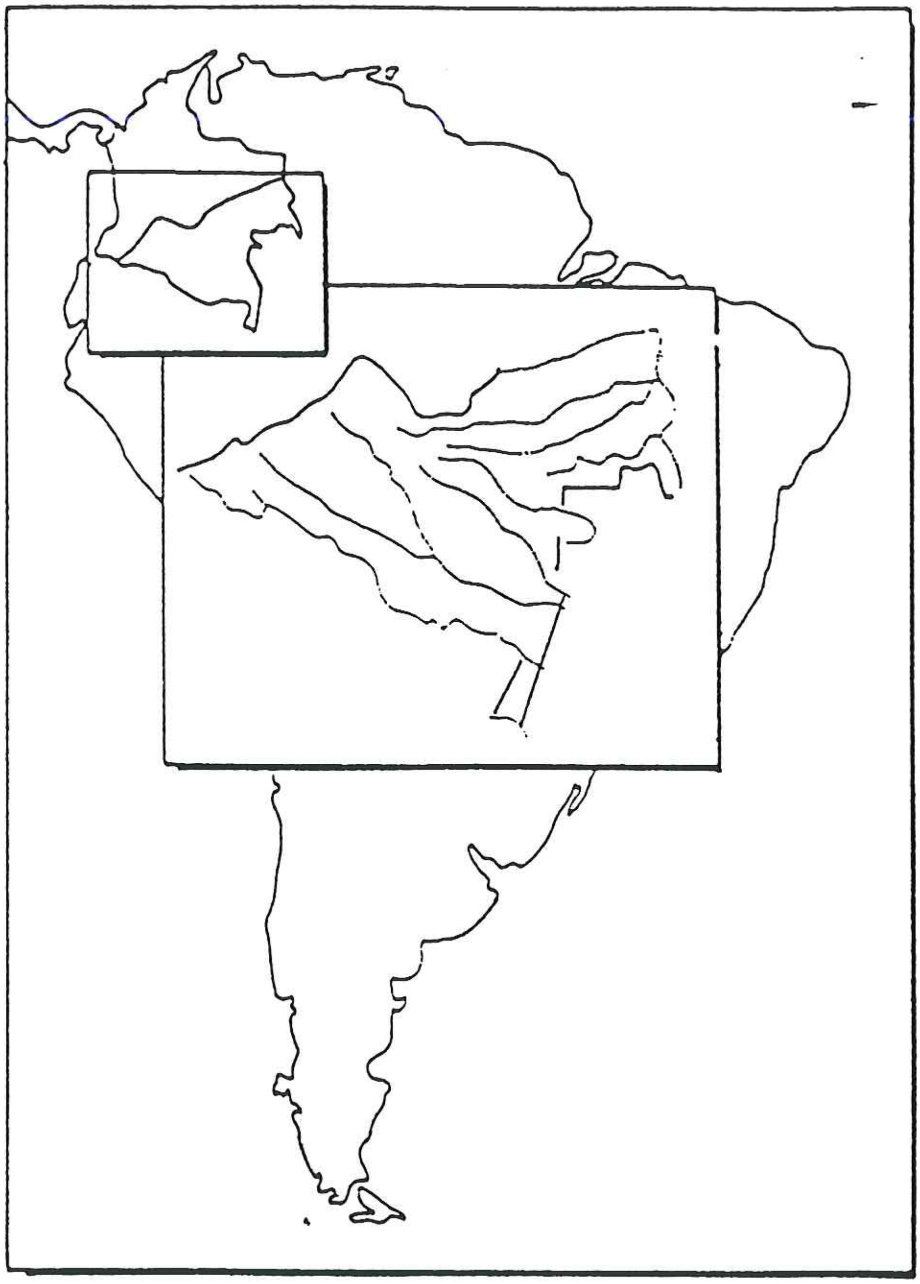
Figure 1



General localization of the Colombian Amazon Rainforest

Source: Etter,1992

Chapter I

Tropical rainforests: What to do with them in the future?

By 2030 the Worldwatch Institute reckons that an increasingly prosperous and industrialised China will need to purchase on the international market 200 million tons of grain for its 1.6 bn people -as much as is exported today by all the world's countries. The OECD is confident that science and technology can produce enough to meet these needs and cope with the demand of a doubled world population, expected to reach 10 bn by 2050, without commodity "price shocks". But even so, it is not clear whether the present pattern of agricultural production based on input and pollution intensive technologies applied to wealthy resilient landsystems, will allow to get food and other basic commodities to the people who need them most: ie. the poorest families in the most fragile and vulnerable landsystems, which will account for most of the expected increase in population. (Serrill, 1994).

More of the same or is it time for change?

Present patterns of technological innovation based on mechanistic manipulation of inputs and factors of production in search of optimising throughput, will therefore soon be rendered ineffective by problems of politics: distribution and utilisation of commodities produced elsewhere, sadly leads to the power struggles, wars, social, economic and environmental chaos which the world is already witnessing in poverty stricken areas (ibid.).

Tropical rainforests are among the oldest most complex and fragile landsystems on earth. They are also among the most vulnerable to depletion and degradation, as many of them represent one of few sources of resources directly accessible to the poor to meet their immediate needs. As has occurred in the past, it is foreseeable that governments facing the coming demographic and economic pressures will continue to use tropical forests as escape valves. Employment and regional development benefits associated with extractive activities, infrastructure development and agricultural settlements in the tropical forest will continue to be overestimated in political calculations, especially as costs of fuel and energy double in the next decade and claim a greater share of national income (Gilis and Repetto,1988; Schucking and Anderson,1991; Carr,1994; Woodall,1994).

Environmental policies that are not aimed at developing patterns of technological and organisational innovation which allow for sustainable and competitive expansion of local economies in tropical frontier areas, will therefore contribute very little to the conservation of tropical rainforests. To be effective, such policies must support the development of local competitive strategies based on sound management of the natural flows of energy and materials which take place in these landsystems. Local social, institutional, technological and economic capabilities have to be constructed in order to create and support a social dynamic of interaction and adaptive response, that leads to cooperative efforts to maintain and increase the local environment's productive capacity, even in the face of sudden or cumulative shocks such as war or climatic change.

Presentation of the paper

This paper attempts to examine the possibilities and conditions for developing a sustainable competitive strategy for a tropical frontier economy located in the northwestern fringes of the Amazon rainforest, in the Departamento de Putumayo, Colombia. It argues that this is possible through the development of local cost advantages and product differentiation opportunities based on the use of the enormous flows of sunlight, rainfall, nutrients, and beneficial plant and animal populations, that take place between the heterogenous structures of the tropical forest landscape. It also maintains that the capabilities needed to crystallise this competitive strategy based on eco-development principles, can be locally constructed by means of a decision support system designed to coordinate and integrate the flow of information and decisions made by public and private agents which affect local environmental management, socio-institutional development and techno-economic efficiency.

Subsequently a palm heart processing project currently being established in the area is used to illustrate the way in which the capabilities required for such a decision support system could be developed in the local setting of a tropical frontier economy. Following the basic procedure designed for the operation of the local innovative social decision support system (**LIDS**), the project is analyzed and several interventions by public and private agents that would contribute to enhance its robustness are highlighted. In the conclusion, some final considerations are made regarding the feasibility of establishing a social dynamic of this nature in the context of the overwhelmingly informal, illegal, violent and low skilled economy of the area.

It is hoped that this paper can contribute to the ongoing debate in relation to the prospects of constructing competitive economies based on pollution free productive configurations. But even more so, it is hoped that it will contribute relevant elements to regional and local policy makers in guiding the use of the massive revenues that peripheral economies in Colombia will receive in the mid term future from the development of the Cusiana oilfields. The future of the natural resource base of these areas will depend on how successfully these revenues are used in order to make these diversified competitive economies.

Chapter II

Economic expansion in tropical frontier regions: The case of the Colombian Upper Amazon Basin.

Limited income and market size as well as the bottlenecks caused by heavily regulatory trade policies, resulted in a generalised "investment strike" in the dynamic sectors of the colombian economy during the 1980's, that seriously undermined its possibilities of continued expansion. Policy changes beginning in 1991, eliminated import quotas and reduced tariffs on imports, pushed for free trade agreements, liberalised foreign exchange and investment regimes as well as labour legislation, and began to privatise public assets (Peelen and Nijmanting, 1994).

The consequent macro-policy environment has thus led to an openly export oriented growth model, which is encouraging investment and dynamic economic expansion based on renewable and non-renewable resource export: products with high resource and energy content such as oil and derivatives, coffee, coal, gold, emeralds, cut flowers, seafood and fruits among others, represented more than 2/3 of export in 1992 (UNIDO, 1993; EIU, 1994).

However the government is also giving priority to diversify exports into manufactured goods such as apparel, textiles, leather goods, light manufactures, autoparts, chemicals, printing services and books. Simultaneously it is expecting a large inflow of dollars in the future as a result of income coming from large oil reserves discovered at Cusiana, in eastern Colombia.

The present value of the revenues of national profits and royalties generated by Cusiana in the period 1007-2002 is reckoned to be close to US $ 19.4 bn. Part of these receipts (36-40%) will be deposited by the central government in a stabilisation fund abroad in order to mitigate the pernicious effects that a massive strengthening of the peso which could cause to national competitiveness. The rest will be distributed directly among regions and municipalities, royalties, transfers and ECOPETROL. (See Table II.1) Particular attention will be devoted to infrastructure and social development in peripheral areas of the country (Gaviria,1993; República de Colombia,1993; EIU,1994).

Table II.1
Distribution of annual national profits from Cusiana
1997-2002
(Present value)

	US$m
Producing municipalities	14.9
Non-producing municipalities	17.9
Port municipalities	22.3
Fondo Nacional de Regalias (Royalties)	299.8

Source: Press report cited by EIU, 1994: 12

This chapter will look at the context of the tropical frontier economies in the Amazon region of Colombia, and assess their possibilities of taking advantage of the present favourable circumstances for sustainable economic expansion. It will conclude discussing some ideas about the orientation of policy intervention in order to develop sustainable and competitive local economies in tropical frontier areas.

The context of peripheral economies in Colombia

Market expansion in Colombia was initially based on income generated mainly by agriculture. Specialisation in export crops -tobacco, coffee, bananas, sugar cane, and cotton among others- encouraged expansion of the agricultural frontier as well as of the demand for manufactured goods. Protectionist tariff policies adopted from the beginning of this century evolved into an import substitution strategy for industrialisation. Favourable relative prices for industry in the expanding domestic market led to the formation of modern family based regional oligopolies, which controlled leading industries in Medellin, Bogotá, Cali and Barranquilla. A distinctly concentrated process of economic diversification followed. Large scale industry and trade controlled by oligopolies backed by nation-wide operating banks, took over small and medium firms in intermediate towns, many times integrating vertically into forward and backward direction and diversifying into related and unrelated activities (Helmsing, 1986).

Asset accumulation in the major centres of industrial expansion led to rapid urbanisation in a reduced number of regions, in the midst of a demographic explosion, with population growth peaking over 3.0% in the 1960's. Annual urbanisation rates in metropolitan regions were even greater, ranging from 4.0 to 6.2% in the intercensal period between 1964-73, and averaged around 3.2% in the following decades (Helmsing,1986; IDB,1992).

Non-farm activities clearly predominate in the economies of these highly urbanised regions, where nearly 46% of the total population lives (75-99% urban), and more than 64% of urban wage employment and 70% of GDP are generated. Consequently real per capita income in these areas has steadily been above the national average (Uribe,1990; DANE,1991;1994).

Other regions with comparative advantages such as Boyacá (iron ore mines) and Cundinamarca (non metallic ores) or with locational advantages such Bolivar and Santander (petrochemical complexes) have benefitted of large scale public and private investment, and have in this way developed an intermediate goods sub-sector with forward linkages to commercial agriculture as well as industries in metropolitan areas. With a share of total population of around 17% and an overall degree of urbanisation ranging from 45% to 71%, these intermediate regions are estimated to have a real per capita income slightly above the national average, sustained by their export oriented regional intermediate goods industries (ibid.). This particular condition is thought to have spared these regions of the effects of the de-industrialisation which has most evidently affected the rest of the non-metropolitan areas of the country, during the past 35 years.

According to Uribe (ibid.), in 1970 pesos, per capita values of industrial production outside of metropolitan and intermediate regions fluctuated between 0.21 and 0.72 in 1960, and 0.17 and 0.65 in 1974. The level of industrial diversification in these regions was also lower, with the Gibbs-Martin indexes ranging from 0.30 to 0.75 in 1960 and 0.26 to 0.64 in 1974 (See Table II.2).

Table II.2
Colombia: Type of industrial regions
(Mean Values)

	Metropolitan		Intermediate		Rest	
	1960	1974	1960	1974	1960	1974
Level of industrialisation (value/capita output)	1.8	2.4	0.9	1.4	0.3	0.4
Degree of diversification (Gibbs-Martin index)	86	88	74	70	48	42
Product orientation (% value added by non-durable industries)	43	40	56	55	95	97

Source: Uribe-Echevarria, 1990: 297.

Based on the analysis of national and regional employment, productivity, and output data for Colombia in the period 1960-75, Uribe (ibid.:302-4) argues that per capita industrial production in peripheral regions failed to respond significantly to income variations there, despite increases in agricultural productivity and income resulting from the development of commercial agriculture in many of these areas. Major factors to which this phenomenon can be attributed to are:

1. Modernisation of agriculture has tended to increase propensity to import in rural regions.
2. Except for food-processing activities, the bulk of intermediate goods consumed in other industrial sectors are imported from metropolitan areas, which make them more favourable locations for industry in general.
3. As capital returns on consumer goods diminished, import substitution policies focused on favouring non-agrobased intermediate industries. Thus competitive advantages achieved in industrialised regions were reinforced <u>vis a</u>

vis rural regions.

In general, trade policies strongly favourable to capital intensive industries located in metropolitan and intermediate regions, together with effective rates of protection discriminating against simple consumer goods and processed agro-based products, have contributed to maintain income in peripheral regions at around 80% of the level in intermediate regions (ibid.). Lower income levels in these areas has also spurred further migration to metropolitan centres.

Migration and economic integration of tropical frontier areas

Migration is frequently described as the mechanism through which labours's mobility as a factor of production is accomplished. It is also associated with loss of productivity or depletion of assets, which cause income to become unsustainable and motivates migrants to seek for better income opportunities (Todaro,1981). In Colombia migration has clearly originated during the past 40 years from rural localities of peripheral regions. Between 1951 and 1964 it is estimated that over 61% of all migrants were attracted to the four major metropolitan regions and of these, 55-71% settled in urban areas (DNP,1972 cited by IGAC, 1986:39).

At the same time, almost 39% of migration in the period was directed to other peripheral regions and more than 17% of the total migrated to frontier areas, mainly to colonise public lands in the savanahs and tropical forests of the Orinoquia-Amazonia and the middle Magdalena river basin (ibid). In the period 1960-67 population growth in the area of the Territorios Nacionales (which includes all of the Orinoquia-Amazonia plus the islands of San Andrés and Providencia) was estimated at an average annual rate of 5.2%, and 4.7% for the period between 1967-75. Census projections indicated that in 1981 the total population of the Orinoquia-Amazonia was 1'189.206, representing almost 5% of the nation's population. Excluding the relatively urbanised Departamento del Meta (350.000 inhabitants of which 62% were urban), only 19-31% of the population lived in concentrated urban areas (ibid:44; DNP,1977:64 cited by Helmsing,1986:83).

Several factors help explain such significant migration to rural areas in this very peripheral frontier region. One is the fact that since the 1950's, peasant crop production began to be displaced by commercial agriculture in Colombia (cotton,rice, sesame sorghum, soya and sugar cane), away from areas connected to the central market circuit which integrated Bogota, Medellin and Cali. As capitalist production extended during the 1960's based on input intensive agriculture, the less profitable crops such as cotton began to compete for land in the extensive livestock production areas of the Costa Atlántica. As a result, livestock production shifted to the marginal grasslands that were being established in the savanahs and tropical forest frontier areas by colonisers (Kalmanovitz,1978; Helmsing, 1979; 1982).

Conditions in frontier areas were thus fairly attractive, especially for "assetless" migrants. On one hand , markets for commercial timber operated on a regular basis in the area and offered reliable -though exploitative- income opportunities for newcomers. Once having claimed a plot of public land by demarcating boundary paths in the forest, colonisers could easily obtain cash advances from intermediaries in order to purchase the equipment and provisions necessary to extract all the commercially desirable timber on their plots and establish subsistence food crops for themselves.

Rapidly decreasing productivity of tropical soils when these are cleared of forest cover, left cultivated land suitable only for grazing after no more than three harvests. Expanding livestock industry in the area, also subject to decreasing productivity as grassland soils were completely depleted, spurred an active market for recently cleared land for livestock. Unsustainable as it was, the process of natural stock liquidation nevertheless represented a short term opportunity for "asset" formation especially for the least well off colonisers, who usually were unable to generate sufficient income to acquire their own livestock (Helmsing, 1982).

In this way frontier regions offered a combination of exploitative but reliable markets and access to unremunerated natural resources, which allowed for informal self-employment opportunities to be taken with minimal -or even total absence- of capital resources. Thus another factor contributing to maintain rapidly growing migration to the region well into the 1980's, was the economic recession that took over in the beginning of that decade. Originally sparked by a drop in basic commodity prices in the world market, the recession affected most severely the agricultural sector: wage employment in coffee and commercial agriculture shrunk at an average annual rate of 4.4% between 1978-84. Consistent with this trend, rural non-wage employment increased during this period at this same annual incremental rate (Ocampo and Ramirez, 1987:66; see Table II.3). A simultaneous average rate of 6.9% increase in annual migration towards the Orinoquia-Amazonia was also observed (IGAC,1986:170).

Table II.3
Colombia: Employment tendencies 1958-84
(annual incremental rate %)

	1958-68	1968-78	1978-84
Urban employment	**4.0**	**4.9**	**3.7**
Wage employment	3.8	4.8	2.69
Public sector	5.9	7.7	4.5
Private sector	3.6	4.3	2.3
Services & others	4.3	4.7	2.6
Manufacturing	2.4	5.2	0.8
Construction	1.9	0.8	4.5
Non-wage employment	4.4	5.1	6.2
Unemployment	12.8	3.1	10.8
Rural wage employment	**1.0**	**0.8**	**0.9**
Coffee	-1.6	3.6	-4.4
Commercial crops	3.0	3.6	-4.1
Rural non-wage employment	0.8	-1.3	4.4
Total employment	**2.5**	**3.2**	**2.7**

Source: Ocampo J.A. and Ramirez M (1987:66)

Thus as occurs in urban areas during recession (Uribe, 1991), overall diminished income opportunities in this phase of the economic cycle induce greater self-exploitation and natural stock dilapidation than usual in rural areas in frontier regions, as the marginal value of the resources exhausted in the process (forest, soil, superficial and underground water resources) is reduced proportionally to the scarcity of income opportunities available in these areas.

Evidence produced in 1975 by a study carried out by the Instituto Colombiano de Reforma Agraria (INCORA) in Guaviare (part of the Amazon region) supports the idea that rural areas in frontier regions play an important role absorbing rural and urban non-wage employment in the economy: only 27.7% of settlers in this zone came here directly from their place of origin, while 72.3% had lived in other areas before settling in Guaviare. Of this last group at least 23% had lived for some time in Bogota and other cities of the country, before coming to settle here (IGAC, 1986:168).

As often happens in exploitative urban informal markets (Bromley, 1978), varying degrees of violence and illegality are often vital elements for efficient market operation in frontier rural areas. In the context of these completely unrestricted or illegal markets, intermediaries play an oligopolistic role and make use of controlled violence in order to assure low transaction costs, as well as to protect "franchise" rights in their areas of influence. With the spread of coca leaf cultivation and processing in the region from the end of the 1970's onward, violence and official corruption became the predominant mechanisms on which markets operated. Highly lucrative margins due to the illegality of the activity resulted in further migration to the area and specialised adoption of the "export crop" by most families. However as traditional foodcrops were neglected, family incomes were burdened by the cost of foodstuffs supplied by intermediaries to a point were they became unsustainable; renewed land concentration in the hands of intermediaries in these areas was only avoided due to the encroaching presence of guerrilla groups (Fuerzas Armadas Revolucionarias de Colombia -FARC-). In exchange for a tributary burden (10% and 8% of producer and intermediary revenues, respectively), wages, working conditions and commercial transactions were regulated and crime was controlled by the guerrilla. Stability of colonisers on there plots was another benefit of their involvement in the area (van Vliet, 1987; Molano, 1987).

Violence nevertheless was intensified towards the end of the 1980's due to simultaneous and crossed confrontations between the guerrilla, the drug cartels and the government. However the impact of generally sustained higher incomes resulted in an increased demand for improved housing, services (education, health) and more diversified consumption. Consequently urbanisation increased (particularly in Caquetá and Putumayo where urban share of the population grew to 49.8% and 48.2% respectively in 1993), and assets there were concentrated in service and commerce activities: in 1990 43.6-46.1% of urban employment in Putumayo and Caquetá was generated by the service sector while 42.2-44.5% was linked to commerce. Between 3.9-6.1% of the employment was linked to construction, transport and other activities, and only 5.8-7.8% was involved in manufacturing (DANE, 1990; 1994).

Sustained higher incomes therefore did not translate into diversifying the areas primary or secondary sectors. This was probably due to the instability created by the continuous sabotage and obstruction of physical infrastructure in the area, a frequent military tactic used by the guerrilla. Complete isolation from the nations main power grid is another constraint for investment in industrial activities, apart from the sectoral and macro-policy considerations already discussed. Taking advantage of the overall slump in investment in the consumer goods industry during the 1980's in Colombia, a number of small and medium industries and services firms located in the neighbouring Departamento del Huila have developed recently, and now dominate their market niches in the larger urban centres of Caquetá and Putumayo.

Sustainable development prospects in tropical frontier economies

The economic circumstances of the near future in Colombia are bound to create during the next 10 years a favourable investment climate in peripheral frontier economies, such as those of Caquetá and Putumayo. But are these prepared and capable to absorb investment productively? As Uribe (1990) observed in regards to the overall context of peripheral regions in Colombia, the relatively sustained increase in income which took place in the area when coca leaf growing and processing became a basic activity from the 1980's on, has not translated into the diversification of the region's economic structure. In consequence, most consumer goods and services markets are expanding and integrating in the area by means of imports from metropolitan and some neighbouring peripheral regions. Thus income growth is contributing to asset formation and internalisation of income multiplier effects elsewhere in the economy.

In the context of the heavily protected and regulated economy of the past, this same pattern of market expansion and integration led to the general de-industrialisation of peripheral regions, depressed factor costs and brought about natural resource asset dilapidation and depletion. Does the new economic and policy environment bring new opportunities for frontier regions to develop basic economic activities that will allow them to diversify away from its present illegal export crops, and benefit from the cumulative effects of sustained income growth[1]?

As mentioned already, urban employment in peripheral frontier economies such as those of Caquetá and Putumayo is located mainly in services (43.6-46.1%) and commerce (42.2-44.5%). As occurs in the rest of the country these activities are carried out by informal units, with an average of 3.2-3.7 workers in service activities and 1.7-2.9 workers in commerce. Manufacturing, which represents 5.8 to 7.8% of urban employment, is also done in mostly informal units with an average of 2.4-2.6 workers, well below the nation's average of 9.1 workers per industrial establishment (DANE, 1991). Figures are not available regarding the level of education, but it is certainly lower than the national average[2], because of the nature of the predominantly assetless, self-employed migrants which have been attracted to these regions in the past.

The degree of informality of these economies in contrast with the nation as a whole is reflected particularly well by the share by size of establishments in industry. While in 1990 an average of 53.9% of the nation's industrial establishments occupied over 50 workers, 95.2 to 99.6 of the industrial establishments in frontier areas (<u>Intendencias</u>) employed less than 10 workers. Evidence shows that informal units involved in activities with minimal requirements of capital, technology and skills, will deliver very simple goods and services that will at best attend a local low income household demand. As household income becomes differentiated in the context of overall income growth, opportunities will be available for these units to specialise and cater for the specific demand "niches" that will emerge (López, 1986; Uribe,1990;1991, DANE,1991).

However it is difficult to see how these micro-units will develop to become the core of the region's basic economic sector, capable of tapping external growth markets and fuelling local economic activity by means of income multiplier effects. Past performance of SME located in metropolitan areas indicates that even this type of enterprises have a low export orientation, and there are few -if any- examples in Colombia of SME's performing a successful and sustainable role as basic economic sector[3] (Uribe and Correa, 1984; Escandón and Berry, 1993).

Potentials and conditions for economic expansion in tropical frontier areas

Rapid regional income growth has occurred in Colombia in those areas where industrial output is concentrated, and where large capital intensive industries involved mainly in import substitution have created favourable conditions for the development of linkages and multiplier effects. Moderately unfavourable relative prices for agricultural products under this model of industrialisation, led growth in total output and total factor productivity in the sector to benefit consumer income more than remuneration of factors involved, and therefore hindered dynamic income growth in regional economies based on agricultural exports[4] (Uribe,1990; Berry,1992).

The elimination of relative price bias against agriculture should favour income growth through expansion of exports as well as by means of direct linkages associated with growth of output in agroindustrial activities and of value added in commerce and transportation. However the impact of the resulting multiplier effects on local economies will depend on the presence of under-utilised resources (ie. excess installed capacity in agroindustry) or resources with very elastic supply (ie. semi-skilled labour). Where neither of these conditions exist, they will have to be created in order for income growth to be translated into internalisation of linkage-multiplier effects and cumulative income growth (ibid.).

At present the tropical frontier economies under discussion do not posses either of the above mentioned conditions. Growth of beef cattle and coca paste, the region's main agricultural exports, is not sustainable in the long run due to the nature and dynamics of tropical landscape, where productivity does not respond to intensity of input use. The region however, does have a very under-utilised resource represented in the structure, function and natural productive interaction of the diverse landscapes contained in the tropical rainforest. This diversity could become a source of comparative advantage for the development of technological knowledge based on innovative material use and productive process organisation. Rather than an input intensive, a knowledge intensive use of the alluvial and sedimentary plains that constitute the large proportion of the Amazon rainforest, could harness the flow of energy and nutrients through which these landscapes interact and are transformed, and bring forth an elastic supply of goods and services based mainly on renewable sources of energy and materials[5].

Peripheral frontier economies cannot attain sustainable dynamic growth and develop while dependent of oligopolistic markets and are subject to rent seeking, exploitative practices. As elsewhere, the competitiveness of these economies will depend on the establishment of export oriented physical infrastructure and the development of an innovation based competition strategy[6]. Such a strategy will be based on a cooperative effort focused on initiating and expanding a process of creative organisational, technical and social learning aimed at achieving high levels of productivity in export activities. The effectiveness of this process will depend largely upon the coordinated involvement of various levels of public policy making and administration, as well as of finance and producer/social/environmental associations, among others, in identifying bottlenecks and allocating resources to design, organise and operate solutions for them (Matus,1987; Esser, 1993).

In the context of developing a local economy based on a competitive strategy, the process of public and private decision making is envisioned as a closely knitted stream of decisions which respond to present needs and changing situations. Simultaneously their impact is permanently monitored through an information system focused on critical and concrete problems and operations. Thus the main objective of regional end local government policy in these areas is to support the development of business opportunities in economic activities where possibilities of success are good, attract resources to support critical services, and improve infrastructure in key areas and locations. Effectiveness in the use of public resources destined for social needs will be improved, in as much as they are concentrated on overcoming the constraints that are not allowing vulnerable groups -especially those who earn their living through self-employment or in informal units- to have access to resources needed to benefit from the opportunities that are being opened.

1. Income in coca growing and processing areas can be expected to remain higher than in other peripheral regions as long as this activity remains illegal. The high risk situation of the activity disincentivates "price cutting" in consumer markets as a viable competitive strategy in the business, as risks of capture per kilo of cocaine become smaller with increase in scale of operation. Taking advantage of an elastic "addicted" demand, the market keeps margins at levels high enough to compensate risks of the smallest scales of operation, giving larger operators a "situation rent". Increases in efficiency of distribution of the commodity are passed on to consumers preferably through improved quality: according to DEA-Miami cocaine purity rose from 30% in 1981 to 50% in 1985, while prices per gram declined from US$ 120 to $100. See Cartier-Bresson et al, 1994.

2. The 1993 census estimates that 49.3% of the population in Colombia over 5 years of age, has reached primary level education, 33.4% secondary and 8.5% higher education levels, respectively. The remaining 8.8% have no formal level of education. See DANE, 1994.

3. In Colombia most branches of manufacturing had a ratio of exports to outputs of 6% in 1988. DANE data for the late 1980's however indicates little difference in the share of output directly exported by SMI (8%) and LSI (10%). See Escandón and Berry, 1993.

4. According to García and Montes (1989:54) the negative transfer due to direct price interventions were little more than offset by non-price transfers to the sector (credit subsidy and public expenditure on the sector), but that the indirect price effect through the overvaluation of the exchange rate accounted for a substantial net out-transfer of 12% of sectoral value added over the period 1965-83. Cited by Berry 1992:207-8.

5. It is foreseen that increasing industrialisation of third world countries will boost demand for raw materials and especially for energy, as these economies grow richer. The International Energy Agency (IEA) forecasts that developing countries' energy consumption will more than double by 2010, raising world energy demand by almost 50%, and that by 2005 the real price of oil will have also risen by 50% to US$ 28 a barrel (in 1993 prices). See Woodall, 1994.

6. According to Hamel and Prahalad (1994) successful competitive strategies depend on a firm's capacity to visualise in the present how "utility" will be perceived by future costumers. Thus firms should be adopting today the organisation and skills necessary to excel in providing in the future those particular kinds of "benefits": 'user friendly' at Apple,

'pocketabilty' at Sony, 'factory management' at Toyota, 'on-time delivery' at Federal Express. Cited by The Economist, 1994:67.

Chapter III

Indicators for sustainable development of tropical frontier economies

The definition of operative indicators for managing sustainable diversification in frontier economies involves answering a number of questions. The first of them is what does sustainability mean in tropical frontier economies. But also, what is sustainable in this age of competitiveness, continuous economic expansion and globalisition? An finally, what are the socio-institutional structures and processes necessary for developing sustainability and competitiveness as a capacity in this local and global context? In answering these questions we will attempt to identify the key problems and operations that have to be monitored for the responsive decision making and management that are necessary for achieving and maintaining sustainable competitiveness.

Sustainability in tropical frontier economies

Human welfare derives from the stock of assets that sustain the flow of goods and services which are consumed to satisfy needs. Income is the measure of availability of goods and services, and its main practical purpose is to serve as a guide for prudent decision-making: it gives people an indication of the amount of goods and services they can consume in the present without impoverishing themselves in the future, that is, without negatively affecting the capacity of their assets to generate income in the future. But as this flow of goods and services is dependant on the complex interaction of social, technical and environmental possibilities and constraints, it is therefore subject to varying degrees of uncertainty. Consequently sustainability is the dynamic capacity to respond adaptively in order to maintain and increase the productive flow coming from a stock of assets, even in the face of major or cumulative shocks such as climatic change, war, pestilence or erosion (Hicks,1946; Boulding,1966; Norgaard,1988, Pearce,1988, Daly,1988; Pearce et al,1989; Daly;1989; Folke and Kaberger,1992).

Economic growth measured in terms of income is therefore a measure of sustainability: the possibilities of dealing with shocks and uncertainty increase with the size and diversity of the stream of goods and services produced by an economy. Made assets (K_m) such as machinery, infrastructure, factories and technology are critical for economic growth and sustainability precisely because they contribute positively to increase the amount and diversity of goods and services at our disposal. At the same time, natural environments also represent a stock of assets (K_n), which are source of a stream of goods and services critical for economic activity: they supply both non-renewable resources such as oil and ore, and renewable natural resources (ecosystem based) such as biomass, genetic diversity and water, among others. They also provide services such as maintenance of the composition of the atmosphere, of climate, the operation of the hydrological cycle including flood control and drinking water supply, waste assimilation, recycling of nutrients, regeneration of soils, pollination of crops and maintenance of a vast genetic library (Ehrlich,1989; de Groot,1992).

As production based on K_m has a more income elastic demand than that of K_n, and therefore a greater capacity to generate income, much of the debate about sustainability is centred on determining the most sustainable combination of K_m and K_n in the economy. Since K_m allows for increased productive efficiency, its value relative to labour and natural resources is often fixed o that returns to it are maximised. The resulting production function for activities which require natural resources and services as inputs, integrates them to the process in an exploitative manner (ie. their factor costs are not completely covered)[1]. Thus depletion of K_n is "traded off" for K_m accumulation.

For many this trade off is desirable to increase the value of the overall capital stock available for income generation, and therefore represents the optimal path of accumulation as well as for achieving sustainability for future generations. As long as K_m continues to increase intensity and efficiency in the use of energy and information, future needs of the coming generations can be satisfied even with a decreasing K_n base[2] (Morton,1994).

However the measure of sustainability cannot be reduced to income growth. The main reason is the uncertainty which hovers on the interaction between the natural environment and the economy. As there is not complete information about the complexities involved in the production of many natural functions, markets are unable to communicate environmental damage -or exclude open access to their use- by means of price signals. More so, the pervasiveness of the benefits coming from natural environments together with their multifunctionality are often overlooked or unknown, and lead to their undervaluation in income calculations (Pearce,1988; Turner,1988; Pearce et al,1989; Beckenbach,1991; World Bank,1991).

Another reason why income growth by itself may be grossly misleading as a measure of sustainability, is the doubtful soundness of the present path of K_m accumulation. The large scale access and capture of the stock of fossil energy associated with industrialisation, enabled production based on K_m to free itself from the dependency of energy captured of the sun through ecosystem management. The subsequent increase in efficiency and scale of throughput has led to the degradation of life-support systems and particularly, their capacity to assimilate waste products and residuals coming from the economic process[3]. As a result, natural regenerative capacity in many areas has been affected , and the resilience of their ecosystems as well as their overall carrying capacity has been diminished (Ayres,1978; Norgaard,1988; Turner,1988; Folke and Kaberger,1992;Daly,1993).

After pressure exceeds certain (usually unknown) thresholds, intricate dependencies and ecosystem interactions based on biodiversity are broken and irreversible effects occur and spill over to future generations: mismanagement of ground aquifers, for example, can lead to degrade them irreversibly as overdraft can result in their collapse or invasion by salt water, and pollution in poisoning as a consequence of the absence in aquifers of the normal process by which sunlight and microbial action breakdown many pollutants in surface waters (Ehrlich,1989). The fact that K_n and K_m are not perfectly substitutable[4], and the possibility that irreversible damage may affect the K_n which provides services like the protection offered by the ozone layer. the climatic regulating functions of phytoplankton or the watershed protection of the tropical forests, seriously undermine the long term sustainability of the present path of K_m accumulation based on optimal substitution or depletion of K_n. Since it is not clear that this path will contribute to enhance the capacity of future generations to respond adaptively to major or cumulative shocks, there is a growing consensus among both ecologists and economists that maintaining the total K_n stock at or above the current level is a prerequisite for sustainability[5] (Pearce,1988; Turner,1988; Pearce et al,1989; Constanza and Daly, 1992; Folke and Kaberger, 1992).

In tropical frontier economies , K_n is by definition the principal asset base from which local populations are directly dependant for their livelihoods: woody biomass and vegetation for fuel, raw materials and livestock fodder; water supplies for domestic and productive use; wildlife meat and fish for protein; crop residues, and animal and organic waste for fertilizer, among others. As the oldest land ecosystems, tropical rainforests are characterised by an enormous and complex set of interconnections based on five to ten times as many species as elsewhere on Earth, and between 100 and 1000 times as many ecological interactions (Raven,1988).

Such complexity has developed in a co-evolutionary dynamic based on flow resources -solar energy, the hydrological cycle, the productive services of plants and animals- each related to each other, but each changing and affecting the evolution of the others (Norgaard,1988). Due to the enormous and permanent pressure exerted by the massive flow of solar energy and water in the tropics, ecological stability in the rainforest is extremely fragile and sensitive to the disruptive use of K_m which does not reinforce the dynamics and potentials of these fundamental flows. Thus the lack of response in productivity to high K_m input use in tropical ecosystems (Janzen,1973), and the poor prospects of natural regeneration of the rainforest where large areas have been destroyed by means of large scale use of K_m based stock resources of fuel energy: ie. tractors and bulldozers in the Brazilian Amazon (Jacobs,1981 cited by Schucking and Anderson,1991:23).

For these reasons, sustainabilty in tropical frontier areas cannot possibly be pursued on the base of substituting any amount of K_n for K_m. Sustainable asset accumulation will depend on K_m which is complementary to K_n, not its substitute. In consequence, in these areas sustainable K_m use will have to reinforce and make productive use of the renewable resource flows -based mainly on the energy of the sun- which determine the dynamics of the natural environment in the tropical forest[6]. Sustainability here will depend on the continued development of values, knowledge, technologies and social structures that fit the long run opportunities of co-evolutionary development based on renewable resources (Norgaard,1988), and are competitive in the medium term (Pérez,1983; Esser,1993)

Sustainability and competitiveness

In an age of continuous economic expansion and globalisation, in which markets have become the predominant mechanism for informing and expressing major individual and social decisions in the use of income and assets, sustainability cannot be properly considered outside the market nor independently from competitiveness. As long as resource allocation depends mainly on markets, sustainability will also depend on the ability of a productive structure to generate revenue in markets, at prices that allow for remuneration of factor costs (capital, labour, raw materials and other inputs) in similar terms as competitors do, and maintain the productive capacity of its assets in order to persist in markets, even in the face of social, technological, economic and environmental changes.

Profit permanently motivates and diffuses innovation in the productive sphere. These innovations, based on key technological developments and their most efficient use in production, help shape through time the main form and direction along which productivity growth takes place within and across firms, industries and countries. Competitiveness arises from taking advantage of the wide range of new opportunities (product differentiation and oligopolistic control of markets in the stages of entry and growth) and developing cost advantages (particularly in the stages of market maturity and decline, through economies of scale, patented or proprietary formulas or production techniques, vertical control of raw materials and/or distribution channels, brand franchise, diffusion of technical standards which cause switching costs to buyers of substitute products,etc.), that emerge in the particular evolution of a given "paradigm" of innovation. Competitiveness is maintained as a consequence of the development of a technological style through a strong feedback interaction between the techno-economic, social and institutional spheres: it feeds on the dynamic complementarity of these spheres that incrementally leads to a "best practice" frontier, increasing productivity and profits.

(Pérez,1983, Austin,1992; Esser,1993).

Within a given technological style, the possibilities of incremental improvements in technical efficiency are based fundamentally on the development and use of a key "cost-cutting" factor. That is, an input which is potentially pervasive in the productive sphere as it allows for savings in labour, materials or capital, and creates opportunities for qualitative product differentiation. At the same time, it is also an input of which there is practically unlimited supply and is thus perceived as having a low and descending relative cost. The development and use of such a key factor largely determines the overall relative cost structure and scale of an economy, as more and more branches of activity will tend to apply its use to improve their technical efficiency, total output, and total factor productivity[7] (Pérez,1983).

Pervasive economic depressions, in which total factor productivity and output fall, are the result of the cumulative disruptions in the previously predictable evolution of most markets caused by the introduction of new key factors which alter the overall cost structure of technical efficiency. But it is also the result of the natural inertia of social and institutional structures functional to the former technological style, which fail to transform responsively to the characteristics of the new technological style[8]. Consequently factor productivity recovers only when obsolete and counterproductive social and institutional structures are replaced through innovation, by others that are complementary to the newly attained technological style or best practice frontier[9].

The long run sustainable competitiveness of an economy will therefore increasingly depend on its capacity to transform itself adaptively. To do so successfully, local economies will have to develop a locally based system of innovation, through which a permanent, interactive and creative organisational, technical and social learning is institutionalised. It aim is to improve the responsiveness of its techno-economic, social and institutional structures to any circumstance affecting the stability of its markets and the relative cost structure on which technical efficiency is based. As the development of such a capacity requires close coordination of a multiplicity of efforts and resources coming from a range of economic and social actors, as well as various levels of government, local competitiveness usually is better achieved through close relationships of coordination and flexible networks of the various actors.

Two basic conditions have to be established before any locally based competitive strategy can successfully operate, and are therefore considered as pre-competitive structures: **1)** an export oriented physical infrastructure; and **2)** the development of technological competence and all the infrastructure necessary to support it (ie. highly user oriented vocational schools and technological learning centres, testing and quality assurance facilities, R&D and financing centres, technology transfer services, and factor and product marketing networks, among others)[10] (Esser,1993). Thus local competitiveness is built on cooperative strategies through which forces and resources are pooled together to interact and complement each other, in order to achieve and maintain a competitive position.

Given the intense use of K_m, the highly qualified occupational profile, and the large scale and intense use of stock energy sources associated with the relative cost structure which at present supports technical efficiency, it is very unlikely that frontier economies can develop any sustainable basis of competition. It is therefore equally unlikely that resources can be pooled here to build local technological competence. However, it is also dubious that the present global relative cost structure can remain stable, particularly in the mid and long term, because of the foreseeable sharp increase in energy and capital costs which is expected by the end of the decade[11]

In such a scenario the "polluter pays principle", which is at the base of many of the best practice frontiers of present day technical efficiency, will be extremely contraproductive and unsustainable. Understood as a disequilibrium in the environment's capacity to assimilate waste as a result of the extraction of exhaustible resources, pollution becomes pervasive and causes long run reduction in both the potential productivity and stability of $\mathbf{K_n}$. Both of these problems are possible to overcome artificially to certain extent, through application of fertilizers and building dams and dikes, for example. But maintaining productivity and stability artificially is not costless and requires the expenditure of "available work" from fossil or other energy sources. Thus a vicious feedback loop leads to accelerating the rate of extraction of exhaustible resources and dispersion of pollution: an extraction occurs and waste discharges eventually flow; these reduce the productivity and stability of the natural environment and to compensate external intervention is required creating demand for additional exhaustible resources[12] (Ayres,1978:48). In the face of increasing capital and energy costs, sustainable technical efficiency will only be achieved on a "pollution prevention pays" principle (Folke and Kaberger,1992).

Constructing and managing competitive eco-development

Developing a competitive basis in frontier tropical economies will therefore be based on a medium to long term strategy, which foresees a scenario with a relative cost structure favourable to best practices and technical efficiency in which pollution prevention "pays". That is , in which renewable flow resources and sources of energy are complemented by K_m in order to enhance K_n natural capacity to regenerate and assimilate waste, while producing a stream of goods and services through which revenues can be generated and a competitive position maintained. Best practice frontiers will probably be management intensive, as efficient, balanced use and control of stocks and flows are critical to prevent pollution. It must be intensive in learning oriented routines that contribute permanently to: **1)** develop local predictive capacity about the functioning of K_n based productive processes as well as of factor and product markets; **2)** construct future scenarios and prepare contingency plans and fall back positions; **3)** develop the capacity of reacting quickly in t e face of the unexpected; and 4) generate and diffuse effective learning from errors committed (Matus,1987).

Thus the "flexible batch production network", where managerial, administrative and productive activities are integrated in a total information intensive system which encourages waste reduction, controls energy use and opens the possibilities of closed loop no-waste systems, seems to be a suitable structure for organising production within this particular competitive strategy (Pérez,1983). However the occupational profile associated with this type of structure (highly qualified at the top and technologically trained at operative levels), indicates the importance of building up the pertinent pre-competitive and support structures.

Therefore a crucial challenge in this process will be to devise a locally based and highly dynamic system of productive innovation, through which permanent and creative organisational, techno-economic and social learning is widely institutionalised. An information system based on indicators and alarm signals, focused on critical problems and operations of the productive process can greatly contribute to single out the skills, routines, technical configurations, norms infrastructure and political services, to which resources must be complementarily allocated in order to support effective learning and innovation. Such a system would thus be the basis for maintaining close and efficient relationships of cooperation between the economic, political and social actors in the process of building local pre-competitive structures, as well as for their subsequent interactive co-evolution in the process of sustaining local technical efficiency (Matus,1987, Beckenbach,1991).

1. Underlying the neo-classical concept of production function is the notion of substitutability: a given product or set of joint products can be obtained from a variety of different combinations of inputs, and one such combination will turn to be optimal under a given objective function and a set of relative factor costs.

However all inputs are not perfectly substitutable: they can be complementary (synergistic), competitive (antagonistic) or fixed. There is no possibility of substitution between complementary inputs because neither is of any use without the other (ie. petrochemical complex and oil). Competitive inputs are those such that the degree of possible substitution has no <u>a priori</u>

technological limit: in principle one factor may completely replace the other (ie. labour and capital). Fixed inputs are those such that the application of other factors can only eliminate marginal wastage: there is a definite physically determined lower limit that can only be approached asymptotically. See Ayres, 1978: 39.

2. The consistency of the present value criterion which supports the common notion of discounting the future in some fashion, also rests largely upon this assumption. Present value is considered a complete criterion because in the context of a "free market", it is a sufficient prescription for allocating efficiently resources and services over time, as long as subsequent generations continue to use the same optimal accumulation path. To maximise present utility, the present value criterion therefore requires future generations to adopt and follow the presently defined accumulation path. See Page,1977; Ayres,1978.

3. This is a major consequence of the entropy constraint to which the scale and throughput of matter and energy passing through the economic system are subject to. See Georgescu-Roegen,1993 and Kaberger, 1992.

In general pollution problems associated with elements and compounds related to hydrogen, carbon, oxygen, sodium, potassium, calcium, silicon, magnesium, aluminum and iron, give rise to environmental problems caused by quantitative excess and imbalances such as silting and erosion, soot and vaporised hydrocarbons, biological oxygen demand (BOD) and oil spills, but not from fundamental incompabilities. All of these problems are feasible to be reduced by a combination of technology and regulations applied to:

- agricultural and construction activities
- combustion of fossil fuels
- waterborne disposal of untreated or partially treated municipal sewage, food processing and pulp paper manufacturing effluent
- oil shipping and operating practices

Pollution problems involving elements such as nitrogen, sulphur , phosphorous and chlorine are pervasive and have uncertain impacts on life supporting systems because when associated with compounds with carbon, hydrogen and oxygen, they become extremely biologically active and sometimes have highly toxic and carcinogenetic effects. Dispersive and dissipative management of these elements increase possibilities of synergetic toxic effects which may affect and breakdown life supporting cycles, and create persistent stock pollutants (ie. substances which have no counterpart degrader populations in the biosphere). All other elements -metal and non-metal- have toxic effects, some more than others. efforts should be devoted to monitor the stock and flow of these elements within the productive circuit and the environment which contains it. See Ayres, 1978.

4. In the case of extractive and service activities either labour or capital can be substituted for each other without an a priori limit. However in activities which involve processing and/or fabricating materials or material components, material inputs bear a fixed or nearly fixed relationship with material outputs. While labour and capital can largely substitute each other, they cannot significantly reduce requirements for materials or energy that are "embodied" in the product: labour and capital cannot create or destroy material or energy inputs; they can only transform them. See Ayres,1978: 39.

5. Thus future generations are allowed in principle to have an equal vote in the selection of their own path for resource allocation. This alternative requires that each generation should pass on its natural resource base without depletion or impairment. For operational purposes resources and depletion should not be measured in physical terms but in terms of their prices relative to the overall economy. A 'no depletion' rule means that the overall index of virgin resource prices should be held constant or declining. A number of management options exist in principle for doing so, including:

- orientation of technological progress to understand and manage flow (renewable) resources efficiently
- exploitation of renewable resources at a rate equal to the creation of renewable substitutes
- fostering diversity of belief systems, environmental systems, organisational systems and knowledge systems, as well as the necessary conditions for their evolution in a mutually reinforcing, in order to increase the overall capacity to adapt to future surprises.

See Page,1977; Ayres,1978; Turner,1988; Norgaard,1988; Folke and Kaberger,1992.

6. In principle, it is possible to make solar energy available for the purpose of doing useful productive work, through natural landscape heterogeneity. The existence of self organising biological systems on Earth, capable of maintaining their structural parts, is attributable to the planet's location in the thermal gradient of the sun. Biological system heterogeneity is a necessary condition for transforming energy differentials into ordered life structures capable of doing "work" on other physical elements: flows of matter and energy between heterogenous biological systems operate and generate information through feedback mechanisms, giving them high degree of order, and therefore stability.

Increasing spatial and landscape heterogeneity increases energy flows between landscape structures (patches, corridors and matrixes), as well as their potential to do useful work on other systems. Sustainable management of the flow resources available in natural systems therefore requires an understanding and respect for the structure, function and dynamics of landscape change.

Disturbances that affect the forms of landscape structures may alter flows of energy, nutrients and species, cause sensitive species to decrease in distribution, favour the spread of other species into disturbed areas, and eliminate, change or create whole new landscape elements. Disturbances that reduce landscape heterogeneity therefore decrease possibilities managing natural flows, as it diminishes the structures capable of transforming flows into "work".

Moderate disturbances normally establish more patches or corridors and thus rapidly increase landscape heterogeneity. Severe disturbances may eliminate patches and corridors and thus increase or decrease heterogeneity. In general however, severe disturbances disrupt the conservation and regulatory mechanisms holding mineral nutrients in ecosystems.

The decision on whether, where and at what intensity should landscapes be changed for productive purposes will be significantly enhanced by the evaluation of:

- how the heterogenous surroundings will affect the proposed change in landscape structure, and conversely how it will affect them
- the relative uniqueness and recovery time of the present landscape at the proposed location
- the levels of intensity of human influence appropriate to the natural conditions of the site (ie. $\mathbf{K_m}$ inputs/$\mathbf{K_m}$ outputs in monetary and caloric terms, pollutant levels of incoming and outgoing atmospheric, water and soil flows, changes in the stock of $\mathbf{K_n}$ at the site)

Potential degradation due to inappropriate disturbance can be easily observed by **1)** changes in the relative abundance of species; **2)** sensitive species begin to disappear and native species decrease; **3)** non-native species begin to colonise; **4)** biomass and cover begin to decrease; **5)** production begins to decrease; **6)** erosion begins to increase. See Ayres,1978; Forman and Godron,1984; Kaberger,1992; Georgescu-Roegen,1993.

7. In an attempt to explain the widespread depressions experienced every five or six decades by the economic system, which correspond to the troughs of the long waves statistically identified By N. Kondratiev in the 1920's, C. Pérez (1983) contends that such crises are brought about by the introduction of a new technological style when -and because- the previous on approaches the limits to its potentiality. She suggests that the role of key factor was played by low cost and steam powered transportation in the second Kondratiev; by low cost steel for the third; low cost energy in the form of oil and energy intensive materials in the fourth; and by low cost micro-electronics in the present fifth upswing.

8. "As examples of what constitutes a technological style one might turn to the most recent and best known, which would be those shaped by low cost energy between the third and forth Kondratiev and, as we propose, by the low cost micro-electronics between the fourth and fifth. The first would be the extension of the continuous flow concept of the chemical industry into the mass production of discrete identical units made with energy intensive materials (the prototype of which was Henry Ford"s assembly line), complemented on the organizational level by a sharp separation of management and administration from production, bringing Taylor's ideas of "scientific management" to their ultimate consequences. The second, taking advantage of the characteristics of micro-electronics, could perhaps be the flexible batch production network where all activities (managerial, administrative, productive, etc.) are integrated in a total information-intensive system to turn out information intensive products or services..." (p.362)

"...Overall though, a very salient characteristic of the new technological system is its capacity to cope with variety, diversity and dispersion at all levels, as opposed to the prevailing need for massification, homogenization, and agglomeration typical of the paradigm about to be replaced. This might mean that the range of valid scenarios is particularly wide and further more, that these might be able of accommodating an ever wider range of social choice and institutional arrangements at the micro-level." (p. 374) See C. Pérez,1983.

9. Therefore C. Pérez concludes "... if the characteristics of the new technological style (which is already in place) can be identified, and the trends created by its diffusion -both in the economic and extra-economic spheres- can be disentangled from those belonging to the waning style, then the general lines of transformation can be prefigured and serve as criteria for purposive action." (p.359)

10. Technological competence means knowing what technologies are available, and being able to assess them, to select the one most appropriate, to use and adapt and improve it, and eventually to develop technologies locally. See Esser,1993

11. The huge demand for energy of developing countries as they industrialise and urbanise, as well as the enormous capital investments required for the development of electric power generation facilities and new oil deposits, are the main reasons motivating this expectation.

According to the World Energy Council (WEC) in a high growth scenario (which assumes that future world economic growth will be lower than in two of the three past decades) annual world energy demand could double today's levels by 2020. Over the next quarter century the consumption of a typical Chinese is expected to grow by 855 and of an Indian by 145%. Both would be then using less than a fifth of the energy consumed by an average U.S. American today. On the other hand WEC estimates that there are 1.5 trillion barrels of oil in the Earth's crust, enough to last 60 years at today's rate of consumption, and 170 years' supply of expensive "unconventional" oil, including heavy crudes, bitumen and oil bearing shales. Thus reserves are not the worry. What matters is the rising cost of developing them. In order to sustain world economic growth, the World Petroleum Congress said in 1991 that investment in the industry has to be 50% higher in real terms in the 1990's than in the 1980's. This forecast, in hand with the WEC prediction that close to US$ 30 trillion (1992 prices) have to be invested in development of different energy sources between 1992 and 2020, motivates general acceptance of substantial hikes in the price of capital and energy by the end of the decade. See E. Carr, 1994.

12. In this context, the polluter pays principle ultimately operates as a tool for finding the optimal allocation of pollution, and is therefore useless as a sustainable management principle. Daly's famous analogy with the "plimsoll line" clearly illustrates this Suppose that the load that a boat carries is to be maximised. If all the load is placed in one corner the boat will capsize or sink. Thus it is necessary to evenly spread out the weight. A pricing system can be a useful allocative tool for this purpose: the higher the water line in any corner of the boat, the higher the price of putting another unit of weight in that corner, and the lower the waterline the lower the price. However the cumulative and incremental use of this allocative tool ultimately leads to continue adding weight (-pollution-) and distributing it equally until the optimally loaded boat (-life support systems-) sinks (-breakdown), optimally to the bottom of the sea. See Daly, 1984; and Folke and Kaberger, 1992.

Chapter IV

Local innovative social decision-support systems: Practical guidelines

Local economies in peripheral regions cannot diversify and expand while subordinated to oligopolistic markets and subject to rent seeking exploitative situations. Sustainable development in these areas will depend on developing cost advantages and product differentiation opportunities based on pollution free productive configurations. To be instrumental in the pursuit of sustainability and competitiveness, actors and resources available locally for environmental management, economic growth and social and technological development, must permanently contribute to a process of relevant, complementary and timely learning and innovation. In other words, they must become integrated into an effective local innovation system. In this chapter we will put forward some ideas regarding the basic elements and functional capabilities necessary for doing so, and illustrate their application to integrate a proposed palm heart processing agro-industrial project to a local innovative social decision-support system **(LIDS)**.

Principles, elements and functional capabilities

Patterns through which technical efficiency and innovation are achieved must be clearly understood by entrepreneurs, government, banks, learning and technological research centres, as well as by environmental and other social groups, if they are to responsively operate, support and interact on the basis of a local competitive strategy. When no such pattern is known nor can drawn from the experience of other localities which are operating successful competitive strategies in similar environments, it is very difficult for such a dynamic and responsive decision-making process to take place spontaneously (Pérez,1983; Fajnzylber,1990; Esser,1993; Messner,1993).

Thus local government investment plans as well as its regulations and tax/incentive system are not sensitive to the critical constraints of the cost structure of entrepreneurs. Not clearly aware of these constraints, technological development agencies (where available) focus on problems and operations which are nor relevant or compatible with entrepreneurs' needs. When entrepreneurs themselves develop innovations and apply for financial support from banks, risk assessment become extremely difficult and conservative criteria dominate. And in the context of very sensitive and fragile environments, damages and risks to life-support systems caused by firms can bring them direct negative costs, sales and image effects, as well as environmental standards and fees imposed by local governments. In such a scenario, the resulting conflicts of interest impede even considering the establishment of close local relationships of cooperation and support, as something desirable (ibid.).

The main reason for this is that absence of clear and well diffused patterns of technical efficiency and innovation, makes social learning a difficult and inefficient process. And as long as a visible and successful pattern of learning clearly related to technical efficiency does not emerge, responsive decision-making that promotes innovation is hindered (Pérez,1983).

It is therefore critical for sustainable and competitive development of tropical frontier economies to quickly unearth visible patterns of successful improvement of technical efficiency and innovation. This is especially critical in view of the characteristics of the technology that has to be developed in these areas (based on the natural flow of renewable energy and materials and oriented to improve natural regenerative and assimilative capacity of landscapes) and the fact that to present date there are no successful similar experiences from which such patterns can be derived (Uribe,1994).

Bearing in mind that sustainability and competitiveness in this context depends on developing technical and organisational innovations which increase efficiency and avoid pollution, an effective social learning and innovation system should have this principle at its core. It should therefore focus on critical problems and operations in the techno-economic and socio-institutional spheres of production which hinder the use of natural flows and the enhancement of their natural regenerative and assimilative capacity. And at the same time it should incentivate and support learning/technological innovation related to these concrete problems and operations. The expected result of the application of these operating principles would be the emergence of a visible and successful pattern of learning/technological innovation and its diffusion through a local decision support system providing entrepreneurs, investors, learning and technological research centres, banks, environmental and other social groups, with relevant information for cooperative and synergistic decision-making in regards to environmental management, investment and social and technological development.

The base on which such a decision support system should be built is an environmental monitoring system **(EMS)**, operated perhaps by the agency locally in charge of considering, granting and following environmental licensing processes **(LELA)**[1]. In general environmental licenses are authorizations to carry out projects which are prone to produce environmental damages or risks, which simultaneously impose a set of requirements, obligations and conditions that must be followed by the beneficiary of the license in order to prevent, mitigate, correct, compensate and manage the impact of the project on the environment (Ministerio del Ambiente,1994).

Consideration of environmental license requests should review the foreseen impacts of the project on its physical, ecological and socio-economic surroundings as well as the processes and operations which are prone to generate risk/damage to worker safety and the environment. Critical control points of processes and operations as well as of impacts and effects on the environment should be identified and monitored[2]. It should also examine the environmental management plan proposed by the beneficiary in order to prevent, mitigate or compensate the estimated impacts and effects of the project. Here it would be convenient to establish as standard procedure the continuous realisation of hazard analysis and energy accounting routines by the beneficiary of the license. By means of these "search routines", information would be collected and furnished to the environmental monitoring system **(EMS)** for permanent assessment of the firm's performance in regards to the conditions and standards imposed by the license. At the same time these routines would promote a continuous review of the elements, structures and patterns related with waste and energy management at these critical points, and encourage the design and adoption of incremental improvements in these operations.

Innovative initiatives related to more efficient use of natural flows or enhancing the natural regenerative and assimilative capacity of landscapes, would be stimulated by a provision included within the license to support research and development as well as technical assistance costs related to adoption/diffusion of innovations, by means of local government incentives, matching funds and subsidies.

To be feasible , many of these innovations will require local support structures (ie. linkages and infrastructure) (Austin, 1992). As it is probable that these will be non-existent or inadequate in frontier economies, private and public investment must be attracted and made available for their local establishment. Thus emerges the need to develop another basic capability within the existent local institutional setting: a local investment promotion unit **(LIPU)**.

Preferably this capability should be located within the framework of whatever -private, public or mixed- organisation is most strategically suitable to serve as an interface between the different local actors. In this context **LIPU** would be engaged in identifying critical investment projects to support the development of a local competitive strategy, and attracting/coordinating private and public investment towards these priorities. Using risk and sensitivity analysis methods, **LIPU** would establish the robustness gained by a new project or innovation as a result of the availability/improvement in the local provision of certain linkages or infrastructure, and in this way contribute to establish and diffuse -locally and extra-locally- clear priorities for sectoral and locational investment (Covello,1987; Brent,1990; Winpenny,1991).

Although primarily oriented to support the development of local innovation and technological competence, **LIPU** could start operating simultaneously with the local environmental licensing system. Information provided on a voluntary basis related to the unit cost structure of projects under consideration for environmental license, would be analyzed by **LIPU** in order to identify the critical factors on which the technical efficiency of their standard configuration is based. Such an analysis would thus reveal local linkages and infrastructure necessary to enhance improvement of the activity's technical efficiency and robustness, as well as the corresponding investment needs and opportunities. It would also indicate those variables for which it would be valuable to seek greater information and help det budgets for local research and pilot studies[3].

In summary the proposed local innovative social decision-support system **(LIDS)** would be based on two linked functional structures: and environmental monitoring systems **(EMS)** operated perhaps by the agency locally in charge of environmental licensing or a university, and a project sensitivity analysis system **(PSAS)** operated by **LIPU**, integrated strategically within the existent institutional framework.

The **EMS** would be structured basically as a database management system offering capabilities to access and manage data regarding:

- evolution over time of local landscape management, and soil, air, and water ambient indicators
- impact of environmentally risky projects on surrounding life-support systems and landscape uses
- locations where pressure on environmental goods and services is increasing/decreasing

Basic analysis and modelling of trends as well as of scenarios for localities prone to severe environmental risk/damage would be the major contribution which this component would diffuse locally among government, entrepreneurs, bankers, learning and technological development centres,and environmental and other social groups. Although it is generally accepted that geographical information systems **(GIS)** are basically oriented to database management with automated cartography and strongly lack analytical capabilities, there is a wealth of experience in incorporating to them spatial statistics as well as optimisation and simulation models (Dixon et al,1987; Beaumont, 1991).

The project sensitivity analysis system **(PSAS)** on the other hand, would be based on the decision model capabilities offered by "spreadsheet" software applications, providing facilities for interrelating project/sector unit costs variables and automatic recalculations for the execution of sensitivity analyses. Identification of factors which can potentially improve/constrain a project's technical efficiency, as well as the type, specification and location of linkages and infrastructure need to enhance its competitiveness, would be the content of the information diffused locally and extra-locally by this component of **LIDS**. Software applications such as EXCEL (Microsoft Corp.. Redwood, WA) and release 3.0 of Lotus 1-2-3 (Lotus Development Corporation, Cambridge, MA) are deemed to have sufficient capabilities to operate this component (Beaumont,1991).

The interactive use of the information flowing through such a **LIDS** among the actors involved with environmental management and the local economic, technological and social development of the area, should lead to the emergence and diffusion of a set of skills, routines, standard configurations and organisational structures based on eco-development principles and clearly associated with successful processes of technical efficiency improvement and innovations. The identification of patterns of activity and support structures which enhance the development of these strategic competencies can subsequently become criteria for improved decision making processes. Private and public investment in local linkage activities and infrastructure, as well as decisions regarding the use of policy instruments such as land zoning regulations, public revenue and expenditure budgets, user charges and fees, and subsidies, among others, would benefit from and enhance the resulting flow of information and knowledge. Ultimately, cumulative interaction through **LIDS** may also contribute important elements and criteria for a local political agenda vis a vis national and international power structures.

A case of LIDS in operation: A palm heart processing plant

Effective decision making processes are flexible reaction strategies to deal with uncertainty. Therefore decision-support systems such as **LIDS**, are not conceived to replace policy or management judgement nor eliminate uncertainty. They are designed to support and enhance the process of dealing with uncertainty by efficiently providing available information about key factors which affect and are affected by decisions under consideration. Effective decision-support systems will provide such information and knowledge in a way which helps decision-makers structure relevant analytical perceptions of a problem or situation, and formulate normative, strategic and operational prescriptions for action in regards to it (Matus,1987; Beckenbach,1991; Giaoutzi and Nijkamp,1993).

Consequently to be effective a **LIDS** does not necessarily require a "minimum critical mass" of information to operate. It is possible to initiate its operation as a cumulative process in which flows of information regarding the evolution of critical variables (environmental, techno-economic and socio-institutional) are made available to local decision-makers.

To illustrate the level of simplicity with which a **LIDS** can operate, we will consider a palm heart processing project which is currently being established in the andean alluvial plains (<u>llanura aluvial andinense</u>[4]) in the northwestern fringes of the Amazon tropical rainforest, in the Departamento de Putumayo. In doing so we will try to identify some critical indicators which need to be monitored in order to predict and follow the evolution of the local demands and impacts of the project over time. Subsequently we will suggest how the flow of information generated at the monitored control points can be used to support and enhance local decision-making processes in the definition of priorities regarding the environment, investment, and social and technological development. Finally some broad guidelines for the definition of a competitive strategy for the local economy will be briefly discussed.

The project takes advantage of the unsatisfied palm heart demand in the international market. According to Colombian Export Promotion fund (PROEXPO), in 1992 the world demand for imported palm hearts was reckoned to be between 22.000 - 23.000 tons/year. About 85% of that demand is located in Europe, and more than half of that share specifically in France. The U.S., Canada and some East Asian countries account for the remaining 15% of world demand. Production for export was estimated around 12.700 tons/year, and came from Brasil (76%), Colombia (8%), Costa Rica (6%), Venezuela (6%) and Paraguay (4%) (CONIF/CAP, 1992).

Palm hearts are obtained from palms such as Euterpe cuatrecasana, Iriartea corneta, Euterpe edulis and Bactris gasipaes, among others. In most cases the whole has to be felled to collect a single palm heart, and industrial processing has led to their massive and unsustainable exploitation in natural tropical forests. The imbalances and damage caused by this operation have consequently inspired ecological campaigns encouraging consumers to boycott palm hearts obtained in this fashion.

However a particular species of palm locally known in Putumayo as 'chontaduro' (Bactris gasipaes) offers potential as a plantation crop for sustained production of palm hearts. It quickly grows numerous basal shoots and forms clumps which can be managed for successive harvesting (2-3 palm hearts/palm/year). Intensive plantations have been established in Costa Rica and Colombia with densities of up to 4000 palms per hectare (ibid.).

Given the poor response of agro-ecosystems in the tropical rainforest to input intensive cultivation methods, the project under consideration is based on management intensive agro-forestry methods. Plantations have been established between 800 - 1200 palms/hectare, allowing for alley cropping of perennial legumes which are periodically pruned and their leaves made into mulch for green manure. Mycorrhiza have also been incorporated to the soil in planting sites to increase intake of nutrients by palms. In this fashion, critical nutrients such as nitrogen, phosphorous, potassium, calcium and magnesium are expected to be made available in sufficient quantity/hectare/year (ibid.).

In order to support a processing plant of a viable size, the project requires a minimum production of 864.000 palm hearts/year, which can be produced in 720 hectares if a density of 800 palms/hectare is used , or 480 hectares with 1200 palms/hectare. The regional development corporation (Corporación Autónoma Regional del Putumayo -CAP-) in charge of environmental management in the area is therefore promoting the project among croppers located in the alluvial plains of the Putumayo and Guineo rivers, and in some adjacent foothill sites judged to be adequate. Only patches which have been fallow for over 4 years are considered suitable for the project, and clearing of forests to make new patches for plantation is strongly discouraged. So far, over 200 croppers have been made aware of the project and some 125 have expressed interest to plant a total of 200 hectares using the mentioned agro-forestry method. At the same time they are being encouraged to consider different alternatives of association in order to establish and operate a palm heart processing plant. All this has been done banking on the croppers own resources. Credit to finance the processing plant will be sought once a cropper association is formalised, and the area under cultivation can guarantee sufficient volume to reach the processing plant's break-even point (ibid.).

As it involves commercial agro-forestry as well as food-processing activities, the project is required by law to obtain an environmental license for its operation (Ministerio del Ambiente,1994). Consequently an environmental impact assessment (EIA) should be carried out to identify potentially hazardous flows derived from the different processes and operations contemplated in the project (ie. from the establishment of the palm heart plantations to the transport and commercialisation of the packaged produce). Impacts caused by these flows on the stocks of $\mathbf{K}^n$ and $\mathbf{K}^m$ affected by them should be also established, as well as the set of actions that are to be implemented in order to prevent, mitigate, compensate and manage them.

In regards to the operation of the palm-heart plantations, the license should impose continuous monitoring of the surroundings to ensure that landscape heterogeneity is effectively increased as a result of the project. Information gathered by croppers regarding natural interaction between plantations patches and surrounding landscape structures and uses can lead the **EMS** to analyze and identify successful combinations of contiguous land which enhance productivity by capturing and controlling natural flows of sunlight, rainfall, winds,floods and beneficial micro-organisms, plants, insects and animals, among others. Information about waste/pollution levels of incoming and outgoing water and air flows can facilitate early detection by **EMS** of areas prone to severe disturbance and in risk of ecological damage.

In what has to do with the processing plant, the license should impose continuous monitoring of waste material/solvent flows deriving from the raw material preparation and chemical operations. The license should also require periodic "search routines" focused on the raw material preparation and the chemical and finishing treatment operations, in order to detect and remedy "leakages" (energy/material/solvent). Finally it should contemplate monitoring the interaction of the plant site with its surroundings to detect any negative impacts on landscape heterogeneity and/or negative downstream effects.

At the same time the license should encourage and commit financial support for technical and organisational improvements/innovations which lead to:

- processing of waste for its transformation into by-products
- reduce volume of potable and process water throughput
- increase physical and biological quality of outgoing water flows
- increase efficiency in use of material and energy inputs
- substitution of stock energy sources by flow energy sources

Together with the documents required for consideration of its environmental license request, the processing plant is encouraged to voluntarily submit information regarding the unit cost structure of its standard operating configuration. This information is considered by **LIPU** in order to establish by means of a sensitivity analysis which items/factors significantly affect the project's economic efficiency (See Table IV.1 - 2).

Table IV.1
Putumayo: Unit production costs of palm hearts
(COL $ 1992)

	$	**%**
Preparation of planting site	7.81	12.0
Production of palm shoots	20.83	32.0
Planting	6.51	10.0
Maintenance	16.51	25.2
Harvest	13.54	20.8
Total	**65.10**	**100.0**

Source: Calculations based on CONIF/CAP, 1992

A first and elementary analysis of the relative weight of the different factors in the unit costs of producing and processing palm hearts, allows for quick assessment of the project's most sensitive spots. In the production of palm hearts, improvements in the production of the palm shoots used to establish plantations (32% of unit costs) would enhance the attractiveness of the project for croppers. Increased efficiency in maintenance (weeding, pruning, incorporation of green manure) and harvesting (46%) would also be of benefit to the croppers and the project as a whole.

However perhaps the most vulnerable aspect of this component of the project are the unforeseen contingencies, particularly regarding the need to complement /supplement fertilization and pest control activities with capital inputs. Viability of the project depends on the capability of plantations to sustain a continuous outflow of palm hearts. This requires abundant and

Table IV.2
Putumayo: unit processing costs of canned palm hearts (500grms) (Col $ 1992)

	$	%
Raw material	300.00	26.1
Transport of raw material	136.00	11.8
Labour (Management/operation)	150.00	13.1
Equipment/machinery	52.50	4.6
Constructions	96.70	8.4
Fuel/lubricants/maintenance	61.97	5.4
Packaging and preservatives	298.00	26.0
Transport and commercialisation	52.78	4.6
Total	**1,147.95**	**100.0**

Source: Calculations based on CONIF/CAP,1992

continuous inflows of nitrogen, phosphorous and potassium, among other nutrients. If the proposed agro-forestry practices of incorporating mycorrhiza and legume mulch are not properly managed so as to obtain maximum benefit from the natural availability of the sunlight, rainfall,floods. wind, beneficial micro-organisms, insects,etc., the need to rely on external capital intensive nutrient inputs will become unavoidable. The same holds true in regards to pest management[5].

A similar analysis of the processing component of the project reveals how sensitive its unit cost structure is to efficiency gains in raw mate rial procurement (38%) and packaging (26%). This once again confirms the priority of supporting activities (research, technical assistance and massive environmental and landscape ecology education) oriented to improve practices of fertilisation and pest control at cropper level in order to keep raw material costs in line. It also points to the need for considering alternatives to improve efficiency in the transport network within the project's procurement area (ie. improving roads or considering projects to enhance fluvial transportation in the region).

The relative weight of packaging costs (26%) also draws attention to considering alternatives to attract investment to develop local linkages in this activity. Research and development of recyclable packaging materials based on local renewable resources (ie. polymers based on palm oil) stands out as an attractive venture capital investment opportunity. As local production volumes of packaged foodstuff increase, a local "packaging assembly" project could prove to be an interesting investment opportunity as well as a strategic local linkage.

More detailed analysis of the project's sensitive spots, particularly in regard to the pervasive effects of increases in fuel and other energy sources or in the cost of pollution abatement measures, may lead to identify other strategic research/development (R&D) and investment projects for the local economy. The realisation of the relevant sensitivity analyses as well as the identification and preparation of the strategic projects would be the main contribution of **LIPU** to support the project.

The pertinent information provided by **EMS** in regards to the evolution of the environmental variables critical for the project's sustained operation, as well as that produced by **LIPU** in relation to investment priorities in infrastructure and local linkages which are strategic to develop its competitive edge, would greatly enhance the support that regional and local decision-making processes can offer it. Discussions of landuse regulations, environmental quality standards, and regional and local public revenue and expenditure budgets, could benefit from learning about these clear priorities. The same would apply to financial decisions by banks and investors considering whether to support the project.

Even more interesting are the possibilities of employing this information to structure policies attaining the local use of the stream of revenues coming as of 1997 from Cusiana, in order to attract interest and resources from outside of the region in support of the project. Thus for example part of these transfers could be used to set up a local fund to finance through a matching fund scheme, R&D in management of legume mulch fertilisation or the development packaging materials from polymers based on palm oil. This fund would also support R&D contracted for example, to improve efficiency in the use of materials/energy/water in processing palm hearts. Processes and technologies developed through this scheme could eventually be licensed or sold, and become a new source of revenue for this local fund.

Another part of the transfers received from Cusiana could be used to set up a fund to finance improvement of local labour skills. Training activities to develop and diffuse technical and organisational skills relevant for the palm heart project would be co-financed or subsidised by this fund. Effective methodologies and materials developed in the process could also be licensed or sold to generate additional revenues for this fund.

Finally, part of these transfers could be used to set up a local fund for environmental management and infrastructure development. An important part of these resources should be devoted to the massive dissemination of the general logic of natural landscape dynamics and its use for specific productive purposes. The main objective of this effort is to shape patterns of public perception and interpretation of changes affecting the local environment, in a way that will support and encourage responsible attitudes in regards to its use and control by all social actors. In other words, concern and action for proper environmental management has to become a legitimate collective commitment. Resources coming from this fund could be used to co-finance projects and activities which enhance local competitiveness in palm heart processing through, for example, rehabilitating sedimented streams and rivers for fluvial procurement of raw materials. User fees and charges included in environmental licenses authorised locally could be used as another source of revenue for this fund.

Local cumulative flow of the type of information that has been described for the case of the palm heart processing project, and its adequate use in decision-making in regards to this and other similar projects, can lead to the development of a local competitive strategy. Standard configurations, routines and skills developed to capture and control natural flows for productive purposes without negatively affecting the natural environment's regenerative and assimilative capacities, will represent a formidable source of costs advantages for extraction and conversion activities in the area, especially as costs of stock energy sources and pollution abatement measures begin to soar. So will the strategic use of the Cusiana transfers to develop key technologies, services and infrastructure linked to the specific demands of the local economy. Cooperative and effective operation of **LIDS** in this context can lead to competitive eco-development.

1. As environmental damages become a limiting factor to the economic system by affecting negatively the value of private property, restricting production/consumption possibilities, reducing income and increasing compensatory public expenditures, governments have become aware that environmental management and conservation must be provided through public regulation, since markets are unable to communicate environmental damage -and exclude open access to many environmental resources and services- by means of price signals that will directly affect the agents causing the damage. Thus during the last decade most governments have given priority to develop institutional structures to respond in an integrated and systematic way to demand for regulation in this field.

Environmental licensing integrates the use of macro-environmental standards such as land use zoning criteria and ambient environmental quality standards for air, water and land, together with economic instruments for the internalisation of environmental costs by means of micro-economic constraints (pollution abatement investments, user fees, etc.). To be effective as a management instrument, environmental licensing systems must operate monitoring systems of the environmental performance of licensed firms. See Pearce <u>et al</u>,1989; Beckenbach,1991; República de Colombia,1993.

2. Environmentally hazardous impacts are caused by disturbances that lead to reduction of landscape heterogeneity, as well as by incremental streams of heat and material waste generated by certain operations in extraction and conversion activities.

Decisions on whether, where and at what level of landscape disturbance intensity are acceptable as a consequence of a project can be assessed by considering:

- impact on landscape heterogeneity of the interaction between the project site and its surroundings
- relative uniqueness and recovery time of the present landscape at the proposed location
- changes of stock and flow of $\mathbf{K^m}$ and $\mathbf{K^n}$ (ie. $\mathbf{K^m}$ inputs/$\mathbf{K^m}$ outputs in monetary and caloric terms; pollutant levels of incoming and outgoing water, air and soil flows; changes in stock of $\mathbf{K^n}$ at the site)

Degradation of landscape heterogeneity due to inappropriate disturbance can be assessed monitoring: **1)** changes in relative abundance of species within different structural elements of the landscape; **2)** disappearance of sensitive species and decrease in native species; **3)** non-native species begin to colonise; **4)** biomass and cover begin to decrease; **5)** production begins to decrease; **6)** erosion begins to increase. See Chapter 3, footnote no.6. See also Ayres,1978; Forman and Godron,1984.

In general streams of heat and material waste are generated by extraction and conversion activities. Extraction activities include all those in which natural resources are converted into commodities by physical removal. Conversion activities embrace all transformation processes leading to the production of finished material/energy forms: ie. refinement, separation, metallurgical, chemical, biological processes and recycling of waste material "ores".

Incremental streams of heat and material waste are generated by extraction and conversion activities based on energy/solvent intensive operations entailing:

- **raw material preparation** involving changes in the energy state of materials (ie. irradiation, electrification or magnetization, heating, refrigerating), physical disintegration (ie. chopping, splitting, blasting, sawing, slicing, drilling, milling, crushing, tearing or picking) or physical dissociation (ie. mechanical dismantling, sifting and sorting, filtration, centrifugal separation, flocculation/precipitation, settle drain, crystallisation, evaporation, melting, condensation or freezing)

- **chemical treatments** involving changes in the energy state of materials, chemical dissociation or decomposition (ie. biological digestion, thermal activation, electrolytic and catalytic reactions, hydrolysis and photolysis) and physical dissociation
- **physical fabrication treatments** involving changes in the energy state of materials, and physical disintegration

- **surface finishing treatments** involving changes in the energy state of materials and physical dissociation. See Annexo 1: Flow diagram stages, taken from Ayres, 1978:76-77

Therefore it is critical to incorporate punctual monitoring procedures in each operation involving these processes in order to assure that: **1)** organic content and temperature of water effluent are reduced to acceptable ambient standards; **2)** excess and toxic suspended solids are removed; **3)** microbiological organisms and biologically active substances are neutralised to avoid negative downstream effects on life-support systems. See Chapter 3, footnote no.3.

Manufacturing and service activities on the other hand, tend to be information intensive. Manufacturing activities comprise the production of material goods from finished materials and energy forms and involve primarily physical transformation processes: ie. fabrication, assembly, construction, blending and packaging.

Services generate non-material benefits using material, energy and labour inputs. Manufacturing is critically determined by material and technical configuration standards, while services are determined by skill and routine qualification. Both activities however can minimise material and energy waste through intensive information use. See Ayres,1978; Austin,1992, Morton,1994.

3. Different technologies and standard configurations make use of different combinations of labour, capital energy raw materials and management inputs, which are clearly reflected in different product unit cost structures. Cost structures also reveal the relative importance of specific support structures such as linkages and infrastructure, which are critical in order for firms to attain technical efficiency in the use of their configuration.

Capital intensive configurations imply large scale operations below which production will not be financially viable. They therefore are heavily dependent on production functions which maximise throughput, rely on intensive and extensive use of stock energy sources as well as of optimal rates of extraction and use of natural renewable resources well above the capacity of life support systems to regenerate them and/or assimilate waste.

Technically disaggregated and modular configurations allow for the use of alternative raw materials and increase opportunities for use of by-products and/or material wastes, particularly in extraction and conversion processes. They also provide the opportunity for worker involvement in routine improvement and innovation, and thus encourages the institutionalisation of the continuous social learning process necessary for the development of local technological competence. Finally, by means of energy accounting methods, they also favour the identification of points in the process where alternative sources of energy may be used and safe application of heat generated in one step of the process to another.

The analysis of product unit cost structure and profit margin of a configuration producing for a given market, reveals the factors which can potentially improve/constrain its technical efficiency. In the case of extraction and conversion activities, amounts, type and costs of raw materials, intermediate inputs, $\mathbf{K^m}$ assets, energy and labour required by a given configuration, will be the most important factors determining product cost structure. The relative importance of each of these factors within unit costs will point to the linkages and infrastructure which are critical and have to be made locally available or improved, so as to allow the project under consideration to develop cost advantages/product differentiation opportunities.

In the case of projects in which raw materials and intermediate inputs represent an important proportion of the total unit costs, for example, adequate linkages and infrastructure for material transport, processing and waste management are fundamental supports for technical efficiency. Transport can become a limiting factor in procurement of raw materials/intermediate inputs, and determine product market boundaries. Where risk of losses of raw materials/products represent an important cost component, transport costs may not be as critical as transport quality (ie. speed and refrigeration).

Availability of intermediate processing facilities to transform raw/waste materials into intermediate products in more stable forms that can be stored/used at lower costs , or render them in more portable forms for handling and transport, may contribute significantly to develop local cost advantages. So can quality support centres if quality control monitoring of materials/wastes represent a major cost component or risk avertor.

Projects based on energy/solvent intensive processes are heavily dependent upon local linkages and infrastructure for adequate power and water supply. Perishability of raw materials in process and costs associated with failure to deliver shipments on time imply the need for in-plant generation capacity, where power grids are not available or reliable. Availability of adequate local technical support for the development, repair and maintenance of in-plant stock/renewable energy generators as well as overall service maintenance of K^m assets, therefore represent important local linkages. Equally important is local water supply infrastructure which can adequately meet three types of water demand:

- **Potable water** which must be also acceptable for boiler feeding in sufficient quantity, pressure and temperature at reasonable cost (including treatment required for final use)

- **Cooling water** which must be available in sufficient quantity for intake as well as easily dischargeable , with minimum costs related to intake works, distance to intake, as well as for abatement of negative environmental impacts.

- **Process water** which is necessary in sufficient quantity and with minimum treatment costs

Finally in order to guarantee the projects ability to attract the necessary skilled personnel, local linkages and infrastructure for the provision of adequate housing, schools health, training and recreational facilities are also basic.

Increases in the robustness or sensitivity of a given project as a result of changes in the local provision of certain linkages or infrastructure, can be tested by means of sensitivity analysis methods. Assuming that uncertainty can be converted into risk, the "switching value" of key variables affecting the project can be estimated to show how large changes in them would be needed in order to reduce NPV to 0. See Ayres,1978, Covello, 1987, Brent,1990, Winpenny,1991, Austin,1992, Morton,1994.

4. This landscape is described by Etter, 1992 as being slightly concave to convex, with slopes not greater than 2%. Soils here are periodically exposed to floods and alluvial sedimentation. They are deep to superficial, poorly drained and potentially fertile. Typical vegetation is comprised of medium-height forests with an important proportion of palms and a dense thickets (sotobosque). Deforestation has affected 40-80% of the area and semi-intensive cropping of maize, rice, plantain and cassava has created patches, some of which are fallow.

This landscape is surrounded by andean foothills (piedemonte cordillerano con influencia volcanica), which are mildly sloped and undulated (2-8%). The soils typical of this landscape have originated through sedimentation of volcanic and colluvial materials. Originally comprised of high dense forests of uncertain floristic composition, these only remain as small patches and corridors of 10-50 ha. each due to intense deforestation (more than 80% of the area). Extensive grasslands predominate with patches of intensive maize , sorghum and rice cultivation. Consequently laminar erosion is the most active geomorphological process in this landscape.

5. The great sensitivity of the project as a whole to the successful management of this variable is confirmed when its 'switching value" is estimated. Annexus 2 shows the effect of including a cost for using external capital intensive fertilisers and pesticides in the project's CBA. When these come to amount 1.6 as much as the unit production cost of palm hearts calculated for the project ($65.10), the NPV of the project is reduced to 0. A relative weight of this magnitude (62%) for fertilisers and pesticides in the unit cost structure of palm heart production is not far fetched, especially in this case where other capital intensive inputs (ie. machinery) are absent. See Brent,1990 and Winpeny,1991.

Chapter V

Constructing competitive eco-development in tropical peripheral regions in Colombia

Current estimates indicate that recently discovered oilfield at Cusiana contain at least 2.2 bn barrels of oil with significant volumes of gas. Overall production of crude oil in the country is expected to increase from 440.000 barrels per day in 1992 to over 800.000 in 1997, when production of Cusiana/Cupiagua is expected to peak above 600.000 barrels a day.

As mentioned before, an important share of national profits coming from Cusiana are earmarked to be invested in physical and social infrastructure in peripheral areas. A total of US $ 5.57 bn is expected to be distributed directly to regions and municipalities between 1997 and 2002. Another US $3.48 bn of royalty revenues have already been destined by law ti finance electric and other strategic projects for the economy during this period (52.5%), while the remaining 47.5% are the net revenue of the Fondo Nacional de Regalias (**FNR**). Resources of the **FNR** are to be distributed among mining activities (20%), environmental management (30%), other investment projects (35%), and 15% is to be left disposable (EIU,1994:13).

Revenues allocated for environmental management will be administered by the Ministerio del Ambiente by means of the Fondo Nacional del Ambiente (**FNA**). A distribution of these resources which clearly favours peripheral regions has also been established by law. No less than 15% must be destined to finance environmental sanitation in Chocó and the Amazon region, and sustainable development of lands within protected indigenous areas located in environmentally significant landscapes. Another 20% is to be devoted to the recuperation and conservation of watersheds all over the nation, and at least 4% is to be transferred to the municipalities in the area of the Macizo Colombiano, which is the catchment area of some of the countries most important rivers. The remaining 61% is earmarked to finance environmental projects carried out by territorial entities, 80% of which are to be targeted to areas outside the jurisdiction of the ten Regional Corporations with the highest revenues in the nation (Ley 99,1993: Art.91).

Translating Cusiana into competitve eco-development

But are the local economies of peripheral regions in a position to translate this massive stream of revenues into sustainable (environmentally sound) economic growth and social development? As long as local economic activity in these areas continues to be subordinated to oligopolistic markets and subject to rent seeking exploitative situations, multiplier effects of this revenue will flow out leaving very little tangible benefits behind. Sustainable development in these areas will depend on developing local capacity to create local cost advantages or product differentiation opportunities through creative technical and organisational innovations, which allow to use efficiently the enormous flow of energy, water and nutrients which takes place in their natural areas. Investment in new business opportunities as well as in research and human resource development, will therefor have to be oriented towards learning how to complement productively -and not substitute- the existent stock and flow of natural assets of these ares. In other words, sustainable development here will be based on successful competitive eco-development.

The local capacity to innovate will necessarily be the product of the cooperative effort and coordinated involvement of different regional and local actors (ie. government, private investors, social movement and organisations, banks, among others). Their collective aim will be to identify bottlenecks for sustainable local economic diversification, and allocating resources to design, organise and operate solutions for them. A process of relevant, complementary and timely learning and innovation can be locally structured and supported by means of a local innovative social decision support system (**LIDS**).

Such a decision support system would be based on defining and developing two basic capabilities within the existing local institutional framework. The first is the establishment of an environmental monitoring system (**EMS**), which for example could be operated by the agency locally in charge of considering, granting and following the legal environmental licensing process for productive projects. It is proposed that this monitoring system focuses on critical processes and operations which cause environmentally hazardous impacts, and incorporates a reward system for improvement/innovations that contribute to significantly reduce these impacts.

To support innovations, local linkages and infrastructure have to be developed responsively. Thus an investment promotion capability has to be developed, preferably as a unit **(LIPU)** within the local concern most strategically suited to serve as an interface between the different local actors and interests. Its main task is to establish through sensitivity analysis the robustness gained by a new project or innovation as a result of the availability/improvement in the local provision of certain linkages or infrastructure. The interactive flow of this information between the local actors involved with environmental management and local economic, social and technological development, should lead to the identification of strategic social, economic, environmental and political priorities, and contribute to improve coordination and effectiveness in local decision-making processes. It may also lead to the construction of 'circular industrial ecosystems', through the development of a systematic approach to local materials use (ie. waste products of one productive activity are reinserted into the system as raw material for the same or another process) (Robins and Trisoglio,1992).

Legitimising concern and action for proper environmental management as a local social commitment

Is there the institutional and organisational capacity in peripheral areas (renowned for their precariousness and often exposed to rampant corruption), to promote and establish such a process of coordinated and responsive decision-making between numerous social actors? Moreover, is such a proposal feasible in the context of the overwhelmingly informal, illegal, violent and low skilled economies of these areas?

Precisely because of their very low governability, it is contended that public -and private- decision making must be seen in these areas as a permanent process of dealing with uncertainty. Access to an elementary decision support system which simply structures available relevant information and knowledge to enable better public and private decision making in the face of uncertainty, may be the only feasible strategy for keeping track of events and building the capacity to learn quickly from mistakes and react effectively to unforeseen situations (Matus, 1987).

Yet undoubtedly effective operation of such a system will fundamentally hinge upon its legitimation. In the context of the peripheral economies in tropical frontier areas which have been described, it is clear that any state-operated mechanism such as the environmental licensing of productive activities will have insignificant impact if its enforcement depends on direct state action: as in every other sate regulated activity in the area, corruption and bribes will blind and paralyse the system. This is why an imperative for any sustainable development initiative in this context, will be the establishment of operative mechanisms whereby local concerns and interests are involved directly in the control and feedback to firms/agents causing environmental damage. A massive action directed to shape public perception, interpretation and attitude in regards to responsible management of the local environment is an essential pre-condition for the construction of local competitive eco-development.

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Annex 1

General Industrial Process Flow Diagram

Source: Ayres,1978:76-77

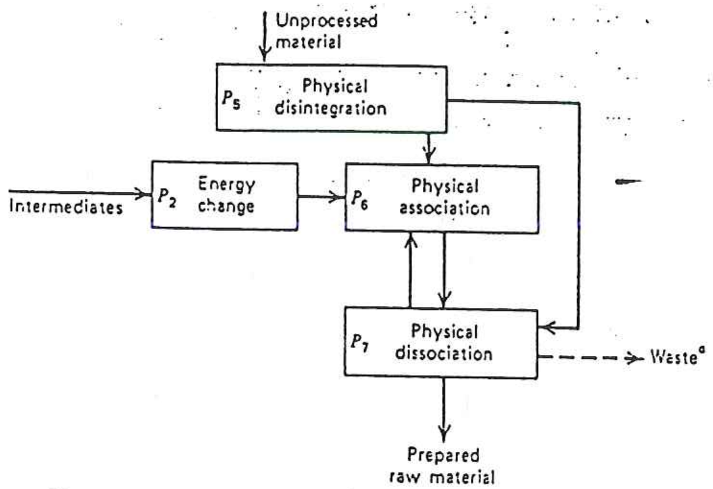

Figure 3-B.2. Stage 1 flow diagram: Raw material preparation. *a*—Waste streams are generally associated with P_7 (physical dissociation) processes simply because the waste must be *separated* from the useable materials by such a process. Losses can, of course, occur at any point in the system.

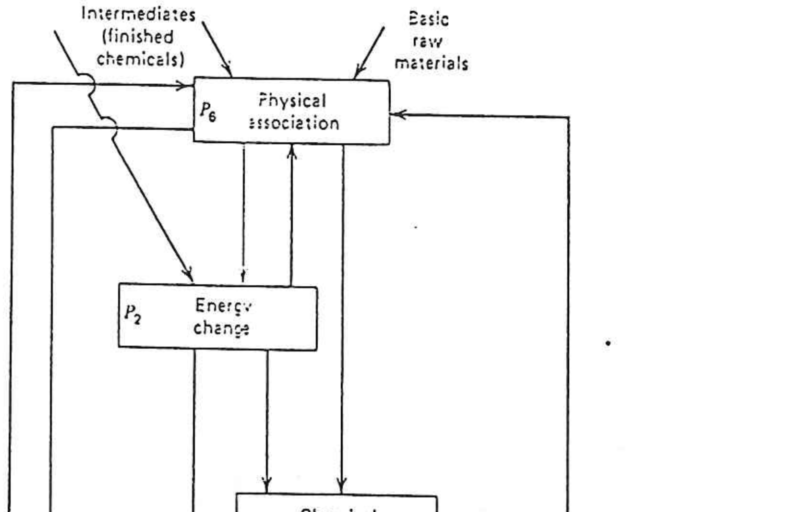

Figure 3-B.3. Stage 2 flow diagram: Chemical treatment.

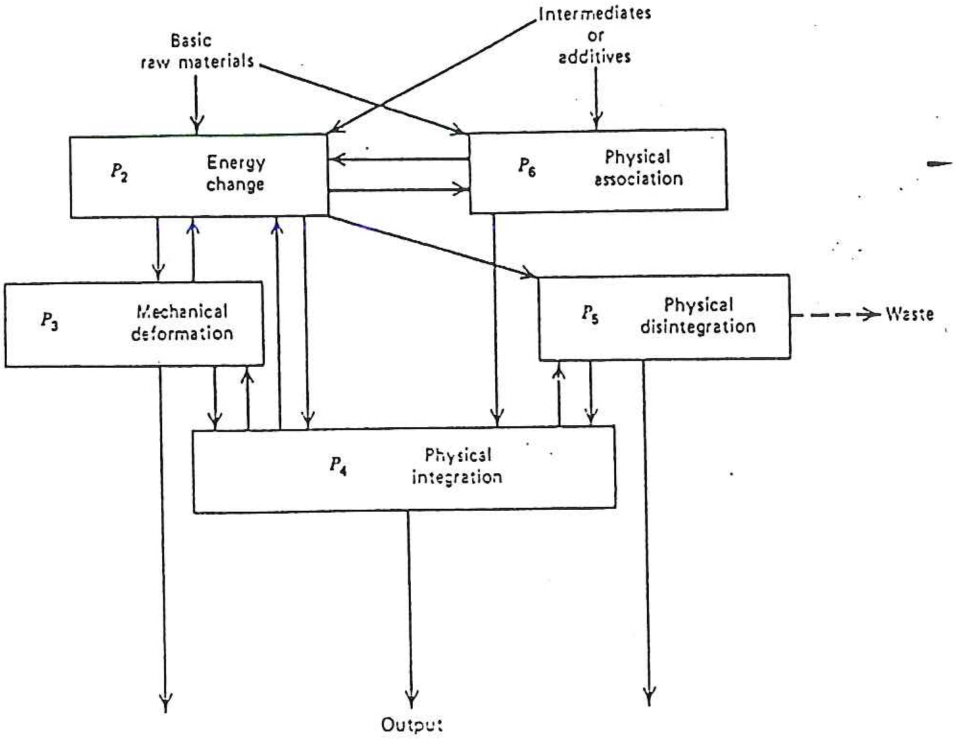

Figure 3-B.4. Stage 3 flow diagram: Physical treatment and fabrication.

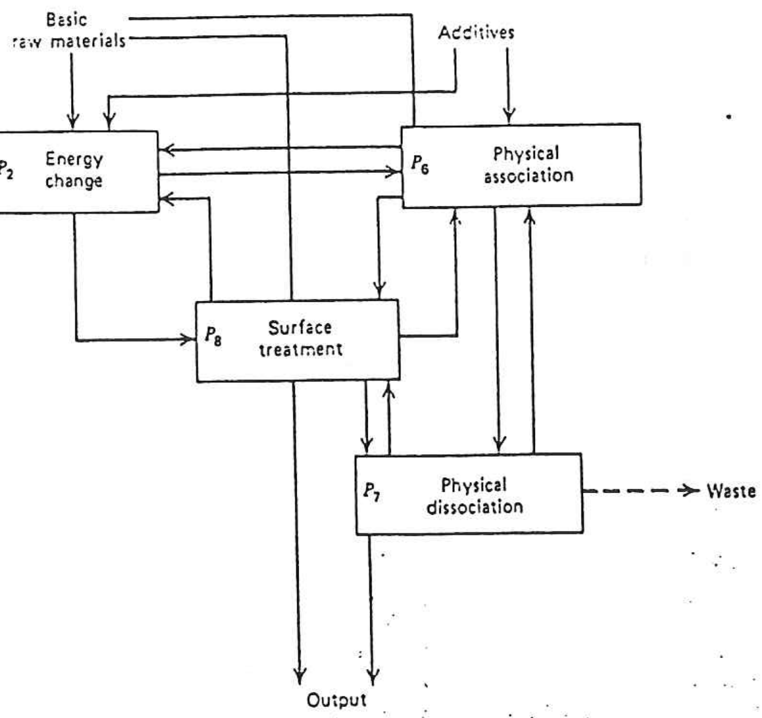

Figure 3-B.5. Stage 4 flow diagram: Finishing.

Annex 2

CBA and 'Switching Value Analysis' of a palm heart processing project in Putumayo, Colombia

Calculations based on: CONIF/CAP,1992

BENEFIT/COST ANALYSIS PALMITO-HEART PROCESSING PLANT
(in Col $ 000.000 of 1992)

	0	1	2	3	4	5	6	7	8	9	10
Revenue accruing to croppers		0.00	0.00	69.00	104.00	138.00	138.00	138.00	138.00	138.00	138.00
Revenue accruing to processing plant		0.00	0.00	550.00	822.00	1098.00	1098.00	1098.00	1098.00	1098.00	1098.00
Total Stream of Benefits		0.00	0.00	619.00	926.00	1236.00	1236.00	1236.00	1236.00	1236.00	1236.00
Crop investment costs		243.00	121.50	121.50							
Crop production costs (1200 palms/ha)											
Labour/management											
Fertilization				3.60	5.40	7.20	7.20	7.20	7.20	7.20	7.20
Weeding		12.00	12.00	12.60	8.40	7.20	7.20	7.20	7.20	7.20	7.20
Harvesting				14.40	21.60	25.20	23.40	21.60	21.60	21.60	21.60
Subtotal crop production costs		12.00	12.00	30.60	35.40	39.60	37.80	36.00	36.00	36.00	36.00
Processing plant investment costs			117.30								
Processing production costs											
Raw material		0.00	0.00	129.60	194.40	259.20	259.20	259.20	259.20	259.20	259.20
Personel		0.00	0.00	64.80	97.20	129.60	129.60	129.60	129.60	129.60	129.60
Packaging/other inputs		0.00	0.00	128.80	193.00	257.00	257.00	257.00	257.00	257.00	257.00
Commercialisation/transport		0.00	0.00	22.80	34.20	45.60	45.60	45.60	45.60	45.60	45.60
Energy/maintenace				26.75	34.80	49.40	49.40	49.40	49.40	49.40	49.40
Others											
Subtotal processing production costs		0.00	0.00	346.00	518.80	691.40	691.40	691.40	691.40	691.40	691.40
Total stream of costs		255.00	250.80	498.10	554.20	731.00	729.20	727.40	727.40	727.40	727.40
Net cashflow		-255.00	-250.80	120.90	371.80	505.00	506.80	508.60	508.60	508.60	508.60
NPV (30%)*		467.48									

* Discount rate used by CONIF/CAP in initial project appraisal

BENEFIT/COST ANALYSIS PALMITO-HEART PROCESSING PLANT
Switching value of chemical fertilisers and pesticides costs
(in Col $ 000.000 of 1992)

	0	1	2	3	4	5	6	7	8	9	10
Revenue accruing to croppers		0.00	0.00	69.00	104.00	138.00	138.00	138.00	138.00	138.00	138.00
Revenue accruing to processing plant		0.00	0.00	550.00	822.00	1098.00	1098.00	1098.00	1098.00	1098.00	1098.00
Total Stream of Benefits		0.00	0.00	619.00	926.00	1236.00	1236.00	1236.00	1236.00	1236.00	1236.00
Crop investment costs		243.00	121.50	121.50							
Crop production costs (1200 palms/ha)											
Labour/management		12.00	12.00	30.60	35.40	39.60	37.80	36.00	36.00	36.00	36.00
Fertilization				3.60	5.40	7.20	7.20	7.20	7.20	7.20	7.20
Weeding		12.00	12.00	12.60	8.40	7.20	7.20	7.20	7.20	7.20	7.20
Harvesting				14.40	21.60	25.20	23.40	21.60	21.60	21.60	21.60
Inputs											
Chemical fertilisers/pesticides *		60.50	90.75	121.01	121.01	121.01	121.01	121.01	121.01	121.01	121.01
Subtotal crop production costs		72.50	102.75	151.61	156.41	160.61	158.81	157.01	157.01	157.01	157.01
Processing plant investment costs			117.30								
Processing production costs											
Raw material		0.00	0.00	129.60	194.40	259.20	259.20	259.20	259.20	259.20	259.20
Personel		0.00	0.00	64.80	97.20	129.60	129.60	129.60	129.60	129.60	129.60
Packaging/other inputs		0.00	0.00	128.80	193.00	257.00	257.00	257.00	257.00	257.00	257.00
Commercialisation/transport		0.00	0.00	22.80	34.20	45.60	45.60	45.60	45.60	45.60	45.60
Energy/maintenace				26.75	34.80	49.40	49.40	49.40	49.40	49.40	49.40
Others											
Subtotal processing production costs		0.00	0.00	346.00	518.80	691.40	691.40	691.40	691.40	691.40	691.40
Total stream of costs		315.50	341.55	619.11	675.21	852.01	850.21	848.41	848.41	848.41	848.41
Net cashflow		-315.50	-341.55	-0.11	250.79	383.99	385.79	387.59	387.59	387.59	387.59
NPV (30%)**		0									

* "Switching value" of this variable is equivalent to the application of a factor of 1.616 to unit production cost of palm hearts ($ 65.10). The relative weight of chemical fertilisers and pesticides in this particular cost structure would represent 62% of the total.

** Discount rate used in CBA prepared by the project