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THE ENVIRONMENTAL SUSTAINABILITY OF DEVELOPMENT AND TECHNOLOGICAL CHANGE IN LATIN AMERICA AND THE CARIBBEAN

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I. WORLD CRISIS, THE NATURAL ENVIRONMENT AND NEW TECHNOLOGIES

The world is immersed in the early stages of a more profound techno-economic revolution than any that have occurred since the industrial revolution (Herrera, 1983, 1986); it is being led by microelectronics and informatics, but is accompanied by a constellation of developments based on new, science-intensive technologies (biotechnology, new materials, new energy sources, etc.).

This new, precipitous wave of innovations will lead to the complete transformation of societies in many ways that are difficult even to imagine today. The working class as traditionally understood will cease to exist, as human labour will no longer be a technically necessary factor of production. These developments are not negative in themselves; on the contrary, they reflect the potential for a qualitative leap forward in the evolution of mankind and the replacement of alienating labour by creative occupations.

The realization of this potential, however, will depend on the structure and organization of societies and whether the will and social capacity exist to make the enormous political, institutional and cultural changes that will be required.

It is a well-known fact that the inertia of political and social structures is generally much greater than that of technological and economical change, and this seriously impedes the ability of countries to adapt to the sweeping technological changes taking place. In the central countries themselves, where the new wave of technology has its origins, the impact of these changes is creating social problems, profound national and international economic readjustments and, most visibly, a growing rate of structural unemployment (Herrera, 1983). This phenomenon is not an exclusive feature of the capitalist system, but manifests itself as well in the socialist countries, although less overtly (Tertseh, 1987). The innovative political changes now taking place in the Eastern European countries are directly related to these circumstances.

In short, the very concept of employment, the idea of wages as a means of meeting human needs and the characteristics of the social division of labour (both national and international) are being called into question. The current cycle of technological innovations will produce even more profound effects on the social structure than on the production system.

The developed countries are theoretically in a position to deal with these changes in a relatively non-traumatic way, in view of their installed capacity for producing goods and services, the fact that the basic material needs of the great majority of their people are already being met, the existence of social cushions (such as unemployment insurance) and a basically stabilized population. However, as the world economic crisis has shown, the process of change is not easy.

From a more general standpoint, it seems clear that human civilization is moving towards becoming a "global village". This is visible in all dimensions, whether social, economic, cultural, political or environmental. Instead of occurring easily and harmoniously, this evolution has been turbulent and plagued by conflict.

These disturbances and current and potential conflicts are of such scope as to suggest that the entire human species --not just one political system or subgroup of nations-- is confronting one of the biggest challenges in its short (biologically speaking) evolutionary history. In recent decades we have been living through a crisis of civilization, characterized by a number of truly new situations (Gallopín, Gutman and Maletta, 1989a).

The nuclear threat is perhaps the most obvious symbol of a hitherto unknown situation in the history of life on the planet Earth. We have become the only species with the capacity (and the possibility) of deliberately destroying ourselves. The risk, although it has recently diminished, is still present in latent form.

The rapid and extensive rate of global change is one of the main features of the new world situation. In the past century, especially in recent decades, changes in societies and in the natural environment have been accelerating and multiplying until they have reached global proportions, affecting the most remote regions of our planet. Political changes are generating profound realignments of world power; scientific and technological advances are stimulating further increases in industrial production and diversification of the economy (and more destructive potential); the exponential growth in the consumption of energy, raw materials and renewable natural resources is nearing global limits; the rise in the human population will continue over the next century (although its growth rate is declining); the rapid change in the biosphere as a result of changes in land use and the accelerated emission of substances into the air and water is reaching (and in some cases exceeding) the range at which planet-wide natural agents operate, thereby interfering with global climatic processes and with the biogeochemical cycles that form part of the biospheric regulation mechanisms.

Nearly all the above trends are on the rise. Even if some of the variables slow down, certain thresholds of change may have already been exceeded. For example, even if all the gas emissions that contribute to the greenhouse effect were immediately halted, the long-term climatic processes that have already been set in motion could continue to be felt for decades, owing to the inertia of the oceans (Speth, 1988; Holdgate et al., 1989).

In more than one sense, change is not only inevitable but desirable, for stability is not a good thing in itself. The problem lies not only in the existence of change itself but in its new speed and scope, resulting in heavy pressures on social and ecological systems (often affecting their capacity to react); in the short-sighted intervention by man in global mechanisms which are not yet very well understood; and especially in the clearly destructive and unsustainable nature of many of the predominant changes. The direction of quite a few of these changes is extremely alarming and might make the future of the human race unviable or even barbaric.

Increasingly evident are the growing turbulence and unpredictability --in addition to the combined effect of the above-mentioned changes-- which reflect the origin and intensification of profound worldwide transformations associated with the techno-economic revolution. There exists a new potential for meeting the human needs of the entire species, eradicating poverty and hunger in the world and making a qualitative leap in mankind's development, while at the same time the possible impact of the changes taking place in terms of increasing inequality and injustice may also be enormous (as can already be seen in Latin America and the Caribbean; see Nochteff, 1987; Lahera and Nochteff, 1983).

The connectedness and interdependence of the "global village" is greater today than ever before, and is growing rapidly, both in the human environment (economic interdependence, trade patterns, migration, information flows, global telecommunications and mass media, the worldwide reverberations of originally local military conflicts, etc.) and in the natural environment, as demonstrated by the increase and intensification of global interconnections between biological and non-biological processes on land and in the oceans and atmosphere, owing to the acceleration of anthropogenic changes. Moreover, existing interrelationships between the human and natural environments are becoming more complex and broadly based, and many linkages can be seen today between seemingly separate events (such as between changes in demand in the North and environmental degradation in the South). Growing awareness of the global implications of these planetary linkages is a very recent phenomenon. This increase in complexity and connectedness (especially unplanned connectedness, or where linkages are not the result of a long evolution) may lead, as suggested by scientific studies in various areas of knowledge (Gallopín, Gutman and Maletta, 1989), to growing instability and vulnerability, with dramatic rises in the cost of errors.

The alteration and accelerated degradation of the ecology of the planet in unheard-of proportions is another recent phenomenon. Generally speaking, it must be admitted that, despite the fact that 1992 will mark the twentieth year since the World Conference on the Human Environment was held in Stockholm, and although constructive measures are being taken in many countries, the planetary ecological system has not only not improved, but has deteriorated.

Two mutually interactive global megaprocesses are occurring throughout the world: i) consolidation and expansion of unsustainable development patterns and consumption styles; and ii) generation of unsustainable impoverishment.

At the global level, a number of major environmental problems (such as global warming, the destruction of the ozone layer, industrial pollution) are today largely produced by the activities of the countries of the North (in many cases associated with wealth, overconsumption and waste). The abuse of biotic resources has been the foundation of the industrial world's economic development, and ecosystems and genetic resources of enormous value continue to be wasted as a result of agricultural, industrial and urban pressures. More indirectly, demands by the countries of the North --either for luxury goods such as tropical woods and exotic animals, or for straightforwardly pathological goods (drugs)-- are prime factors in the ecological degradation of the planet.

At the Latin American and Caribbean regional level, the environmental degradation associated with growing socioeconomic poverty 1/ obviously has an enormous impact. Most deforestation, soil erosion and desertification processes originate in the often desperate attempts of local or immigrant populations to subsist. Miserable environmental conditions in many parts of the cities of the region are partly attributable to economic difficulties and a shortage of government resources in the region. What must also be borne in mind, however, is the great number of environmental problems within the region itself that are attributable to the action of powerful, affluent social agents (including the State), overconsumption and waste, and minority population sectors whose lifestyles and consumption patterns are comparable to those of the North.

It is increasingly clear that unsustainable impoverishment cannot be eradicated through unsustainable development in a repetition of the same historical path of today's industrialized countries. A few arithmetical calculations will suffice to demonstrate this; an extrapolation from the present per capita material and energy consumption of the developed countries to the entire world population is simply unfeasible in physical terms.

The reversal of environmental deterioration and the eradication of poverty are related and absolutely critical objectives at the global level. Attacking these two scourges will require a thorough rethinking of the development models of the Latin American and Caribbean countries (and all the countries of the South), as well as a rethinking of the model of the advanced countries.

We share with the World Commission on Environment and Development the deep conviction that a new development path is required, one that sustains human progress "not just in a few places for a few years, but for the entire planet into the distant future" (WCED, 1987). The urgent need for renewed global solidarity is patently obvious, and the signs that this may be possible seem to be growing (although they are still weak). They need to be translated into political will and concrete actions.

If the new and emerging technologies were to be used for these purposes, they could represent a very powerful tool for achieving a new and sustainable world path to development. Military expenditure represents an enormous source of economic resources already in existence which could be made available if present trends towards peace become consolidated.

II. POSITION OF LATIN AMERICA AND THE CARIBBEAN VIS-A-VIS THE NEW WAVE OF TECHNOLOGY

Latin America's future is directly linked to the above-mentioned global changes (and its own internal situation). The present period of history is extremely critical, not only in the sense of harbouring serious threats to development but also in terms of opening up new opportunities and options; in order to establish the right conditions for these to be taken advantage of, the short-sightedness of those who are daily immersed in the crisis must be overcome.

The current situation in Latin America vis-à-vis the new technological revolution is very different from that of the industrialized countries, and some would even hold (Herrera, 1986) that it is worse than the regional position during the process of "modernization" that reached our countries following the Second World War.

The primary development style in the region during this process was first of all imitative, and was proposed as a more or less direct transfer of the apparently successful experiences of the central, consumer-based countries, including the importation of these countries' values as well. Secondly, strong support was given to massive inflows of capital and technology from abroad. Thirdly, an attempt was made to achieve development without significantly changing the prevailing economic and social structures (which had been modified in the central countries), and it was assumed that the problems of poverty would be solved automatically by raising the gross domestic product ("trickle-down effect"). Finally, the development style was extremely damaging to the environment, threatening its own ecological base of sustainability.

The development style predominantly adopted by the region meant that the benefits of modernization and strong economic growth (faster than demographic growth) that occurred during the period reached only a minority of the population, while large sectors remained in conditions of marginality and extreme poverty. The process utlimately led to hyperinflation (in the more industrialized or "successful" countries) and to a huge external debt.

In view of this lesson from the past, the question arises as to what Latin America's present position is with respect to reaping the benefits of the new wave of technology and resuming its path to development. Clearly, the situation is highly critical in absolute terms. In particular, the historically predominant development strategy is obviously no longer viable (irrespective of any arguments concerning its desirability). The region is facing a new situation, with a paralysing external debt, low capacity for accumulating capital, extensive segments of society which, although they do not yet enjoy the benefits of the previous wave, must coexist with the impact of the current series of technological innovations, high demographic growth rates and chronic structural unemployment representing a legacy from the past which presents a much more complex set of problems than in the developed countries. Fundamentally, moreover, the short- or medium-term renewal of massive flows of capital and technology into the region (the driving forces of the previous development strategy) is unlikely, even if a political solution is found to the Latin American debt problem.

If the prior wave of technological innovations that reached Latin America after the war did not generate a significant improvement in the distribution of wealth, although the product grew during most of that period more rapidly than did the population, there is no particular reason to expect that the new wave will make it possible to reverse this situation more or less spontaneously or automatically (and this is even less likely considering the situation now being faced by the region).

The social and economic impact of the new wave (which has only recently begun to reach Latin America) will be tremendous if profound changes in the socioeconomic structure are not made. As examples, one need only consider the still incipient effect on employment produced by the penetration of informatics and robotization (in countries with chronic unemployment); the loss of international markets (such as the food market in Europe, owing to advances in agricultural technology, including biotechnology); the loss of the region's economic and technological autonomy; and the growing disparity between Latin America and the developed countries.

In brief, the development style followed in recent decades in Latin America and the Caribbean is no longer viable. We are faced with the disruption of trends and the onset of a historical period marked by widespread uncertainty. This is not a temporary phenomenon, but a profound world restructuring.

The countries of the region urgently need to define and implement new development strategies to allow for the incorporation of the opportunities provided by new technologies without paying enormous social and economic costs. These strategies, in order to be viable and desirable, must be socially, economically and ecologically sustainable in the long run (ECLAC, 1990). They should therefore be aimed at achieving a society whose basic attributes include a significant increase in popular participation in decision-making, a more equitable distribution of wealth and intrinsic compatibility with the environment.

These new national and regional economic and social development strategies must be firmly based on science and technology, with priorities and goals that are established by the countries of the region. This is essential because of the strong high-technology (science-intensive) component that characterizes this new wave of worldwide socioeconomic restructuring, and the inherent potential of new technologies to promote progress in the region.

The environmental dimension of the predominant development style in the region, the impact of the crisis on the region and its role in future alternatives are aspects that are often ignored in forward-looking analyses. However, it is the environmental component which determines the long-term ecological sustainability of development.

The development and dissemination of new technologies in the region may produce very significant environmental changes, both beneficial and harmful.

It is extremely difficult to make a detailed prediction of medium-term ecological changes in the region for the following reasons:

i) A multiplicity of socioeconomic changes will occur, representing virtual complexes of interconnected causes rather than a sum total of isolated changes. Obviously, it is unacceptably simplistic to try to define the impacts of the new wave of technology as the total amount of specific individual impacts associated with each technology (as if all the rest were equal). What will really occur in the region will be a series of large-scale, deep-seated and turbulent changes in societies, with many dimensions and many causes. In all probability, the indirect environmental impacts will be much more extensive and penetrating than the direct effects. The main environmental consequences will be associated with a thoroughgoing restructuring of production and consumption systems, including new integrated technology packages; nothing would be more mistaken than to restrict the discussion to identifying direct impacts, technology by technology. This is easily demonstrated on the basis of past experience. For example, if a timely prospective study had been made in the post-war years on the possible direct environmental impacts of the introduction of the tractor, such consequences as the compacting of soils and some contribution to air pollution might have been identified. These effects were actually felt, but they were trivial in comparison to the enormous and extensive environmental impact of agricultural mechanization, which, combined with other technologies (fertilizers, new varieties, herbicides) and operating in the prevailing socioeconomic context, contributed to a profound change in production systems throughout the region and the marginalization of large masses of peasants who had no access to the new means of production. The ecological impacts of these new agricultural systems, and the effects of the peasants being driven off highly vulnerable lands, went far beyond the direct effects associated with the tractor.

ii) The ecological future of Latin America will depend to a great extent on what major social options are chosen in the region in response to the lack of viability of the present development style. The basic attributes of the development strategies are the major determinants of how, where and why the technologies are applied, and therefore the location, direction and intensity of the impacts (Gallopín, 1981, 1982).

iii) Forward-looking ecology cannot be reduced to a mechanical extrapolation of historical trends into the future. The main reason for this lies in the fact that ecosystems (and ecological systems in general) are not merely passive receptors of human action; on the contrary, they have their own complex dynamics which result in often unexpected ecological responses, determined by complicated interactions between human activities and ecological processes and "rationale", leading to either homeostatic behaviours (within certain limits) or sudden discontinuities; retrogressions but also progress towards new configurations (Holling, 1986; Gallopín, 1980, 1983). These considerations, although they do not obviate the possibility of prediction at the ecosystemic level (particularly in the case of extreme disturbances), suggest the need to use extrapolative thinking very cautiously, especially during periods of intense change such as the present one. Advances in knowledge and the social and environmental rationalization of human activities could easily lead, in the not too distant future, to the appearance and reproduction of new ecological and social configurations that are now unimaginable.

The main questions about the ecological future of Latin America are centred on two basic levels: firstly, on the changes that will take place in the location and nature of the predominant human activities in the region (which will depend basically on the national and regional social responses to the crisis and the wave of technological innovations); and secondly, on the ecological responses to the changing range of human activities (which will depend on the ecological functioning of the various ecosystems and their present conditions). These two levels --but primarily the first-- are surrounded by uncertainty, making detailed and rigorous predictions impossible.

However, it is possible to suggest three possible lines of thinking. The first is based on the ecological trajectory established by the trends of the past decade, assuming the absence of significant socio-cultural and political changes, and obviously taking into consideration foreseeable technological advances. These are described in chapter III.

The second line of thinking postulates a significant change in development patterns: a revolution in production generated within the capitalist social formation which will involve substantial modifications in production patterns. This scenario is the subject of chapter IV.

The third possibility is to identify a normative scenario, indicating the direction of the strategic measures that need to be taken to reinitiate a viable and desirable development path that is intrinsically compatible with the environment, together with the probable consequences of these measures, and to predict in general terms the types of environmental implications of such a socioeconomic scenario. This line of thinking is presented in chapter V.

III. THE ECOLOGICAL TRAJECTORY OF THE REGION IN THE CONTEXT OF OBSERVABLE TRENDS OF THE PAST DECADE 2/

The ecological prognoses offered in the early 1980s (Dourojeanni, 1982) predicted that agricultural lands would increase from 9% to 14% of land surface by the year 2000. Most of this land would come from the High Amazons (eastern Andes), with catastrophical ecological consequences owing to soil fragility. A similar situation was expected to occur in Central America, with agriculture encroaching upon closed forests. Pasturelands would probably expand from 26% of total surface area to 34%, mainly at the expense of natural forests, which would diminish from 49% to 33%, or perhaps to 20%. Fallow, urban and wasteland areas would increase from 16% to 18-20%, mainly owing to desertification. It was anticipated that air and freshwater pollution would tend to rise markedly, as would ocean pollution, which is already serious in the Caribbean.

Many species and complete ecosystems, such as the Araucaria forests of Brazil, the Podocarpus forests in a number of countries, some forests of southern Chile and the Matto Grosso wetlands would probably become extinct. Trends indicated that ecological problems throughout the region would worsen and could lead to a collapse during the first decades of the twenty-first century, associated with the inability of the predominant, ecologically degrading forms of agriculture (particularly stock-raising) to feed the existing population.

It is important to note that the analyses on which the above predictions were based were mostly made at the beginning of the decade, and therefore do not take into account the additional current pressures that are leading to the overexploitation of the resource base to produce exports in order to service the external debt, nor the pressures associated with the present deterioration of the international terms of trade. This suggests that the trends towards regional economic degradation will be exacerbated (ECLAC, 1989), while at the same time large-scale development projects and colonization will be cut back or eliminated. These analyses also fail to take into account the impact of new technologies on the ecology of the region, as discussed in the previous section.

On the basis of the initial situation and visible trends, a probable scenario has been outlined as a framework for anticipating future ecological changes in the region in the next 50 years. This scenario would involve the continuation of current stagnation to some extent, followed by a moderate increase in economic growth that will be lower, however, than before the present crisis (Furtado, 1984; Gallopín, 1986). The development model would not undergo major changes, and transnational corporations would be increasingly influential. The new wave of technology would mainly be det rmined exogenously (Lahera and Nochteff, 1983), with the region maintaining its current passive, defensive attitude.

This scenario was used to explore the probable environmental changes in the region if deep-seated political and socioeconomic changes are not made. Mathematical simulation models 3/ of land use were constructed (see annex 1), taking into account the baseline situation and existing prognoses at the beginning of the 1980s (corrected in accordance with current data) and the probable changes in landuse and technology on a year-to-year basis. The conceptual structure of the models appears in annex 1. The following overall regional assumptions are used (specified according to the features of each of the 18 main ecological zones of the region --Winograd, 1989):

- regional annual population growth of 2.2% in 1980, gradually falling to 1.2% in 2030;

- average annual increase in per capita agricultural production of 0.5%;

- average annual increase in crop yields of 1%;

- increase in yields and carrying capacity per hectare in stock-raising (0.6% animal units/hectare in 1980 and 1.1 animal units/hectare in 2030);

- increase in intensity of land use (and use of inputs) with worsening degradation owing to pressure on forestry;

- decline in rate of advance of agricultural frontier in tropical zones owing to increase in yields and depletion of newly accessible lands in some zones;

- crop diversification and increase in lands used for export crops.

The land categories used in these simulations are as follows (Gallopín, 1989; Winograd, 1989):

Natural ecosystem: undisturbed areas of primary vegetation, and areas disturbed in the past but currently having vegetation similar to original vegetation.

Altered ecosystem: areas altered by human action (forestry, shifting agriculture, stock-raising, etc.) coexisting with the original ecosystem and having secondary vegetation.

Agricultural ecosystem: areas planted and harvested annually, including annual, permanent and non-traditional (coca and marihuana) crops. Fallow land from shifting and peasant agriculture falls within the "altered ecosystem" category.

Grazing ecosystem: areas with natural or artificial pasturelands used for stock-raising.

Plantation ecosystem: reforested areas for forestry or watershed protection.

Wasteland: areas suffering from severe anthropogenic erosion and desertification, with irreversible changes in their structure and function (not including natural deserts).

Urban areas: urbanized areas (basically cities).

The results of running the simulation models indicate, for the whole region, the following major ecological changes under the "current trend scenario" (Gallopín, 1989):

Table 1

Ecosystem	Initial (1980)	2030	Total change (%)
Natural	40.6	30.0	-26.7
Altered	22.1	21.0	-6.4
Wasteland	2.0	3.2	69.6
Agricultural	7.5	11.0	46.5
Grazing	26.8	32.0	20.4
Plantation	0.3	1.5	443.2
Urban	0.7	1.3	92.7
TOTAL	100.0	100.0	

Table 1 shows anticipated changes in the scenario for eight major ecological zones, regrouped on the basis of the original 18.

For the region as a whole these figures mean the transformation of 4.4 million hectares annually (as an average for the next 50 years) of natural ecosystems. Of this land surface, 78% will come from tropical areas, 19% from subtropical areas and only

3% from temperate zones. Of this transformed area, 45% will become croplands (30% under shifting agriculture and 15% under permanent agriculture); 30% will be used for stock-raising and 22% for forestry (Winograd, 1989).

Two main processes explain most of this evolution: a) the advance of the agricultural frontier, which translates into a decrease in natural ecosystems and a growth in agricultural, grazing and altered areas, and b) intensification of land use, implying that wastelands will encroach upon altered ecosystems in arid zones, while altered ecosystems will expand in humid zones and, within them, subsistence farming will intensify. The total land area of altered ecosystems in the region will shrink, since in many altered ecosystems stocks are reaching their limit and land use is therefore being intensified as an alternative to the expansion of territorial occupation.

An analysis of the eight major ecological zones in the region would seem to indicate that most problems involving ecology and depletion of the region's natural and cultural resources are linked to patterns of land use (underutilization and urbanization of croplands, overuse and monoculture in hillside, irrigated zones, reconversion and deforestation of forests and overgrazing in arid and pasture zones). The effects of this type of management are numerous and in some cases irreversible, affecting not only ecosystems but also the sustainability of economic activities.

Deforestation is the most serious problem facing the region in connection with land use and the waste of natural resources, with the main causal factor being the advance of the agricultural frontier in tropical zones. This means that during the period 1980-1985 the region lost 17.5 million hectares of tropical and subtropical moist forests, 2 million hectares of mountain forests and 8 million hectares of tropical and subtropical dry forests.

From the trends in land use in Latin America revealed by the detailed results of the simulation models, the conclusion may be drawn that the zones representing the <u>advance of the agricultural frontier</u> show the greatest absolute changes. The advance of the frontier is primarily evident in the tropical forests and involves the loss of forest resources and possible extinction of between 15% and 35% of existing species by the year 2030 (Lugo, 1988; Winograd, 1989). In the tropical forest zones, the natural areas will shrink by 177 million hectares by the year 2030 (138 million in the moist forests and 39 million in the dry forests). In the mountain forests the advance of the agricultural frontier is less serious, but these forests will disappear in Central America and the Andean countries roughly between the years 2010 and 2020, as will the tropical moist forests of Central America.

The cleared lands will be used for stock-raising, since in the zones where the frontier is advancing the growth of this activity is based on the obtaining of new lands, while in the other zones increased production is based on the intensification of use of the land. Thus, in the tropical moist and dry forests, agriculture will increase by 0.9% annually and 1% annually respectively from 1980 to 2030. Stock-raising will increase by 1% annually between 1980 and 2030 in the tropical moist forests, while in the tropical dry forests this rise will represent 0.7% annually for the same period.

There are other zones, however, that will show significant changes in land use, such as grazing areas in the tropical savanna, which will grow by 0.6% per year, and croplands in the mountain zones, which will increase by 1.5% annually. This annexation of agricultural land in the mountain zones is based on the incorporation of already cleared areas.

Urbanization, although a more recent phenomenon, affects part of the best lands in some countries with a shortage of natural land, such as El Salvador, Costa Rica and some regions of Colombia, Brazil and Mexico.

Plantations, although they are expanding significantly, continue to be insufficient; the gain/loss ratio will shift from 1:9 in 1980 to 1:6 in 2030.

Lastly, altered zones, which have received little attention and have not been taken into account as a source of resources, are expanding in area in the tropical moist forest zones by 1.1% annually, while in the other zones they are diminishing as a result of the intensification of land use and the shortage of new land.

Problems of soil erosion originating in deforestation, inappropriate agricultural techniques, overgrazing and overexploitation will particularly affect tropical and subtropical moist mountain forests and the subtropical moist forests of Central America, the Andean countries and Brazil. To a lesser extent, the Argentine pampas will continue to suffer from erosion.

The degradation of watersheds owing to deforestation and dam construction will mainly affect the tropical and subtropical mountain and lowland moist forests in Central America, the Andean countries, parts of South America, Brazil and Mexico, and the temperate moist forests of Chile and Argentina.

Floods, due to watershed degradation, deforestation and natural processes, will mainly affect the tropical and subtropical mountain and lowland moist forests in Central America, the Andean countries and Brazil and some of the savannas, subtropical forests and pampas of the Andean countries, Argentina, Brazil and Bolivia.

Desertification, associated with overgrazing, excessive extraction of fuelwood and cyclical droughts, will advance mainly in the Patagonian steppes, the puna, the tropical dry forests, the tropical and subtropical desert shrub lands and the temperate thorn forests in the Andean countries, Brazil, Argentina, Chile, Peru, Mexico and Central America.

Agricultural pollution will continue in many of the croplands throughout the region, and agricultural, industrial and urban pollution will rise in the deltas and mangrove swamps of Central America, the Caribbean and parts of South America.

The deficit of fuelwood will continue to increase in most ecosystems, affecting more than 50 million persons living in arid zones and the Andean highlands.

By the year 2030, the average calories provided will increase to over 3 000 per capita daily. As a result, relative levels of undernutrition will decline, but the absolute figures for persons in this condition will be higher.

All these data combine to indicate that the development model or style predominant up to now (and presently in crisis) is not ecologically sustainable and is therefore not viable in the long run.

IV. POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH A NEW DEVELOPMENT PATTERN

The role of the hitherto prevailing development style with respect to the environmental impacts on the region associated with post-war socioeconomic and technological changes was described in the previous chapter. Such factors as these changes have brought the region to its present situation. What trends will be inherent in future permutations?

A central, primary point is that this "third industrial revolution" does not represent (in terms of its origin) a transition to a new social formation but rather a revolution occurring within and generated by the capitalist social formation. This industrial revolution and the new techno-economic, dominant paradigm associated with the emergence of a new economic, social and cultural pattern represent the response by "organizational capitalism" to the crisis involving the exhaustion of the potentialities of the post-war paradigm in terms of ensuring the economic and social growth of the large State-run and private organizations of the more highly industrialized countries. The new paradigm is thus a product of these large organizations, with potentialities which respond functionally to their needs and can be generated, hegemonized and developed by them. As a result, the increase in degrees of human freedom afforded by technical change tends to be distributed unequally; the new freedom is gained mainly by the large organizations of the more advanced countries (Nochteff, 1987).4/

As we have indicated in another study, the foreseeable general impacts on Latin America (empirically documented in their present phases --Notcheff, 1987--) will be centred on the loss of the autonomous ability of the countries of the region to define their own production, consumption and distribution patterns; the transfer of thought processes abroad (through the accelerated incorporation of skills --even intellectual skills-- into capital goods, the cross-border flow of data and decisions, etc.); the widening income gap between the advanced countries and those of the region (due to such factors as growing disparities in productivity and in capacity for capital accumulation, the widening technological gap, the lessening significance of comparative advantages based upon cheap labour or raw materials and the increasing importance of advantages based on the scientific and technological know-how, and the underutilization of existing high-technology capital goods in the region); technological unemployment (including a polarization of the skill profile of the labour force, to the detriment of skilled workers); a regressive income distribution (among social classes and among countries); the concentration of power in the large organizations of the more advanced countries (particularly transnational corporations); and the structural tendency towards imbalance in the external sector of the regional economy (due to the growing need to import capital goods to maintain the competitiveness of the other sectors of the economy). These trends, generally negative for Latin America, arise from the rationale of the original and unfolding process, and they will affect the region if the current (essentially exogenously determined) pattern of incorporation of technological change is not modified (Gallopín, 1988).

The fundamental ecological implications of this scenario (possible and viable in the relatively long run) are profound and varied.

International agreements --mainly between industrialized countries 5/-- combined with the intrinsic features of the new technological paradigm (especially the saving of energy and raw materials and the capacity for recycling and recovering byproducts of possible commercial value in closed cycle, multi-product effluent-less plants) will tend to check and possibly reverse the ecological deterioration of the planet (global warming owing to the greenhouse effect, changes in climatic zones, destruction of the ozone layer, sea and air pollution, depletion of marine resources, etc.). Most of these problems affect all the countries of the world, although they have mostly been generated by the industrialized countries. The direct effect on Latin America of this deceleration in planetary deterioration will obviously be positive from the ecological standpoint.

However, it should be noted that the industrialized world has already used up most of the planet's ecological capital 6/ (WCED, 1987) (both in terms of natural resources and of planetary capacity for absorption and dilution of wastes and contaminants), and the concerns of the advanced countries, together with the above-mentioned loss of the region's autonomy, favour the possibility that the "first world" will try to impose new conditions on the economic growth of the third world, based on global environmental considerations. There may also be a countertrend, represented by an agreement between the developed countries and their large organizations, for the purpose of helping to alleviate extreme poverty in the developing countries, especially in aspects and locations where the global environment is deteriorating.7/

In future, the global environmental issue will definitely represent one of the clearest areas of interdependence (and therefore of negotiations) between the industrialized and the developing countries.8/ In many other aspects, the techno-economic revolution will help to increase the autonomy of the developed countries with respect to the developed world and planetary resources.9/

At the regional and national levels, the situation appears to be much more problematic. However, a relatively systematic conclusion about environmental consequences may be drawn from the general trends noted above (Gallopín, 1982).

The loss of the Latin American countries' autonomous ability to define their own patterns of production, consumption and distribution, together with the concentration of power in the hands of transnational corporations, are associated with the penetration of exogenous economic rationalities and an increasing probability of further weakening of the feedback between economic activities and ecological degradation.10/ This tends to generate the overexploitation of certain natural resources, the underutilization of others and the externalization of the ecological costs away from the large organizations and into the region. In view of the content of the new techno-economic paradigm as it is shaping up, there will probably be a consolidation of the trend towards maladjustment between the structure of production and that of consumption, with production being directed even more towards demand originating in high-income minority sectors, and additional pressures to create new demands and increase the obsolescence of durable goods, thus exacerbating the dumping of wastes into the environment 11/ and the marginalization of broad sectors of the population (which will then contribute to the ecological degradation associated with poverty).

The orientation of production towards non-essential consumer goods and the visibly explosive upward trend in the supply and diversity of durable consumer goods are instrumental in generating continually growing pressure on the environment and on scarce resources for non-essential uses,12/ even more so in view of the fact that the trends do not favour a transition towards the collective consumption of goods and services, where appropriate, but rather indicate the accentuation of individual consumption, multiplying the number of units needed to satisfy demand.

The current worldwide trend is towards decentralization of industrial production systems, but centralization of control over the creation of knowledge (and therefore of technology and output).13/ Transnational corporation activities in Latin America (such as the establishment of the microelectronics industry) tend to be implemented in such a way that daily production planning and the repair of integrated circuits are carried out at the head office located in a developed country, while the work itself (automated or semi-automated) is performed at a local installation in Latin America, through the use of telematics. Moreover, in the case of microelectronics, transnational corporation investments in the region tend to be targeted to increasingly less remunerative and less technologically significant tasks, often taking the form of "enclaves" without vertical or horizontal linkages with the rest of the local production system (Nochteff, 1987). With regard to materials, the apparent directions of change (Pérez, 1986) are, first of all, the geographical relocation of the production of traditional materials on the basis of comparative advantages in terms of the cost of energy, or in order to save transport costs and gain flexibility because of the nearness of the source; secondly, the growing diversification of factories in the developed countries with respect to more sophisticated and appropriable new materials. The trends towards relocating highly polluting industries in the developing countries having permissive legislation is well known; resource-based, pollution-intensive industries are growing faster in developing countries (WCED, 1987). Many of them are affiliates of transnational corporations.

All these elements together mean that in the establishment of industries and other productive activities there is probably an increasing tendency to ignore local ecological limits and environmental adaptation of activities, with the consequent aggravation of environmental problems. The possibility that some environments in the region may be used by major organizations as testing grounds for new technological developments having a high environmental risk or in order to explore the comparative advantages of the local germ plasm or ecological organization cannot be ignored.14/

In terms of their origin and rationality, it is obvious that the production technologies and forms generated by the major organizations of the developed world will not tend to adapt spontaneously to the needs and potentials of the countries of the region. This implies that new technologies, introduced under exogenous criteria, will in most cases entail significant maladjustments with respect to their adaptation to the ecological cycles of local ecosystems. Technically, it is possible in many cases to minimize these maladjustments, given the flexibility and programmability of the new technologies and their advanced capacity to adapt plant layouts and product design to the specific cultural and environmental conditions of certain countries or localities. In practice, the degree of maladjustment will be determined by the rationality (in the sense of an objective to be maximized) of the application of technology, public reaction (particularly in the urban centres where politically powerful actors are concentrated) and the capacity (declining, as discussed earlier) of national and local governments to require and ensure the implementation of pro-environmental adjustments.

Another foreseeable macro effect, according to the exogenous rationale of technological dissemination, is the faulty adjustment between the structure of production and the profile of natural resource endowment in the countries of the region, generating trends towards excessive pressures on some resources and at the same time the non-use or underutilization of others. The rationality of the large transnational corporations and their capacity for moving capital throughout the world will in many cases tend to produce higher rates of utilization of renewable natural resources than of ecological regeneration, leading to the degradation of productive ecosystems and their abandonment (in a degraded state) when their profitability becomes lower than that of alternative locations in the world.

The tendency to transfer the thinking process outside the region also has environmental implications. The fundamental capital input within the new techno-economic paradigm is science, which will become increasingly separate from technology and more directly linked to the requirements of hegemonic organizations, as well as more and more concentrated in the developed countries and large organizations (Nochteff, 1987). At the same time, scientific and technological protectionism by these organizations, as reflected in their publishing and patenting policies and in the tendency not to transfer technologies which are "unincorporated" from goods, and the possibility, through telematics, that parent companies may merely respond to specific problems rather than transferring methods (Nochteff, 1987) combine to produce a situation where technologies are becoming increasingly "opaque", and where the countries of the region have fewer possibilities of copying and/or adapting them (as Pérez (1986) notes, even the capacity to copy and adapt requires an increasing amount of scientific and technological expertise). All these factors not only limit access by the countries of the region to technological packages but also hinder the adaptability of the technologies to local ecological potentials and constraints (except those specifically designed to be reprogrammed and adapted).

The widening disparity of income between the advanced countries and those of the region and the structural trend towards imbalance in the region's external sector indicate that there will be pressure to relax environmental and ecological protection regulations, and that the tendency to overexploit the ecological base for export products will grow. These trends, combined with social tensions due to increasing technological unemployment and regressive income distribution, are leading many countries of the region to function with "war economies", abandoning environmental (and social) development objectives.

Rising technological unemployment would likely lead to an increase in the disadvantaged population (including a significant component of skilled labour), which could reverse the historical trend in some countries towards migration to the cities, with concomitant ecological and social consequences.

The social effects of trends towards the polarization of income within countries, would favour an increase in the ecological deterioration associated with both poverty and overconsumption.

Moreover, the increasingly regressive income distribution trend among countries would contribute not only to widening the economic disparity between the countries of the region and the advanced countries but also (unless intensive, sustained policies are applied to prevent it) increasing inequality among the Latin American countries themselves, in view of the initially greater capacity of the bigger, more industrialized countries to absorb technological change compared to the poorer countries.

In the above study, mention was made of the fact that the ecological impacts associated with the general redefinition of comparative advantages are hard to anticipate because of the likelihood of new, unexpected advantages. The possibilities for highly efficient "flexible manufacture" (Pérez, 1986) opened up by microelectronics would permit plant scale to become increasingly independent of the scale of each market, as productivity becomes less dependent on plant scale, and this would involve profound changes in the factors that determine competitiveness. The result would probably be the appearance of "economies of coverage" based on the optimization of the range of products, "economies of specialization" based on narrow nitches in the market, and "economies of location" based on proximity and the speed of response (Pérez, 1986). In this situation the number of factors that determine comparative advantages (as well as increase their volatility) could multiply. The reduction in the relative weight of wage costs within the new techno-economic paradigm would tend to diminish the importance of comparative advantages based on cheap labour, affecting the development possibilities of those countries which have based their growth on this factor (those which could either lose this relative advantage or would be forced to reduce wages even further, with regressive effects on income distribution --Nochteff, 1987). The reduction in the raw materials/product ratio, together with materials substitution, will more directly affect the countries whose capital accumulation has been based upon their mineral or forest resources. The new technologies (particularly biotechnology) are already affecting traditional farmers, transferring the rate of return and control of production and marketing to the large transnational chemical and pharmaceutical companies and international traders. The increases in agricultural yield in the advanced countries (made possible by new technological developments) tend to reduce edaphic and climatic comparative advantages, closing off traditional markets for Latin American agricultural products, while at the same time international competition from the central countries is increasing for those products (Gallopín, 1988).

A number of comparative advantages could arise in the region, with a variety of ecological consequences. The range includes the advantages associated with access to cheap sources of energy, the reduction in transport costs owing to the proximity of natural resources, the establishment of enterprises as a result of permissive environmental or health legislation and the exploitation of local ecological or climatic components (such as the discovery of new rare, critical or strategic natural resources --whether renewable or non-renewable-- or the use of open-air bioprocesses --Pérez, 1986-- which need to be carried out directly in the natural environment, such as bacterial leaching of mineral wastes or biological control of agricultural blight). In ecological terms, this changing pattern of comparative advantages in the countries of the region could generate risks of severe increases in pressures to exploit as yet untouched fragile or remote areas or ecosystems, the sudden valorization of particular ecological elements or functions (and the devalorization of others), the introduction of new biological organisms or even exotic ecosystems into the region, etc. In the absence of social regulation, these phenomena could lead to the overexploitation and degradation of regional ecosystems (and to the loss of the associated comparative advantages). If well managed, however, they could open up new sources of prosperity.

The above discussion has been focused on the major determining factors and general types of indirect ecological impacts on the region, a level of analysis which was complemented by the earlier presentation of the environmental impacts directly associated with each new technology (microelectronics, biotechnology, new materials and new energy sources). The ecological panorama that can be inferred from this regional scenario is quite discouraging (although it includes a few somewhat isolated positive aspects). Paradoxically, the technical potential for sustainable management of ecosystems, for controlling, monitoring and reducing pollution, for adapting factories and technologies to local social and ecological conditions, for making a spectacular improvement in the production of goods and services to satisfy human needs, for diversifying the uses of ecological resources and for designing a development pattern that is ecologically sustainable in the long run is today higher than at any time in history.

However, the direction in which the trajectory of the new techno-economic paradigm is moving would seem to imply that, unless Latin American countries adopt active, sustained strategies that are endogenously defined and shared among the social actors and countries of the region (in order to implement the necessary social, economic and technological structural changes), the above-mentioned technical potential will mainly benefit the more advanced countries, while the region will face a serious risk of a further intensification of the pernicious effects of the techno-economic revolution.15/ In that regard, it is important to avoid the mistaken assumption that, since the new techno-economic paradigm saves material inputs and energy, total consumption of natural resources will tend to diminish and therefore pressure on them will be eased. These savings in materials involve an increase in the economic productivity of natural resources, but they do not result in a decline in the overall use of materials, since global production will grow, product life cycle will be shortened because of technical obsolescence, and the number of products will probably increase; what will tend to decline is the rate at which the consumption of materials rises in proportion to the growth of the gross product. The use of traditional materials as a proportion of total consumption will continue to be high for a long time (Pérez, 1986). In addition, the inertia of productive stock transformation is much greater than the growth rate of production as a result of new technologies (Nochteff, 1987).

Although the analysis in this section has concentrated on the possible regional ecological effects of new and emerging technologies, the ecological impacts of the dissemination of already existing ("modern") technologies and of the change in products based on the use of current technologies are of equal (or greater) importance. The recent history of Latin America exhibits impressive product and technology shifts in the agricultural sector (where the rate of innovation is generally relatively slow). For example, of the 15 million hectares incorporated for agricultural use in the 1970s, 60% were planted with soya, a crop which was almost non-existent 20 years before; the Green Revolution spread rapidly throughout the third world (Gutman, 1985). This clearly shows that the ecological effects of new technologies will not replace those associated with "modern" and "traditional" technologies in the region, but will be complementary to them, at least in the next few decades.

As has been shown, many of the foreseeable ecological effects on the region are closely linked to the rationale and behaviour of transnational enterprises and large-scale organizations in the advanced countries. This has been clearly recognized by the World Commission on Environment and Development, although, as has been rightly pointed out (Centro Tepoztlán, 1987), the ways in which this document addresses the issue of transnational corporations, and the recommendations made concerning them, are naïve and voluntaristic. Since the main problem goes back to the appropriation of the benefits of the technological revolution, there is no reason to expect that pleas for good will will have any discernible effects.

In view of the initial discussion in this chapter, it is obvious that the issue revolves around what the potential effects may be, depending on the total socio-techno-economic configuration (including the linkage of new technologies with pre-existing ones) and on what political decisions are implemented (including environmental policy). Tables 2, 3, 4 and 5 present the result of an effort in this direction for each of the major representative areas of the new technological wave (Gallopín, 1987). The tables give a partial picture of the complex environmental implications of possible combinations of various technological developments and how their potential may be used.

Table 2

MICROELECTRONICS: Possible general and environmental effects of technological change in Latin America

1. AREAS OF APPLICATION:

* Computation, data processing, artificial intelligence and telecommunications. In services, industry, agriculture, business administration and management of complex processes.
* Automation and robotics in manufacturing and services.
* Telemetry and detection of resources, anticipation of events.

2. DIRECTION OF POSSIBLE EFFECTS ON BASIC COMPONENTS OF THE SOCIOECONOMIC STRUCTURE:

* Potential for high-efficiency decentralization.
* Potential for centralization of information (and hence power).
* Feasibility of incorporating small-scale production into cycles of large volumes of capital (presently limited by the high cost of communication and control).
* Greater access to the lowest links in the production chain, together with monopolization of the highest links (for example, public access to production and reproduction in communications through video and audio cassettes, but monopolization of satellite communications).
* Possibility of significant changes in international comparative advantages (for example, loss of comparative advantages of cheap labour).

3. DIRECTION OF POSSIBLE EFFECTS ON RURAL ENVIRONMENTS:

* Improvements in administrative management and reduced commercial risk to individual and small-scale producers (in relation to access to information on prices, markets and products), through information networks and electronic data bases.
* Improvements in technical agricultural management (optimal use of irrigation water, dosage of fertilizers, etc.) through information networks, expert systems, simulation models and new rural training systems based on microelectronics and telecommunications.
* Possibility of managing complex agro-ecosystems through computerized models and systems.
* Possibility of decentralization of information and decisions, generating new production systems or, alternatively, possibility of centralizing decision-making

to be transmitted over long distances vía telecommunications and data banks.

* Possible exclusion or displacement of groups of producers who have no access to the new technologies.
* Improvements in weather forecasting, predicting of natural disasters and hazards and monitoring of environmental changes that affect rural production through telemetry and information and telecommunications networks.
* New and better information on hard-to-reach natural resources; detection or discovery of new resources through telemetry, informatics and telecommunications, to allow for better governmental supervision or to help private monopolies, depending on the social context.
* Risk of sharply increased pressures to exploit fragile or untouched ecosystems, as a result of newly available information and techniques, and abrupt valorization of particular ecological elements or functions. In the absence of regulation, this could lead to the overexploitation and degradation of regional ecosystems. If well managed, it could open up new sources of prosperity.
* Feasibility of exploiting natural resources in remote or inhospitable areas through the use of automation, robotics and telecommunications.
* Possible reversal of current rural-to-urban migration if high urban unemployment levels result from automation, informatics and robotics.

4. DIRECTION OF POSSIBLE EFFECTS ON URBAN ENVIRONMENTS:

* Automation of the tertiary sector.
* Drop in industrial employment and reduction in number of new industries established in cities.
* Possibility of major changes in the organization and efficiency of public services.
* Significant changes in the supply and composition of employment.
* Possible changes in the comparative advantages of large cities in relation to medium-sized and small cities, for both industries and inhabitants.
* Problems related to urban unemployment.
* Changes in the design of cities as the amount of work time versus free time begins to change.

Table 3

BIOTECHNOLOGY: Possible environmental effects of technological change in Latin America

1. AREAS OF APPLICATION:

* Genetic engineering (plants/animals), modification of germ plasm, tissue culture, cloning.
* Biotechnology for food production.
* New food processing and preservation techniques.
* New sources and kinds of biomass energy.
* Biotechnology for industrial processes (mining, biometallurgy, industrial enzymes, new industrial products and processes, etc.).
* Biotechnology in medicine and pharmaceuticals.

2. DIRECTION OF POSSIBLE EFFECTS ON BASIC COMPONENTS OF THE SOCIOECONOMIC STRUCTURE:

* Possibility of significant advances in food production and and in the health and nutritional conditions of the population.
* Possible contradiction between a form of biotechnology concentrated on export-oriented agriculture (forage, oil-seeds, tropical export products) and concentration of R & D priorities on food production for the domestic market; between emphasis on increasing production in existing areas or on new areas or resources; between food crops and energy crops, etc.
* Changes in the structure of industries.
* New social and ethical problems associated with the use of biotechnology on human beings (diagnosis, genetic therapy, genetic engineering); new possibilities of finding cures.
* Possibility of significant changes in national and international comparative advantages (for example, loss of the advantage of fertile soils).

3. DIRECTION OF POSSIBLE EFFECTS ON RURAL ENVIRONMENTS:

* Problems of access and control; danger that the technical conditions of production will begin to diverge increasingly from the producer's ability to control them (special seeds, imported inputs, etc.).
* Possibility of appropriation and monopolization of germ plasm originating in the region by transnational corporations (patenting of germ plasm, etc.).
* Possibility of new forms of sustainable, multi-purpose use of many ecosystems (for example, tropical forest).

* Risk of selective and despoiling exploitation of ecosystems to extract substances or components that are valuable in biotechnological production (pharmaceuticals, etc.).
* Valorization of new renewable natural resources; creation of new ecosystems and generation of new ecological impacts.
* Changes in relative advantages of production systems and traditional resources.
* Possibility of recycling nutrients and wastes, with new ecological impacts (both positive and negative).
* Possibility of new ways of overcoming the natural limitations on animal and plant production: new varieties that can resist extreme environmental conditions; use of technological packages containing seeds with their own doses of fertilizers and herbicides; creation of varieties that determine their own nutrients.
* New techniques for processing and preserving agricultural products, enabling them to be stored locally.
* New impetus for biological control of pests and pathogens, favouring reduction in the use and impact of pesticides and the production of biological pesticides.
* Significant increases in agricultural yields.
* Synthesis and introduction into the environment of new substances and forms of life, with new ecological impacts. Long-term effects of genetic engineering.
* Feasibility of increasing the diversity of production, reducing the current predominance of monoculture.
* Possible increase in vulnerability of certain varieties owing to reduction in genetic variability (cloning).
* Revalorization of technologies for producing energy from biomass, and competition for natural resources for other uses.
* Differential impact on rural producers depending on their access to biotechnology.

4. DIRECTION OF POSSIBLE EFFECTS ON URBAN ENVIRONMENTS:

* Possibility of a high-yield, economically competitive urban or peri-urban agriculture.
* New biotechnologies to recycle urban waste and to increase the environment's assimilation capacity; treatment of sewage by biotechnology (genetic engineering).
* New biotechnologies that enable urban services to be decentralized (health, energy, education, waste treatment, etc.).

Table 4

ENERGY: Possible general and environmental effects of technological change in Latin America

1. AREAS OF APPLICATION:

* Technology of energy sources: biomass, solar, wind, geothermal, hydroelectric, nuclear, etc.
* Technology for developing principal uses: transport, air conditioning, residential, energy-intensive industries.
* Technology of conservation and recycling: domestic, industrial, construction-related and in the tertiary sector.
* Technology of energy transmission, transport and storage (particularly in relation to superconductors).

2. DIRECTION OF POSSIBLE EFFECTS ON BASIC COMPONENTS OF THE SOCIOECONOMIC STRUCTURE:

* Significant impacts on the situation of producers and importers of hydrocarbons.
* Differential effects on natural resources (for example, implications of ongoing, large-scale hydroelectric projects in the region, energy technology effects of biomass on tropical forests).
* Deconcentrating effects of development of small-scale energy-efficient systems (solar, wind, hydroelectric, etc.).
* Possible concentration/deconcentration of sources and uses.
* New opportunities for recycling and conservation.
* Changes in comparative advantages of energy sources originating in possibilities for large-scale storage (superconductors), with revalorization of variable energy sources (solar, hydroelectric, wind, etc.).
* Local effects of saturation and contamination on health.

3. DIRECTION OF POSSIBLE EFFECTS ON RURAL ENVIRONMENTS:

* Diminishing rate of deforestation resulting from harvesting of fuelwood.
* Increasing pressure towards the use of the forest in the biomass energy industry; possible interaction with biotechnology to create high energy yield varieties.
* Competition for land, technology, inputs and credits between the use of biomass for food and its use for energy.
* Possibility of large-scale power plants aimed at the export of electricity (made feasible by new transmission and storage techniques based on superconductors).
* Environmental effects of large-scale hydroelectric works, and accumulated impacts of a myriad of small power plants.

* Possible interaction with telecommunications in rural areas (for example, remote stations fed by solar energy).

4. DIRECTION OF POSSIBLE EFFECTS ON URBAN ENVIRONMENTS:

* Changes in design of human settlements to take advantage of new sources of energy and new conservation, transmission and storage techniques.
* New opportunities for recycling domestic wastes.
* Pollution problems.

Table 5

NEW MATERIALS: Possible general and environmental effects of technological change in Latin America

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1. AREAS OF APPLICATION:

* New materials in industry, transport and services (superconductors, optic fibres, ceramics, carbon and glass fibres, new cements, new metal alloys, amorphous metals, powder metallurgy, multi-material composites, special types of glass, plastics and polymers, crystal semiconductors, etc.).
* Petrochemicals.
* New urban building materials.
* New materials in medicine and prosthetics.

2. DIRECTION OF POSSIBLE EFFECTS ON BASIC COMPONENTS OF THE SOCIOECONOMIC STRUCTURE:

* Possibility of lowering costs of meeting non-food basic needs (particularly housing and transport).
* Possibility of combining traditional local materials with new materials.
* New opportunities for recycling.
* Changes in competitiveness between natural and synthetic materials.
* Loss of relative advantages of strategic mineral deposits (particularly copper, nickel, chrome, cobalt and manganese).
* Significant changes in the structure of production, with the phasing out of entire industries and appearance of new industries.

3. DIRECTION OF POSSIBLE EFFECTS ON RURAL ENVIRONMENTS:

* Changes in demand for natural products (wool, industrial crops, wood, minerals). Generation of new demands for natural products to be used in the manufacture of new materials.
* Pollution by new types of biodegradable and non-degradable material waste. Appearance of new polluting and non-polluting industries.

4. DIRECTION OF POSSIBLE EFFECTS ON URBAN ENVIRONMENTS:

* Use of non-traditional building materials.
* Changes in urban design made possible by new materials.
* New possibilities for recycling waste.
* Changes in transport systems.
* Relocation of industries; possible new human settlements based on opportunities for different infrastructures; many new industries would be established closer to urban centres where skilled labour is concentrated.

V TECHNICAL FEASIBILITY OF ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN

In view of the current situation in Latin America and the Caribbean and the probable consequences of maintaining the above-mentioned present or past development strategies, the question of possible alternatives for a different type of development that would be socially, economically and ecologically sustainable must be addressed.

The concept of sustainable development adopted here does not postulate the conservation of nature in its original state as a primary goal. It implies, however, a pattern of development that minimizes the degradation or destruction of its own ecological base of production and habitability. The goal of sustainable development is the long-term amelioration of the quality of human life, and this entails the management (or even the transformation) of the structure and function of ecosystems in order to derive benefit from the goods and services provided by them, while minimizing the conflicts inherent in their exploitation, maximizing mutual support among the necessary actions and activities and distributing the ecological costs and benefits among the populations involved (Gallopín, 1988).

This section will discuss the technical feasibility of environmentally sustainable development in Latin America and the Caribbean, taking into account the ecological situation and potentialities of the region.

The findings of recent research (Gallopín, Gómez and Winograd, 1989) indicate that:

i) There are no serious ecological constraints (at the level of the region as a whole) on the satisfaction of human needs and the attainment of sustainable development (including food production).

ii) There is presently no critical lack of available technologies (in the sense of representing a regional bottleneck) that could impede the sustainable management of Latin American ecosystems.16/ Even without taking into account the potentialities of the new technologies, there is a battery of appropriate technologies which, if applied, could significantly help to solve most of the serious current ecological problems.

iii) The ecological future of Latin America and its possibilities for making the most of ecological opportunities while minimizing constraints are much more directly linked to the major social options adopted in the region than to the search for new knowledge and new ecosystem management techniques (although these are also needed).

Taking these factors into account, a possible and desirable scenario for endogenous development of the region has been identified (Gallopín, 1989c; Winograd, 1989). It is based on the assumption that this endogenous development pattern will be directed at achieving adequate satisfaction of the basic needs of the whole population, providing a better distribution of wealth and being intrinsically sustainable in environmental terms. Strong emphasis will be placed on increased participation of the population and the decentralization of decisions.

This scenario implies that there will be active policies aimed at regional integration and complementation; a selective opening of some key industrial branches to international competition; regulation and promotion of rapid incorporation of new technologies according to social priorities; regional decentralization, including social and economic reforms; land use zoning and regulation of the agricultural frontier; conservation and sustainable management of the environment and renewable natural resources; reinforcement of the industrial sectors associated with renewable and non-renewable natural resources and agriculture; development of local energy sources (mainly hydroelectricity and biomass); promotion of technological innovations in relation to the revalorization of renewable natural resources and the development of new, sustainable productive uses and of domestic and international market niches, particularly in relation to tropical forests and agricultural production.

In terms of environmental sustainability, the issues of technological pluralism (complementary use of traditional, "modern" and high technology) and of technological blending (constructive integration of new and emerging technologies with traditional or modern technologies) assume particular importance, requiring new forms of organization and an integral strategy for the development and dissemination of technology. The revalorization and promotion of existing traditional technology and empirical knowledge in the region are likely to be especially important for the medium- and small-scale sectors in rural areas. Many traditional technologies are better adapted to local ecological conditions and cycles than are the "modern" technologies that are currently being expanded. Technological blending could improve yields and avoid some of the limitations of traditional techniques. Such technological integration would enable these techniques to be made more compatible; it could promote self-sustained technological innovation, would be easily absorbed into and adapted to local situations and would promote social, cultural, economic and environmental sustainability.

Special emphasis is being placed on the development of new production systems based on the use of altered ecosystems, including "neoecosystems" generated by earlier human activities on virgin and abandoned land, and modernization and improvement of yields in more appropriate land already being farmed.

Strategies for assigning ecological areas for protection (and in some cases management) of large-scale ecological functions and processes (for example, watershed management, biogeochemical cycles, etc.), often involving co-operation among a number of countries, would be developed.

The enhancement of cultural diversity and participation naturally would include respect for indigenous cultures and their production methods and life-styles.

Food production would cover nutritional needs as the total population increases in number, providing no less than the current surplus for export, and would be capable of increasing exports in response to increased international demand (without endangering domestic self-sufficiency).

The rural activities to be emphasized (Gallopín, 1989) would involve a combination of capital-intensive production systems, labour-intensive systems, high technology systems, hybrid systems and integrated management systems, taking advantage of subregional and local environmental opportunities. It is assumed that structural reforms and technological innovations aimed at transforming the present subsistence farming sector into an efficient, sustainable peasant agricultural system would be implemented; the present large-scale stock-raising sector, including the harvesting and use of native species and management of fauna would be modernized and rationalized, and agricultural systems for more up-to-date collection and management of germ plasm (mainly in high-diversity ecosystems) would be put into practice. Where appropriate, integrated production systems (agriculture, animal husbandry, forestry) would be favoured. Particular emphasis would be placed on the development of productive activities in accordance with ecological aptitude zoning.

The running of simulation models (Winograd, 1989; Gallopín, 1989) indicates that, under this scenario,17/ the region would be capable of sustainably satisfying domestic agricultural, stock-raising, fishing and forestry requirements with a substantial surplus for export.18/

Three major processes account for a large part of the dynamics in this scenario: a) emphasis is placed on productive rehabilitation of deteriorated and altered ecosystems (which today cover approximately 22% of total land area), representing the most realistic strategy for managing many of the complex tropical and sub-tropical ecosystems; b) integrated rural production systems (agriculture - stock-raising - forestry - aquaculture), are favoured whenever appropriate; and c) integration of new technologies with traditional and modern technologies is actively pursued.

The results of the simulation models indicate that the pattern of land use would change roughly as follows (Gallopín, 1989):

Table 6

Ecosystem	Initial (1980)	2030	Total change (%)
Natural	40.6	36.4	-10.4
Altered	22.1	20.1	-8.7
Wasteland	2.0	1.8	-5.9
Agricultural	7.5	13.0	70.6
Grazing	26.8	23.5	-12.7
Plantation	0.3	4.0	1 303.3
Urban	0.7	1.2	81.5
TOTAL	100.0	100.0	

In addition to the quantitative differences between this scenario and the pattern derived from current trends, the qualitative changes in the modality of rural production would involve a drastic reduction in ecologically degrading processes.

For the whole region these figures represent the transformation of 1.7 million hectares per year of natural ecosystems (97% in tropical areas). Protected areas represent 35% of the remaining natural ecosystems. Altered ecosystems would cover 20% of the area, the same figure as in the scenario derived from current trends. However, in this scenario, most of the altered ecosystems become rehabilitated and restored to productive activities (agricultural, animal husbandry, extractive activities and forestry), permitting considerable increases in the production of lumber, fuelwood, foodstuffs and products with a wide international market. This is an important change, since marginal zones which had previously been considered entirely worthless would be recovered for productive activity, while peasant economies would be bolstered. Cultivated lands would increase to 13% (7% under intensive agriculture, 3% under agro-forestry and 3% under shifting cultivation). This translates into 0.34 hectares/person of cultivated land, which could produce twice the amount of regional food needs with the aid of available technologies. Rangelands would decrease because of increments in carrying capacity (15% under intensive and semi-intensive grazing systems and 7% integrated with forestry). Projected livestock carrying capacity (1.5 animal units/hectare) would lead to a livestock population of 720 million animal units, which could produce 75 kg/person/year. As a consequence of the rehabilitation and restoration activities, wastelands would be reduced to half their initial surface area. To ease the pressure on natural and altered forests that results from the need for lumber and fuelwood, and to preserve and conserve watersheds, fauna and flora, forest plantations would sharply increase, eventually covering 4% of total regional land.

The table in annex 2 shows the most important changes in land condition anticipated in the sustainable scenario for the eight major environmental zones. The type of development under consideration would make it possible to recover and preserve mountain slopes and stop the uncontrolled advance of the agricultural frontier. In the sustainable scenario, only 1.5 million hectares would be deforested annually (compared with 3.8 million if current trends continue), and an average of 1.5 million hectares annually would be reforested, so that by the year 2030 there would be a forest gain/loss ratio of 1:1.

An estimate by Winograd (1989) indicates that the level of direct resources needed to carry out rehabilitation, restoration and reforestation activities would represent an annual investment of some US$1.35 billion a year.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. ENVIRONMENTAL OPPORTUNITIES AND CONSTRAINTS

1. Taking Latin America as a whole, the evidence indicates that there are no strong constraints in terms of ecological resources for sustainable development. The resource base is sufficient to radically improve the living conditions of the present and future population of the region and to meet food needs in the coming decades. There is a great potential for a sustainable increase in production using already well-known technologies, and an additional potential --much more difficult to estimate, but also very significant-- for an increase in production through the use of new technologies and new management and production systems (Dourojeanni 1982; Gómez and Gallopín, 1989a, 1989b; Higgins et al., 1983). These potentials are sufficient, at the regional level, to augment production considerably without compromising the maintenance of areas in natural conditions that serve as providers of habitats, ecological regulators and biospheric reserves.

2. An analysis of current trends clearly shows that the prevailing development style in the region is ecologically unsustainable and therefore not viable in the long run.

3. Latin American environments exhibit a number of constraints and opportunities for the potential application of technological change. These may be linked to a number of technology-related general problem areas which are and will continue to be fundamental to all viable scenarios, although they would be treated differently in each of them. Some of the main problem areas are as follows: technologies for producing, processing and distributing food for the whole population at an affordable cost (food problem); technologies to resolve the housing deficit, such as basic housing and services (urban problem); productivity and competitiveness of technologies for export activities (balance-of-payments problem); capacity to generate productive employment that will cover the spatial distribution and growth requirements of the labour force (employment problem); national and regional accessibility to technological innovations in terms of material and human resources, time lags and the extent of monopolization of know-how (problem of technological self-dependency); ways of channelling R & D and new technologies to potential users (problem of technology transfer); differential accessibility among social groups (different levels

of producers, different levels of consumer income) and among spatial environments (rural-urban-metropolitan) (problem of social distribution).

An environmental analysis makes it possible to identify a number of ecological opportunities or potentials that suggest major areas of interest for the application of known and new technologies.

Tropical red soils (which cover around 50% of the land surface in South America) represent serious fertility constraints on traditional farming; however, there have been some promising advances. New combinations of soil treatment, scientific management and potential applications of biotechnology could radically augment their productive capacity. New forms of multi-level and multi-purpose management could overcome these constraints.

Deserts and semi-deserts cover 15-20% of South America and 35-40% of Central America and Mexico, while only about 3% of the surface runoff in the region is being used, and there are indications of the existence of large quantities of unexplored groundwater sources. Many of these ecosystems are being subjected to strong pressures from overgrazing, and desertification is increasing rapidly. Here, the combination of efforts in biotechnology (drought-resistant varieties), telemetry (exploration for groundwater supplies), informatics (optimum management of irrigation, aquifers and agriculture) and more traditional techniques could pave the way for large increases in production and could halt the advance of the deserts.

Tropical forests constitute an enormous reserve of resources (the Amazon rain forest alone contains over 700 million hectares), and they are among the most productive regional ecosystems in terms of natural ecology, estimated between 11 and 17 tons of dry weight per hectare, or between 17 and 20 tons including root and tuber production (Gómez and Gallopín, 1989a). The considerable complexity and diversity of these ecosystems (traditionally seen as an obstacle to beginning production) may represent one of the most important and least utilized renewable natural resources in the region. The application of biotechnology, informatics, telemetry and new energy processes could lead to an enormous and sustainable increase in production through the use of multi-level agricultural systems, wildlife management, decentralized, diversified and integrated management of complex, multi-purpose systems, providing new substances, new materials, foods, energy and lumber.

The genetic potentials of the region are almost entirely unexplored, but their importance is enormous. There are approximately 375 000 (known) species of plants in Latin America, many of them endemic (exclusive to the region). A significant portion of the proteins consumed by the peasant and indigenous populations are provided by wildlife, but this subject has not received much attention. This genetic endowment represents a vast natural resource of germ plasm for biotechnology, including the adaptation and domestication of animal and plant species and the obtainment of new materials and substances for medical, industrial and agricultural use.

In general, agriculture operates at low-yield levels in the region, and food self-sufficiency is deteriorating (despite the availability of potentially arable lands). Animal husbandry currently extends over 27% of the total surface of Latin America, and overgrazing represents the most important individual factor in ecological degradation in the region. In both cases, there is a significant potential for sustainable increases in yields through the application of known technologies associated with biotechnology (better varieties adapted to local conditions), informatics (for education, training and agricultural management) and telemetry (monitoring of weather and crop conditions) to both commercial and subsistence production systems.

Many other opportunities could be cited, such as the use of diversified empirical cultural experience in the traditional management of agrosystems, including techniques that have survived from the pre-Colombian era, which could be combined with modern scientific know-how and new technologies to offer options that are radically different from current methods; the role of technology in the recovery of degraded soils, sustainable exploitation of marginal lands and fragile ecosystems, etc., but the examples mentioned are enough to indicate the wide range of possibilities.

Some of the main environmental constraints include the following (besides those which also represent opportunities, such as red soils and desert expanses): the fragility of some ecosystems (estuaries, mangrove swamps, some tropical ecosystems, mountain ecosystems, etc.); the deterioration and present over-saturation of environments with a long history of human occupation (Andean zone, islands, etc.); health problems in tropical and subtropical zones with endemic diseases (malaria, Chagas' disease, etc.); the currently overburdened assimilation capacity of local environments (metropolises, mining zones, deforested areas, etc.); the presently degraded state of a series of natural resources, owing to overgrazing and the recent expansion of the agricultural frontier; lack of know-how about management technologies appropriate to certain ecosystems; and high rates of demographic growth in many countries of the region.

4. The possibility of taking advantage of ecological opportunities while at the same time minimizing the negative environmental impacts of the dissemination of new technologies will largely depend on what social policies and strategies are adopted in relation to the development and application of science and technology. The new technologies show a high degree of flexibility in terms of scales and styles of application, unlike the

technologies which appeared during the post-war modernization period (generally associated with economies of scale). It is clear that informatics, microelectronics and telecommunications may be used to centralize information and decision-making power and control, but they also have the potential for contributing to the decentralization of decisions, the augmentation of participation and the linking of isolated and remote areas; biotechnology may favour monopolistic concentration of large-scale agricultural production or may be used to increase the yields of small-scale subsistence farmers. The dissemination of new technologies may result in the strengthening of present trends towards more homogenous production in the region, often unsuited to local ecological constraints and resources, but it also has the potential to lead to the diversification of products and production systems by making the most of the ecological gradients of the region. The same is true in the field of education, where informatics and telecommunications may be used to overcome cultural differences or to stimulate local creative potential. It should not be taken for granted that the area of application of the new, more sophisticated technologies is limited to the "modern" sector of the economy (essentially urban-industrial). These technologies may play a very important role, given the current context of the region, in the generation of new solutions to problems like critical poverty, using high technology to develop new and effective low-technology solutions that would be accessible to marginal populations, or to reformulate and revalorize native technologies already in extensive use in the region. The concept of appropriate technology (leaving aside its automatic association with primitive and labour-intensive techniques) thus becomes especially relevant.

B. ENVIRONMENTAL PRIORITIES FOR RESEARCH AND DEVELOPMENT

By analysing regional environments and their potentials and limitations, it is possible to identify and emphasize those regional demands and priorities that are not covered --or are only partially covered-- by the technological innovations being promoted in the industrialized countries, and to determine the types of modifications needed in order to adapt them to local conditions and resources. The identification of these regional priorities and demands is of great importance, since nearly all technological change in the region has been and still is stimulated by advances occurring in the central countries, and therefore there is no reason to assume _a priori_ that their design will address the region's problems and possibilities.

A systematic comparison between the direction of technological change under different scenarios and the regional profile of problems and opportunities suggests some criteria for decision-making concerning: a) directions for focusing R & D efforts in terms of filling the gaps left by imported technological innovations; b) where to develop (or recover) wholly local technologies; c) how and where to use imported technologies, and what adaptations will be necessary in relation to local resources and priorities.

Only the major priorities resulting from a comprehensive analysis of environmental conditions in Latin America are presented here, in accordance with two complementary criteria. It should be emphasized that the elements mentioned below are only those most directly related to the ecological sustainability of development, and do not attempt to include or replace those priorities which arise from the use of other social and economic criteria.19/

1. By major areas of new technologies

a) Biotechnology: emphasis on the development of sustainable food production systems (commercial and subsistence farming), and sustainable management adapted to local environments of renewable natural resources. Utilization of regional germ plasm and ecological diversity. Emphasis on food self-sufficiency. In some countries where mining is important, biometallurgy may be a priority area.

b) Computer technologies: emphasis on education, in expert microcomputer systems developed endogenously for rural community units (e.g., medical diagnosis, agricultural management), for natural resources development planning and for the management and administration of complex, diversified systems of production, marketing and distribution.

c) Telemetry: emphasis on detection and evaluation of natural resources, monitoring of erosion, crop conditions and pollution, weather forecasts and prediction of natural disasters, monitoring of the quantity and condition of national supplies of renewable natural resources.

d) Telecommunications: emphasis on access to information (prices, products, meteorology, blights, alternative agricultural management methods, etc.), education and training, participation, decentralized linkages, telediagnosis of problems and diseases, early warning systems, etc. Efficient systems to link remote and isolated areas.

e) New energy sources: emphasis on energy self-sufficiency in rural communities, taking advantage of local conditions (biomass, winds, solar radiation, waterfalls, etc.). Development of small-scale energy systems. Energy interconnection in isolated areas.

f) New materials: use and improvement of locally available biological and mineral materials for building houses, roads, dams, tools, etc. Development of the comparative advantages of regional natural resources.

2. By types of environmental problems

a) Study of the functioning of most Latin American natural ecosystems, including their responses to human actions and natural disturbances. Most of the existing ecological studies in the region are essentially descriptive, and shed little light on the dynamics, evolution and limits of ecosystemic resilience, particularly concerning alternative sustainable management schemes.

b) Study of disturbed and degraded ecosystems and the stabilized neo-ecosystems that have been generated by anthropic changes, in order to recommend appropriate management or recovery techniques. These new ecological configurations are not necessarily low in productivity; in many cases they provide a supply of new, potentially utilizeable resources (Morello, 1989).

c) Comparative study of concrete local forms of the society/ nature relationship in Latin America. These studies are essential in order to find realistic and acceptable solutions to the problem of ecological degradation that take into account ecological dynamics as well as the rationality and conditions of social actors.

d) Study of interactions between the major ecosystems in the region that may generate effects across long distances and over long periods of time. This study would include aspects such as the regional effects of the transformation of the Amazon basin, continental-level relations between the Andean range --as a major supplier of water, sediments, nutrients and species--, and the lowlands, which receive, accumulate and distribute materials and energy; regional and subregional impacts of the growing number of newly designed hydrological systems; impact of changes in land use on cross-border natural disasters, etc.

C. ENVIRONMENTALLY SIGNIFICANT ATTRIBUTES OF A SCIENTIFIC AND TECHNOLOGICAL STRATEGY

This section will attempt to identify some strategic features of a scientific and technological policy from the standpoint of its significance for the ecological sustainability of the future trajectory of the region. Some of the major features are as follows:

a) Definition of needs, and development of a basic scientific competence in relation to the main problems (sustainable food production, sustainable management of renewable natural resources, improvement of environmental quality, minimization of the negative environmental impacts of human activities, etc.). Intensive and sustained effort for at least 10 years.

b) Development of mechanisms and incentives to co-ordinate basic research capacity (both existing and new) with applied research and technological development.

c) Development of mechanisms to link the R & D system with the production sectors and their demands and resources (incentives, channels of communication, etc.).

d) Emphasis on R & D with regard to major problems, not limited to certain disciplines or sectors. As a result, encouragement of interdisciplinary and intersectoral R & D. For example, efforts to solve the food problem should involve joint ecological, agronomic, economic, social and cultural studies. Biotechnological solutions should interact with applications of informatics, telemetry and telecommunications, and with the use of new energy sources and possibly of new materials. A comprehensive solution may involve a balanced combination of mature and new technologies.

e) Strengthening of co-operative research, involving different centres within the countries and also among countries. May entail the development of new research and management styles.

f) Development of efficient mechanisms for the communication and transfer of research findings and experience within the region (currently much weaker than communication between the centre and the periphery).

g) Development of mechanisms for the full utilization of local creativity (implies redefining the application of international criteria for excellence and approaches derived from current research topics; recovery and revalorization of traditional, local know-how and technology; participation by the local population in defining problems and the acceptability of solutions, etc.).

h) Development of an institutional capacity for the management of technological pluralism, optimizing human and plant operating capacity (combining new technologies, "modern" technologies and traditional technologies).

i) Emphasis on low-income rural producers'accessibility to technology, and on local self-sufficiency (avoiding the Green Revolution effect), together with the development of large-scale, sophisticated production systems. Mechanisms for linking homogeneous, large-scale farm production with small scale, diversified production (thereby minimizing the expulsion of rural labour to marginal lands). Decentralizing and deconcentrating approaches.

j) Emphasis on flexibility and adaptability in response to local conditions and unexpected changes in directions and priorities.

D. CONCLUSION

The present regional situation under the influence of new global changes --including a huge external debt that cannot be paid, a reduction in the per capita gross product, more and more restrictions on the influx of external capital and a continually growing population-- has resulted in an interruption in the historical course of events and considerable uncertainty about the future. This crisis represents a grave threat to the region's future development possibilities but is also providing some opportunities, in that it is forcing governments and countries to explore new paths and alternative approaches to an increasingly less viable development style. The current situation seems to represent a break with past regional trends and an "innovation explosion". The world economic crisis and the social and economic impact of the dissemination of the new wave of technology will most probably act as triggering factors in global and regional realignments, with profound social, economic, cultural and environmental consequences. The resulting changes in direction could in principle lead to a worsening --or even an improvement-- of the situation as compared with past trends; in particular, Latin America's ecological future will very largely depend on the way it resolves the crisis and the major social options it chooses within the turbulent context of the present international situation. There are a number of potential socioeconomic scenario open to the region in the future; while certain possibilities may be identified in each of them for improving the management and conservation of environmental resources, the opportunities and constraints vary considerably depending on the scenario in question.

Perhaps the most important point, however, would be to stress that futures never merely "arrive"; they are partly the result of circumstances, but mostly of decisions taken by social actors. When the probable future looks grey, if not black, hope lies in breaking with trends, exploring the sources of uncertainty and innovation, and in having the imagination and ability to take advantage of the crisis in order to choose the right path in the future and make the deep-seated changes that are needed.

Notes

1/ Although the situation varies depending on the country, it is estimated that in 1960 the number of persons living in poverty had reached 110 million (of whom 56 million were below the extreme poverty line), representing 51% of the population. The proportion dropped to 40% (112 million) in 1970 and 35% (130 million) in 1980. The situation changed in the 1980s, however, and it is estimated that the number of poor in the region now represents at least 40% (163 million) of total regional population (61 million of whom are living in conditions of extreme poverty). The absolute number of poor people in 1985 was nearly 50% greater than in 1960, and 25% greater than in 1980. Thus, if the trends of the period 1980-1985 continue, the number of poor will reach 204 million in 1990. As for basic needs, it is estimated that 40% of households do not consume the minimum number of calories needed; out of 12 million children born every year, more than 700 000 die before reaching the age of 12 months; the drop-out rate in primary school is 15% (greater than in Africa or Asia); unemployment and underemployment affect 44% of the labour force; and 68% of dwellings may be classified as inadequate (UNDP, 1989).

2/ This chapter is based on "Gallopín, G.C., I. Gómez and M. Winograd (eds.), 1989, "El futuro ecológico de un continente: Una visión prospectiva de América Latina".

3/ The simulation models were run (Gallopín and Gross, 1989; Winograd, 1989b) for each ecological zone. Each zone is considered to be composed of a series of compartments representing different categories or conditions, with varying structural, functional and productive characteristics. Every year, a proportion of the land is transferred from one category to another, depending on the intensity and type of human activities (as defined by the postulated scenario) and natural processes (see table 1). The simulation models cover the years 1980 to 2030. Each compartment represents the land surface of a category of land for each ecological zone. The general formula of the models is as follows:

$$S_{t+1} = S_t + \Sigma\ Gains_{t,t+1} - \Sigma\ Losses_{t1,t+1};\ 0 \leq S_t \leq S_{max}$$

where S = surface of a given category (km^2); gains = land surface from other categories converted during the annual period under consideration in the category in question (km^2/year); losses = land surface in the category under consideration converted to other categories (km^2/year); S_{max} = maximum potential surface area in the category (km^2). The scenario annually spells out the process that generates transformations (human activities, natural regeneration) for each category and ecological zone, specifying the proportion of the category affected by the process and the rates of conversion to other categories. The scenario is determined exogenously, taking into account the current situation, the predicted rate of growth of the activity and the availability of land.

4/ Nochteff systematizes the bibliography on the subject and presents a lucid analysis of the origin, trends and current and probable socioeconomic impacts on Latin America of the current "industrial revolution". This analysis concentrates on the so-called "electronics complex" (microelectronics, informatics, telecommunications), which forms the core of this revolution; but Nochteff's main conclusions may be generally applied to other new technologies, which share a number of important characteristics and interact synergetically with each other. Moreover, biotechnology, new materials and new energy sources will tend to be subordinated to the technological system that revolves around microelectronics. In general terms the primary direct impact of microelectronics will focus on services and manufacturing, while that of biotechnology will more directly affect agriculture, mining and the primary sector in general, as well as the chemicals industry. The development of biotechnology thus fills the lacuna left by the information technologies complex; both types of technologies complement each other at various levels (Pérez, 1986).

5/ For example, the recent agreement concerning the scheduled reduction in the production of the clorofluorocarbon compounds which are destroying the ozone layer, international agreements on whaling, etc.

6/ This is another of the factors which has damaged the regional ability to deal with the new situation as compared to the period prior to the wave of technology.

7/ Generally speaking, this a matter of cumulative deterioration caused by a myriad of local actions by poor peasants, such as the increased emission of carbon dioxide owing to the clearing of land by burning tropical forests and the global climatic effects of deforestation and desertification (largely associated with poverty situations). The report of the World Commission on Environment and Development to the United Nations General Assembly (Our Common Future) strongly emphasizes the role of poverty as the origin of many environmental problems. Another factor will probably be the loss of genetic resources that are of economic or technological interest to large organizations (although other more altruistic motives do exist at the international level).

8/ For example, one of the bases for negotiation could be the argument in favour of international access to new technological developments in order to promote changes in the industrialization processes of developing countries as a prerequisite to reducing the global ecological impact associated with continued growth under the traditional industrialization profile. This argument has logical validity, in view of the fact that the developed countries are now the major consumers of planetary ecological resources, whose present deterioration will probably limit the possibility for third world countries to develop in the traditional sense.

9/ Some have even suggested (M. Ikonicoff, personal communication) that the main challenge to the developing world today is not merely how to reduce dependency but how to avoid simply being excluded from the world economic system.

10/ This feedback is essential to the stability of interactions between the environment and development (Gallopín, 1980).

11/ This refers to wastes associated with consumption. As for waste materials resulting from production, they may eventually be reduced owing to the increasingly in the efficient use of inputs made possible by the new technologies.

12/ On the other hand, there is a natural ceiling on the production of basic goods (in relation to the domestic market) which is determined by the satisfaction of the basic material needs of the population.

13/ This has led Celso Furtado to anticipate the possibility of a "remote-controlled" destiny for Latin America (Furtado, 1985).

14/ This is not mere speculation. The use of frontier technologies has already joined the list of known cases of experimentation with drugs on human populations in the region (experimental contraception methods, new drugs etc.). The Wistar Institute in the United States, with funds from private organizations such as the Rhone-Merieux Laboratory, the Transgene Laboratory and the Rockefeller Foundation, carried out a clandestine experiment in 1986 at the facilities of the Pan American Health Organization in Azul, province of Buenos Aires, Argentina. The experiment consisted of inoculating cattle with a new recombinant rabies vaccine obtained by genetic engineering. This was the first test of this vaccine ever outside the laboratory. The experiment was hidden from the Argentine government, its health authorities and, according to public reports, the peasants who handled the inoculated cows and drank their milk without pasteurizing it, as well as the people of Azul (who drank the milk after it had been pasteurized and marketed). The experiment was halted by the Argentine health authorities when its existence was leaked to the public. The case caused a scandal in the United States (typically, a much less serious scandal than in Argentina). See Revista Humor, Nos. 186, 187, 190 and 191, 1986/1987, Buenos Aires.

15/ Even the optimistic study done by Carlota Pérez (cited above), in which she explicitly points out the new opportunities available, refers mainly to the possibility of new, open spaces for medium-sized and small enterprises, the technical potential for improving production, the prospects for centralization, the appearance of new degrees of freedom, the chances for diversification and adaptability, etc. But all these are postulated in an ambience dominated by the giant enterprises. The author also suggests that there is an ineluctable need for new development strategies for the countries of the region.

16/ Management techniques are today available that are economically, socially and ecologically sustainable for such varied ecosystems as tropical moist forests, tropical dry forests, tropical mountain forests, puna, temperate dry shrublands, temperate moist forests and Patagonia (Winograd, 1989).

17/ In view of the delays that normally occur in the implementation of changes, the sustainable scenario is assumed to be the same as the current trend scenario during the first 10 years covered by the simulation model. Subsequently, land use would gradually change in a more sustainable direction. The sustainable scenario was derived by roughly calculating, for each land category and ecological zone, the land surface under each activity that would be needed to meet the needs of the population at the time and to generate surpluses for export. Land aptitude for different uses was estimated within each ecological zone, and appropriate, efficient management was assumed (on the basis of known, sustainable technologies). This scenario also includes a new activity (restoration).

18/ The simulation models do not calculate the amount of production, but rather the land areas under different categories and systems of production. Production estimates are based on probable improvements in yields.

19/ Regional and national research and development priorities will obviously have to be determined on the basis of how needs, resources and opportunities can best be combined and harmonized, taking into account social, economic, political, cultural and environmental factors and, basically, a social programme that defines and justifies the choice of a scientific and technological strategy. There are certainly other non-environmental criteria that can validly be considered in defining various technological profiles, e.g., criteria based on the need to increase exports. In order to be competitive, export technology should either produce the same goods and services that are being marketed internationally or different products which satisfy unmet international demands.

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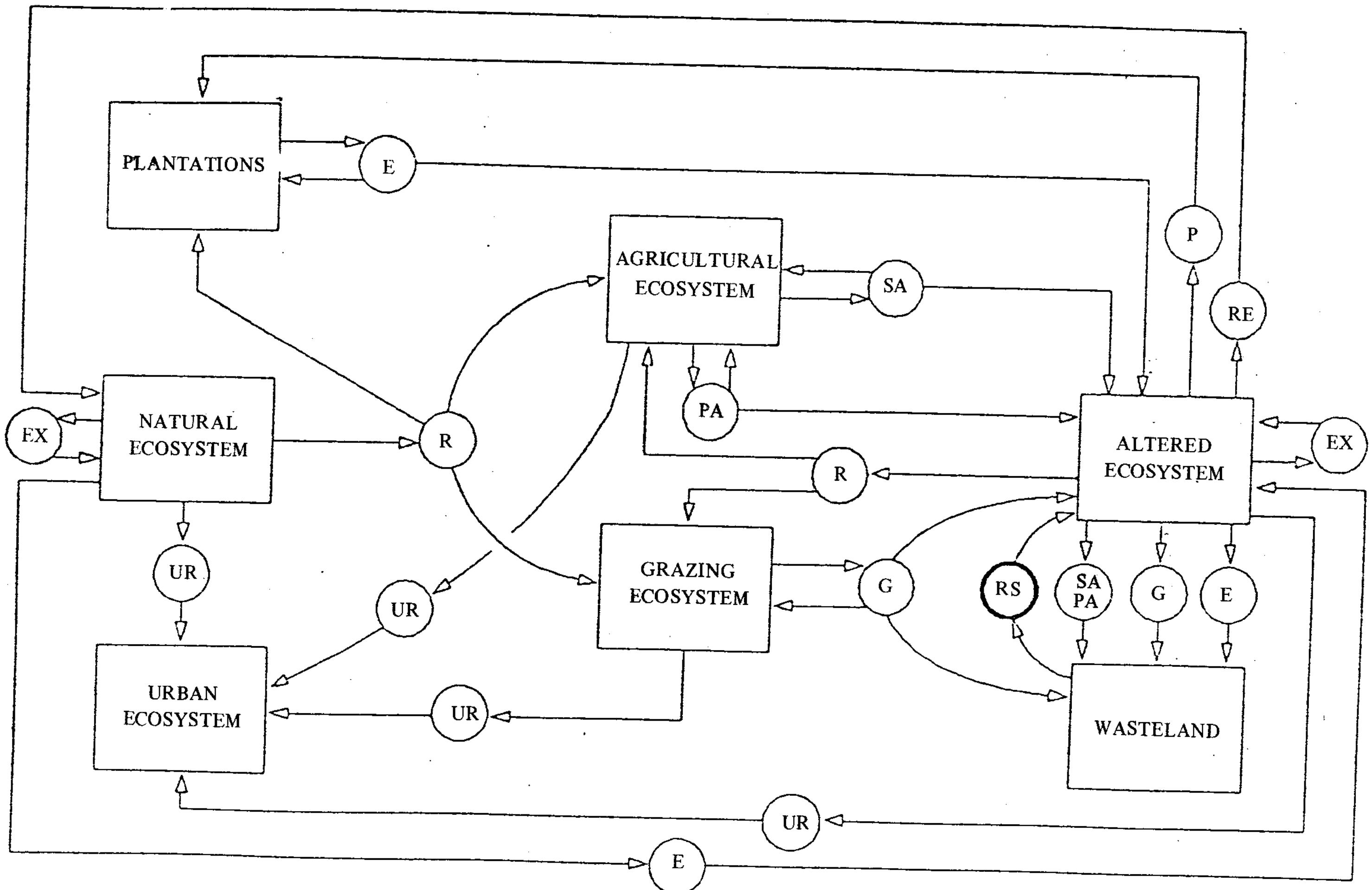
Annex 1

CONCEPTUAL STRUCTURE OF MODELS

Rectangles indicate categories of biomass; circles, activities; and arrows, changes in land use (surface flows)



SA : shifting agriculture
PA : permanent agriculture
E : exploitation of forests
EX : extraction of products
G : grazing
P : plantation
R : reconversion
RE : spontaneous regeneration
RS : restoration
UR : urbanization

Annex 2

	MAJOR ECOLOGICAL ZONES								
	LA	TmF	TdF	TMmF	TS	STS	M/D	D/S	Pu/Pa
Area: (10^3 km^2)	20 417	9 375	4 747	339	1 066	1 038	186	2 744	922
%	100	45.9	23.3	1.7	5.2	5.1	0.9	13.4	4.5
Condition									
Natural									
1980	40.0	63.0	22.0	15.0	40.0	1.0	28.0	21.0	19.0
T 2030	29.0	47.0	14.0	7.0	27.0	1.0	18.0	11.5	11.5
S 2030	37.0	57.0	20.5	15.0	33.0	2.0	40.0	23.0	17.0
Altered									
1980	22.5	16.0	33.0	44.0	12.0	15.0	43.5	28.0	27.0
T 2030	20.5	20.0	21.0	30.0	9.0	14.0	48.5	27.0	22.0
S 2030	20.5	14.0	27.0	30.0	10.0	11.0	33.5	36.2	24.5
Wasteland									
1980	2.0	0.1	2.0	5.0	0.0	0.2	0.5	8.0	5.0
T 2030	3.5	0.5	3.5	8.0	0.0	1.0	1.0	15.0	7.5
S 2030	2.0	0.0	1.5	4.0	0.0	0.2	0.0	9.0	4.0
Agricultural									
1980	7.5	8.0	8.0	6.5	3.0	22.0	4.0	4.0	2.5
T 2030	12.0	13.5	12.0	10.0	5.0	25.0	4.0	6.0	5.0
S 2030	13.0	14.0	15.0	10.0	9.0	29.5	7.0	7.0	6.0
Grazing									
1980	27.0	12.0	34.0	27.0	45.0	60.0	23.0	38.0	46.0
T 2030	32.0	17.0	46.0	31.0	59.0	56.0	27.0	38.0	53.0
S 2030	22.0	10.0	30.0	20.0	46.0	48.0	16.0	22.0	46.0
Plantation									
1980	0.3	0.3	0.5	2.0	0.0	0.3	0.0	0.0	0.0
T 2030	1.5	1.0	2.5	13.0	0.0	1.0	0.0	0.0	0.0
S 2030	4.0	4.0	5.5	20.0	1.0	7.0	2.0	0.3	1.5
Urban									
1980	0.7	0.6	0.5	0.5	0.1	1.5	1.0	1.0	0.5
T 2030	1.5	1.0	1.0	1.0	0.2	2.0	1.5	2.5	1.0
S 2030	1.5	1.0	0.5	1.0	1.0	2.2	1.5	2.5	1.0

Initial (1980) and final (2030) land areas for the major types of ecosystems in Latin America, according to model predictions for current trend (T) and sustainable (S) scenarios.

Source: Recalculated on the basis of tables 10 and 13 of Winograd (1989).

LA = total regional
TmF = tropical moist forests (including tropical and subtropical moist forests and tropical and subtropical hilly and mountainous moist forests)
TdF = tropical and subtropical dry forests (including tropical and subtropical dry forests and extremely dry tropical forests)
TMmF = temperate moist forests
TS = tropical savannas and rangelands
STS = subtropical savannas and rangelands
M/D = tropical mangrove swamps and deltas
D/S = deserts and semi-deserts (including tropical and subtropical deserts and desert shrublands, subtropical thorn forest, steppes and temperate savannas)
Pu/Pa = puna and paramo.