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The Environmental Impact of Globalization on Latin America: a Prospective Approach

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Abstract

Current changes in Latin America include the abandonment of the economic pattern of import substitution, a growing opening of the national economies, a continental wave of political democratization, an apparent economic recovery from the "lost decade" (the 1980s), a growing social polarization, a worsening of environmental problems, the growing influence of the market, and the most intense urbanization process on the planet. The aim of this paper is not to discuss the advantages or disadvantages of the prevailing economic pattern, but only to analyze some of the possible environmental implications derived from the way of insertion of the countries of the region in the global economy. The region as a whole is relatively well endowed in terms of natural resources. With little more than 8% of the global population, Latin America has 23% of the potentially arable land, 10% of the cultivated land, 17% of the pastures, 22% of the forests (and 52% of the tropical forests), and 31% of the permanently usable freshwater. It has not less than 3% of the world reserves of fossil fuel and 19% of the technically usable hydroelectric power.

Regarding economic globalization, the general argument from the environmental point of view is not that international trade is negative and that autarchy is desirable, but rather that a certain degree of regulation is necessary to reach a "sustainable free trade." The technological aspect of globalization is so important that it is possible to speak of a true techno-economic revolution or *Knowledge Revolution* (see also Chichilnisky's chapter in this book), led by microelectronics and the information technologies, and accompanied by a constellation of developments based on new technologies intensive in science (biotechnology, new materials, new energy sources, nanotechnology, etc.). From the point of view of their environmental implications, many of the new and emergent technologies exhibit interesting differences with the previous technological paradigm. The attributes of the new paradigm having higher strategic interest can be characterized as ambivalence, flexibility, and knowledge-intensivity. The *technical* potential for ecologically sustainable development is higher today than in any moment of the past. However, the direction toward which the trajectories of the new techno-economic paradigm seem to be moving suggests that, unless Latin America adopts active and sustained strategies to carry out the necessary social, economic, and technological structural changes, the mentioned technical potential is likely to materialize only in the most advanced countries, with the region running the serious danger of concentrating the perverse effects of the techno-economic revolution.

A prospective analysis was carried out, based on simple simulation models of the ecosystemic transformations associated to land use in each of the 18 major life-zones represented in Latin America. Two basic socioeconomic scenarios were defined by the whole region: the reference scenario and the sustainable scenario. The reference scenario suggests the type of environmental consequences associated with land use that an unrestricted and unregulated opening of the economies (in the context of an absence or widespread weakness of environmental and social policies) would have. The sustainable scenario shows that, from the ecological and technological points of view, it is possible to change direction toward a much more desirable long-term situation, without too large direct economic costs. Implications of strategic importance for the sustainable development of the region are identified.

Introduction

At the turn of the millennium Latin America is breaking away from its recent past. The pattern of import substitution is giving way to a growing openness toward the global economy, and there is an increasing wave of privatization and market orientation within the national economies. This economic change is taking place in the context of a continental wave of political democratization, an apparent economic recovery from the "lost decade" (the 1980s), a growing social polarization, a worsening of environmental problems, and the most intense urbanization process on the planet.

The similarity in the patterns adopted by the countries of the region (except Cuba, where economic changes are nevertheless also happening) has been attributed to a growing realization of the merits of the market economy. However, the changes have been attributed by others to strong international pressures from the international organizations, the Bretton Woods institutions created by the industrial nations after the Second World War.

From either perspective, there is an agreement that the process of economic globalization within which Latin America is evolving is one of the most dramatic developments of our times. Between 1965 and 1990 world trade of merchandises tripled, and the global trade of services increased more than 14 times. Financial flows reached gigantic levels. More than a trillion dollars circulate in the world economy every day. This capital flow offers unprecedented opportunities for profit, as well as for loss. At the same time, however, global financial markets leave even the strongest countries with somewhat limited autonomy over interest rates, exchange rates, and other financial policies (UNDP, 1996: 8).

The aim of this paper is not to discuss the advantages or disadvantages of the prevailing economic situation, but only to analyze some of the possible environmental implications derived from the way of insertion of the countries of the region in the global economy. Latin America has some of the most precious remaining environmental resources on the planet and is following an accelerating process of resource exploitation (Sunkel & Gligo, 1980; Gallopín et al., 1991), which appears to intensify with globalization.

From the social viewpoint, the indicators of poverty and unemployment in Latin America, which had been decreasing since the 1950s, have been increasing from the 1980s (PNUD, 1989; ECLAC, 1995). Although during the five-year period 1990–1994 some countries registered progress in their fight against poverty, others did not. In addition, starting from 1994, some worrisome trends appeared in some of the countries mentioned as successful above. Also, the rhythm and characteristics of the current economic growth continue generating less employment than necessary to productively absorb the growing work force (ECLAC, 1995).

The incidence of poverty in the region increased 5% in the short period 1985–1990 (a period of "economic recovery"—UNDP, 1996: 60). More recently, ECLAC (2000) estimated that the number of households in poverty decreased from 41% to 36% between 1990 and 1997, but the absolute number of poor increased slightly. The World Bank (2000), using additional data, reported that between 1987 and 1998 poverty, in relative terms, remained roughly constant, but the number of poor rose by about 20% (or 14.5 million).

In only 12 countries of Latin America and the Caribbean was the per capita income in the 1990s higher than that obtained in the past; in 22 countries of the region, the current income levels were reached in previous decades, which suggests an economic decline or stagnation. What is more serious is that the latter include more than 85% of the regional populations (UNDP, 1996: 3). The growth of the region in real per capita income was 2.9% per year in the decade of the 1960s, 3.7% in the 1970s, –0.7% in the 1980s, and 1.0% in 1990–1993 (UNDP, 1996: 14).

Income distribution improved in Colombia, Costa Rica, and Uruguay, and it worsened in Argentina, Bolivia, Brazil, Peru, and Venezuela (UNDP, 1996: 17). Income inequality also increased in Mexico, a country that quickly liberalized its economy beginning in the mid-1980s. In 1984, before the reforms, its Gini coefficient (an indicator of disparity) was 0.43, but by 1992 it had increased to 0.48. And in Chile, one of the most open economies in Latin America (and considered to be an example of success by many international financial organisms), income inequality has been increasing markedly from the 1970s. In 1970 its Gini coefficient was 0.45, but by 1990 it had increased to 0.57 (Berry, 1995). These negative social impacts have occurred while the region adopted increasingly market-driven economies, which has led many to believe that market economies can exacerbate economic inequality and poverty in the region.

It should be pointed out, however, that the increase in economic disparity is not unique to the Latin American region, but can be considered a global phenomenon (WRI, 1996). Income disparity appears to have increased in many countries that opened their economies, while the market has become a dominant economic institution globally. For example, in the last three decades, the share of global income by the poorest 20% of the population of the Earth decreased from 2.3 to 1.4%, while that of richest 20% increased from 70% to 85%. That doubled the ratio of the shares of the richest and the poorest—from 30:1 to 61:1 (UNDP, 1996). The differences among the developed and developing countries are moving, according to the latter report, " from the unjust to the inhuman."

The growth in disparity appears to be associated, at least partially, to the globalization of the economy. The patterns differ by region. Several countries of East Asia became successful examples of export-driven development, combining fast economic growth with low inequality and a high level of human development. In contrast, many sub-Saharan African countries have been increasingly marginalized by the forces of globalization.

A similar phenomenon is observed within countries. For example, by the late 1970s China began to liberalize the markets, privatizing the economy and opening rapidly to trade and international capitals. In 1979 its Gini coefficient was 0.33 (smaller than in any other country of East Asia). By 1988, it had gone up to 0.38—surpassing that of Indonesia and the Republic of Korea. And inequality keeps increasing, especially in the coastal area, which is the most directly bound to the world economy (Tabatabai, 1995).

From an environmental point of view, the deterioration in the Latin American region seems to be increasing (Gallopín et al., 1991; Gallopín, 1995; PNUMA et al., 1990; CDMA-ALC, 1990; UNEP, 1999). Although there has been some recent progress (particularly the elimination of economic incentives for deforestation in Brazil), the general situation continues worsening.

The question addressed here is: How will the evolution of the globalization process affect these tendencies of Latin America? Do opportunities exist, within the new context, to achieve sustainable development? We will argue that there are

opportunities to turn the tide of environmental degradation. Simplifying for the purpose of this discussion what is a rather complex issue, this paper will analyze two contrasting scenarios, one that leads to positive economic, environmental, and human outcomes, supported by "the Knowledge Revolution,"[1] and another that leads to lower performance on all these counts.

While studying the changes in the Latin American region, it seems worth taking into consideration that these changes take place in an international context that is far from stable. There are reliable indications that the world is moving through a widespread period of turbulence and change that could lead to a breakdown of historical trends and the emergence of new possible futures for the global system. Some of these futures are alarming, but others represent positive opportunities. The idea has been advanced that the world economy is moving toward structural changes that are so deep that the only appropriate metaphor is the concept of "punctuated" evolution, which some call a "Knowledge Revolution" (Thurow, 1996; Chichilnisky, 1996, 1998).

Among the processes propelling global change are:

- The collapse of the Soviet system, the end of the Cold War, and the almost universal expansion of market-oriented economies, also affecting countries that remained Socialist such as China, some other Asian countries, and Cuba.
- An unprecedented demography, with a fast-growing juvenile population in poor countries (according to the United Nations, 97% of the population increase between 1994 and 2015 will occur in the developing countries; United Nations, 1994), and an aged population economically dependent on the social security system in rich countries. The emergence of the "global teenager" (Schwartz, 1991) represents an enormous potential force of change, amounting to about 2 billion members by the year 2000 (in a world increasingly interconnected) and whose behavior is unpredictable.
- The techno-economic revolution supported by knowledge-intensive technologies, a revolution that is transforming not only the production process but also the social structure, as well as generating a global information economy and an unprecedented global connectedness (Chichilnisky, 1996, 1998; Herrera, 1986).
- The growing environmental degradation and the emergence of truly global environmental problems (such as climatic change).
- The growing social polarization between and within countries.
- The globalization and transnationalization of the economy, with growing influence of the big corporations, the creation of new commercial blocks, and the relative weakening of the nation-state.

[1] See, e.g., Chichilnisky (1996, 1998), who has been awarded a trademark for the use of "the Knowledge Revolution."

Two Global Scenarios

Globalization is a phenomenon that exceeds the strictly economic aspects to include environmental, technological, political, and cultural dimensions. It can result in radical transformations of the global system in the next decades. One possible trajectory represents scenarios of "barbarization" characterized either by a widespread societal decomposition and fragmentation, associated with high political and economic turbulence, or by an authoritarian world where the rich minority keeps (or attempts to keep) the rest of the population under conditions of low consumption (Gallopín, 1990a, Gallopín & Raskin, 1998).

In the other extreme there is a positive scenario (a Great Transition) where the emergence of a new sense of global solidarity, combined with the deployment of the potential of the new technologies and the empowerment of the civil society, leads to a new planetary order and qualitatively improved development paths.

While it is not possible to predict the future, it seems safe to predict that the "business as usual" scenario, based on the continuation of the historical tendencies and with indefinite economic *material* growth, is the less likely to occur. It appears to be intrinsically unsustainable in environmental terms. The scenario for Latin America that actually develops, as well as the way the region inserts in the global economy, will be very different depending on which global scenario materializes.

Historical Background in Latin America[2]

At the beginning of the century the Latin American economic system was entirely based on the production and export of primary products, and hence highly vulnerable to changes in the world economy. The crisis of 1929, prolonged by the Great Depression and followed by World War II, led to serious export constraints, forcing the countries to redefine their development patterns. This can be considered an immediate precedent to the situation of the region at the end of the 20th century, in which about 70% of the region's exports are still resources.

All countries (with the exception of Argentina) were forced at some point to suspend the service of the foreign debt.

Significant environmental changes took place between 1950 and 1980. The most important were (1) the expansion of the agricultural area allocated to short-cycled crops, (2) increase of the areas of permanent pastures, and (3) reduction of the areas covered by forests and expansion of the urbanized areas. These environmental changes were due to the widespread adoption of a new development model by the states of the region and the emphasis given to urban-industrial development and private foreign investment. This was driven by economic growth based on the expansion of internal markets, and was obtained through industrialization policies focused on import substitution using strong protectionist measures, overvaluation

[2] This brief historical synthesis is based partially on PNUMA-AECI-MOPU (1990).

of the national currencies, and facilitating imports of capital goods to develop the industrial infrastructure. This process generated a remarkable economic bonanza, also reinforced by a general improvement of the terms of trade of primary products.

The new productive strategies had a high environmental cost; the environment was subordinated to the need to accelerate growth. In this period the large cities grew quickly, as a consequence of the employment generated by the industrial sector and the expulsion of labor from the rural areas where the new agricultural technologies, added to problems of land tenure, displaced the traditional worker. Marginal areas grew around the cities, and an informal urban labor sector arose.

Also during this period the agricultural frontier unfolded, fundamentally at the expense of the forests. In the tropical areas cattle raising expanded in order to respond to a sustained external demand and to the internal demand of the high-income urban sectors. Cattle raising generated deep environmental degradation due to the use of land unsuitable for that activity and to the colonization of forests with inadequate technologies that led to their fast deterioration. In addition to the environmental costs there were high social costs, associated with agricultural modernization: displacement of the traditional productive systems reducing rural employment, expulsion of the population, and social polarization.

What has been described so far is representative of the model of import substitution. The economy felt the effects of the first fluctuations of the balance of payments, the public deficit, and the economic perturbations in the early 1970s. During this period the development strategy generated a modern, consumerist, and export-driven social sector and an increasingly marginal low-income sector.

Internally there were strong inflationary processes and indebtedness due to the use of external credit to develop the industrial and financial sectors, low redistribution, and authoritarian non-elected regimes that expelled many people out of the system contributing to the impoverishment and marginalization of important sectors of the population.

External constraints were associated with the restriction of markets in the industrial countries leading to a retraction of world trade, a deterioration of the terms of trade, the unfavorable insertion of the region in the international market, the global techno-economic revolution, and the increase of international interest rates with enormous impact on the foreign debt.

Following the first period, since the mid 1980s a new model spread in the Latin American region. The new model emphasized the liberalization of trade, non-traditional exports, and at least in some cases, foreign exchange and financial liberalization. Significant privatization took place in many sectors of the region. An effort to attract foreign capital was evident, as well as the expansion of the transnational companies. In many countries inflation decreased dramatically, and the rates of economic growth, depressed during the "lost decade" of the 1980s, showed important increases. As mentioned before, inequalities increased, and the population below the poverty line grew; there are indications that the economies of the region became more vulnerable. Several regional free trade agreements were cre-

ated, such as the North American Free Trade Agreement (NAFTA) among the U.S., Canada, and Mexico, and the Southern Common Market (Mercosur).

Latin American exports of merchandise grew at an annual average rate of 3% in the 1980s, and by the end of the decade the region attracted around a third of the private flows of capital to the developing countries (UNDP, 1996: 17).

The environmental effects of the new economic model followed since the mid 1980s are not still completely documented or even understood. As many ecological processes unfold through several decades, there may be impacts that have still not been perceived. Some of the clearest examples of the environmental impacts of this model are agricultural intensification of cash crops for export, in many cases in unsustainable form (as in the Brazilian cerrado; da Silva, 1994), the externalization of environmental costs that makes it possible for the soybean produced in the Bolivian agricultural frontier to be exported to Colombia at lower prices than the Colombian soybean (in spite of an exceedingly longer transport route) and the dismantling of the infrastructure (wire fences, water tanks) associated with the rotation between cattle and crops in the Argentinean pampas, thus shifting from a relatively sustainable production mode to one that shows growing problems of environmental degradation.

Environmental Issues in Latin America

The region as a whole is very well endowed in terms of natural resources. With little more than 8% of the global population, Latin America has 23% of the potentially arable land, 10% of the cultivated land, 17% of the pastures, 22% of the forests (and 52% of the tropical forests), and 31% of the permanently usable freshwater. It has not less than 3% of the world reserves of fossil fuel and 19% of the technically usable hydroelectric power (Gallopín et al., 1991).

This favorable regional profile masks, however, important internal differences. Demographic pressure is high in some of the countries, and low in others. There are countries in which the current cropland and even the potential arable land is scarce in comparison with the present population and that projected for the future. Latin America as a whole could only feed about 40% of the population forecasted for the year 2030, by using a low level of inputs. More than half of the South American countries (Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Suriname, and Venezuela) and practically all Central American countries should surpass the intermediate level of inputs (equivalent to the one used currently in the region) and 11 countries (Ecuador, Peru, Suriname, Venezuela, the Bahamas, El Salvador, Guatemala, Haiti, Jamaica, Santa Lucia, and Trinidad/Tobago) would not feed their population of 2030 even using a high level of inputs (recalculated from the basic data of the model FAO-FNUAP-IIASA, 1984, by Gómez & Gallopín, 1995).

Many and serious environmental problems exist in Latin America and the Caribbean, as well as a number of not yet used opportunities.

All analyses of the recent history of Latin America indicate very high and fast rates of ecological deterioration, which appear in the form of deforestation, deser-

tification, erosion, and loss of fertility of soils; agricultural, industrial, and domestic pollution; accumulation of wastes; and growing vulnerability to landslides, droughts, and catastrophic floods (Sunkel & Gligo, 1980; Dourojeanni, 1982; Gallopín, 1995). The problem does not consist of the mere transformation or alteration of the natural ecosystems, but in the modality and result of these transformations that imply a degradation of the ecological base of the production, a true impoverishment and destruction of the renewable natural resources and the vital ecological processes of the region. Many of these alterations, such as desertification and soil erosion, are irreversible in practical terms. On the other hand, the environmental problems in the human settlements are very serious, and they are worsening.

Efforts have been made to identify and prioritize the main regional environmental topics in Latin America (CDMA-AL, 1990; Gallopín et al., 1991). The two dominant topics at the present time are those associated with land use and those associated with the urban environment, in the face of which the other ones (although important in themselves) become secondary in relative terms.

Globalization and the Environment

The globalization process, as already indicated, exceeds international trade and its broader economic dimensions. This article focuses on the economic and technological aspects, in the belief that globalization is a phenomenon intimately associated with the techno-economic revolution.

There are differing views on the impact of international trade on the environment. Some economists believe that free trade has a beneficial influence, because they foresee negative consequences from protectionism; see, e.g., Repetto (1993). On the other hand, a study of the environmental implications of the changes in the export profile of nine countries of Latin America and the Caribbean for the period 1980–1995 suggests that the opening of the economies in these countries resulted in an increased participation of dirty and natural-resource-intensive sectors (Schaper, 1999). In this context, it is often argued that trade leads to increased economic growth, and that growth itself has a positive impact on the environment. This argument, which is developed further below, does not take into account the problem that certain types of economic growth generate, by themselves, environmental degradation, and the existence of irreversible environmental damages (as in the extinction of species) (Ekins et al., 1994; Røpke, 1994).

Those who propose market regulation argue that investment could move toward the developing countries that offered lenient laws on environmental use, with possibly negative consequences for the environment. However, using existing data, supporters of free trade have observed that international investment has not moved preferentially to those developing nations that become "pollution-heavens" (e.g., Grossman & Krueger, 1991; Lucas et al., 1992).

In general terms, therefore, the free competitive market need not by itself produce incentives for environmental destruction although, in specific circumstances,

it could. Leaving aside general principles on the positive and negative impact of markets on the environment, we will concentrate instead on the specific circumstances prevailing today, in order to elucidate the actual connection between trade and the environment.

We focus on the specific structure of trade between industrial and developing nations as it is today, and as it has developed over the last century and particularly since World War II. Called generically "North-South trade," this pattern consists mostly of resource-intensive products (Chichilnisky, 1994a, 1995, 1995–1996, 1997; Chichilnisky & Heal, 1998) exported by developing nations to industrial nations in exchange for capital-intensive products. A generally accepted view is that an expansion of such a resource-intensive pattern of international trade can have damaging effects on the global environment by intensifying the extraction, exports, and consumption of natural resources.

Recent results have helped elucidate how this pattern of North-South trade may have emerged and developed, and how it could be overcome. One commonly accepted view is that the pattern of trade we observe today could have emerged from historical circumstances in which developing nations, which are in great measure agricultural societies, treat natural resources as "common" property while industrial nations, which have completed the industrial revolution, treat resources more as private property (Chichilnisky, 1993, 1994). This work showed that when such differences exist in property rights between the two regions, it leads to developing nations specializing in resource-intensive exports that are sold to industrial nations at prices that are below replacement costs. Under these conditions, it was shown that an expansion of trade amplifies environmental problems in developing nations, as well as globally, through a global version of the "tragedy of the commons" (Chichilnisky, 1993, 1994). When developing nations are exposed to large international markets for inexpensive and abundant natural resources from the industrial nations, the extraction of their common property resources intensifies and deepens, leading to lower prices and global consumption that exceeds efficient resource use. A case in point is the oil market, consisting mostly of exports from the South to the North. In this market oil sells at relatively low prices leading to the overuse of petroleum worldwide, delaying the commercialization of alternative clean technologies and increasing problems with the emission of carbon dioxide into the atmosphere (Chichilnisky, 1994a, 1994b, 1995, 1995–1996, 1997, 1998; Chichilnisky & Heal, 1998).

Under the specific conditions that prevail today, therefore, the standard assumption that countries can obtain mutual benefits through specialization and trade according to their comparative advantage must be revisited. When resources are common property in the exporting nations, a generally accepted condition in developing nations today, the market prices of resources are artificially low giving an impression of relative advantage even where none exists (Chichilnisky, 1993, 1994). In such situations some of the fundamental premises for effective market functioning, namely the existence of private property rights in all traded goods,

are not fulfilled in the reality. As stated by Daly and Goodland (1994), if markets were perfect and capital were immobile internationally, then unregulated trade in products would be advantageous for all nations. But in the real situation prices do not generally reflect social and environmental costs[3], and the benefits from unregulated trade may not be achieved.

A question that arises is whether the process of growth and industrialization can by itself ameliorate this situation in developing nations. It is generally argued in this context that growth and economic liberalization are good for the environment because the preferences of the consumers and the structure of the economy change as a country develops so that development brings new (often cleaner) technologies and that growing economies can invest more easily in environmental improvements. According to this line of thought, the countries in early stages of development necessarily concentrate on basic production and improvements of the infrastructure, accepting the associated environmental cost. This argument is based on empirical correlations between environmental degradation and per capita income (also called "environmental Kuznets curves"), which suggest that economic growth worsens environmental conditions until a certain point, but that at higher income levels, additional economic growth is associated with an improvement of environmental conditions (WRI, 1996).

Although some such environmental indicators as access to drinking water, urban sanitary conditions, and urban air quality show an improvement with increasing income, other indicators show a progressive deterioration (for instance, the emissions of carbon dioxide and the per capita production of urban wastes). In reality, the data show that the Kuznets curve is valid for local pollutants, such as air particulates, which appear to improve as the countries achieve higher levels of income. However, for global environmental problems such as greenhouse gas emissions, ozone depletion, and biodiversity destruction, the connection between income and environmental quality is generally reversed. The industrial nations have by far the largest negative impact on the global environment, through biodiversity destruction, ozone depletion, and greenhouse gas emissions (Chichilnisky, 1994a, 1995, 1995–1996, 1997, 1998; Chichilnisky & Heal, 1998). In addition, a substantial body of theoretical and empirical work shows consistently that the income elasticity of demand for environmental assets is lower than one, which means that poorer people tend to spend a larger part of their income on environmental quality than do richer people (for a review see, e.g., B. Kriström, 1996). It seems, therefore, that the connection between income and the environment cannot be described in simple terms[4]. Even in those cases in which Kuznets curves are applicable to environ-

[3] Other relevant analysis of the underlying assumptions and the environmental and social implications appear in Runnalls and Cosbey (1992), and in the special issue of the journal *Ecological Economics* (Vol. 9, No. 1, 1994), dedicated to Trade and Environment.

[4] The environmental Kuznets curves, based on empirical correlations, do not take into account the possibility that environmental degradation can harm the possibilities of future economic growth, or the possibility that part of the reduction in pollution observed in the industrialized countries could be due to the transfer of polluting industries to developing countries, a process not replicable by the latter (WRI, 1996).

mental indicators, it would be expected that economic growth in those countries (and for those variables) will continue increasing pollution, because the great majority of the world population has mean incomes below the inflection points of the curves. On the other hand, it is difficult to anticipate the impact on these curves of economic polarization associated with globalization (in other words, what will happen when and if economic growth becomes negative for some groups and countries).

The general argument from the environmental point of view is not that international trade is negative and that autarchy is desirable, but rather that under a variety of situations prevailing in today's world economy, which includes a variety of market imperfections, some market regulation may be necessary to reach a "sustainable free trade" (De Bellevue et al., 1994) or a "balanced trade" (Daly & Goodland, 1994).

The technological aspect of globalization is often associated with a third Industrial Revolution. This is also called a Knowledge Revolution because it is led by microelectronics and information technologies, and accompanied by a constellation of developments based on new technologies that use science and human knowledge intensively, such as biotechnology, new materials, new energy sources, and nanotechnology. This new wave of innovation is unfolding at a vertiginous pace, and the socio-economic changes associated with the emergence of the economy of information is leading to drastic transformations of human societies, some of them difficult to imagine today.

The development and diffusion of the new technologies in the region have the potential to produce very significant environmental changes (both beneficial and detrimental, direct and indirect). It is possible to anticipate that such changes will generate important impacts on the Latin American ecosystems, implying major effects on the ecological sustainability of the productive activities, alterations in the subregional water and nutrient cycles, changes in agricultural yields, disappearance of some ecosystems and emergence of new ecosystems, changes in the ecological supply of natural resources, and modifications in the limiting factors and ecological constraints.

Direct ecological impacts will result from using new technologies in food, industrial, and energy crops; exploiting new natural renewable and non-renewable resources; the creation and dispersal of new biological forms; and the emission of new substances into the environment. An attempt of identification of possible direct effects appears in Gallopín (1995a).

Indirect ecological impacts will result from social, economic, political, and demographic rearrangements associated with changes in price and demand, in the social organization of work, in the systems of production, in employment, in the international division of labor, in services, and in the relocation of human settlements and industries. Indirect ecological impact induced by the diffusion of the new technological wave is likely to be more extensive and pervasive than direct impact.

From the point of view of their environmental implications, many of the new and emergent technologies exhibit interesting differences with the previous para-

digm. The strategically important attributes of the new paradigm can be characterized as: ambivalence, flexibility, and knowledge-intensivity (Gallopín, 1995a).

Ambivalence. It is clear that information applications, microelectronics, and telecommunications can be used to centralize both information and the power of decision and control, but they also have the potential for decentralization of the decisions, to increase participation, and to link isolated and remote areas; biotechnology can favor the monopolic concentration of large-scale agricultural production or it can be applied to increase the yields of the subsistence farmers of small scale.

Flexibility. The new technologies allow (potentially) easier adaptation and adjustment to the local social and ecological conditions (an extremely important aspect for the sustainability of development) than the previous technologies. The information technologies make possible (and economically efficient) the implementation of new operational modes, such as "flexible manufacture," "tailored" or "on-demand" production, and the minimization of stocks ("zero inventory"); these modes are incorporated in the recent concepts of re-engineering of organizations. This leads to the scale of the plant becoming increasingly independent of the scale of each market, and productivity increasingly independent of the scale of the plant, with deep changes in the defining factors of competitiveness (Pérez, 1986). This last element implies a very significant difference with the previous paradigm: in many cases the new technologies are not (inherently) associated with economies of scale.

Knowledge-intensivity. The new technologies are generally (in fact or potentially) much more efficient in the use of energy and materials than the modern technologies originated in the postwar period. They can be can qualified as "knowledge-intensive" or "science-intensive" technologies, rather than capital-intensive, energy-intensive, or material-intensive. The new technologies are reducing the ratio of raw materials/product, are substituting materials (a clear example is the substitution of the much more efficient optic fiber for copper wire in communications; interestingly, the material base of microelectronics is silicon, one of the most abundant elements on the planet); and they are increasing the efficiency of other processes (the case of electronic regulation of fuel combustion in automobiles). All of this can contribute to the currently visible process of relative dematerialization of the economy, to the conservation of natural resources, and to the reduction of pollution per unit of production or consumption.

Both economic globalization (in the sense of the elimination of trade barriers among countries) and the new technologies possibly represent elements of an unavoidable stage in the evolution of civilization. These processes obviously have the potential of greatly improving the living conditions of the population, to support the rational use of planetary ecological and human resources, and to reduce military conflicts. However, the distance from potential to realization is a long one. In an asymmetric world where inequalities continue growing, there is no guarantee that the potential benefits will be obtained by all or by the majority of the population. It is often argued that some social cost is unavoidable in any historical transition, and that transitory sacrifices will be compensated by a general improvement. Again, this may be so, but it is not guaranteed. In an asymmetric

world, the risk of a monumental *unnecessary* cost in human suffering of the techno-economic transition is high, and the risk of a consolidation and accentuation of the inequalities driving to a "global barbarization," as described in Gallopín (1990a) and Gallopín & Raskin (1998), is not negligible.

Although globalization has often helped growth in the strong countries, it has bypassed the weak ones. The share of world trade for the poorest countries, including 20% of the world population, has fallen between 1960 and 1990 from 4% to less than 1%, and they receive a mere 0.2% of the world's commercial lending (UNDP, 1996: 9).

The total flows of capital to the developing countries tripled between 1987 and 1994. Their composition moved markedly from official development assistance (ODA) and toward private capital flows, which increased from a participation of 37% of total flows to 76%. In real terms, ODA fell 9% between 1985 and 1993. The seven-fold expansion of private flows to developing countries, from 25.1 billion in 1987 to 172.9 billion in 1994, could be seen as compensating to some degree the fall in ODA. But private funds have generally ignored the most capital-scarce developing countries, going instead toward the semi-industrialized "emergent markets." Of the total flows in 1993, 68% went to Argentina, China, Mexico, Singapore, and Turkey. Direct foreign investment (which not only provides fresh capital but also contributes higher technological levels) is also concentrated: it is estimated that a record 37% (84 billion dollars) arrived in developing countries in 1994. Nearly 40% of this went to China. Another 24% went to Hong Kong, Indonesia, Malaysia, Singapore, and Thailand. By contrast, sub-Saharan Africa only received 3.6%, and the least developed countries only 1% (UNDP, 1996: 78).

From a historical perspective, it is important to recognize that both globalization and the Knowledge Revolution do not represent (by their origin) a transition to a new social formation but a revolution taking place within, and generated by, the industrial capitalist society. This current process is associated with the emergence of a new economic, social, and cultural pattern, which can be interpreted as the response to the inability of the paradigm of resource-intensive industrialization that emerged in the postwar period to insure the continued and sustainable economic growth in the industrialized countries[5].

Certain tendencies have been observed, including the increasingly asymmetric income distribution between social groups and nations, and the loss of some national autonomy of those countries in which the largest organizations (specifically

[5] Nochteff (1987) provided a lucid analysis of the origin, trends, and proven as well as likely socioeconomic impacts of the current techno-economic revolution on Latin America. His analysis concentrated on the "electronic complex» (microelectronics, information sciences, telecommunications), which constitutes the nucleus of that revolution; however, the main conclusions can be extended to other new technologies. Those share several important characteristics and interact synergically with each other. Besides, biotechnology, new materials, and the new energy sources would tend to subordinate to the technological system centered in microelectronics (Pérez, 1986). In general terms, the main direct impact of microelectronics will concentrate on services and manufacturing, while biotechnology would affect most directly agriculture, mining, and the primary sector in general, and the chemical industry. In this sense, the development of biotechnology fills a gap left by the complex of information technologies; both technologies are complementary at several levels.

the transnational companies and the most powerful states) do not have their main nucleus of decision-making, operations, and development (Nochteff, 1987). To this we may add the opening of the services sector to international competition, which leads to a centralization of the power of the transnational corporations, which already control about 70% of world trade (Daly & Goodland, 1994). These tendencies are in general negative for Latin America and are likely to affect the region if the current (exogenously determined) technological change continues.

The current situation of Latin America vis-à-vis the globalization process and the new technological revolution is very different from that of the industrialized countries. At the same time that a minority of the world population lives in the "post-industrial" civilization, in Latin America and the Caribbean three different technological waves coexist: the new technological wave, the industrial revolution, and even the agricultural revolution (large numbers of peasants survive at pre-industrial technological and production levels). As indicated by the United Nations Development Program, one of the risks of globalization is that the groups and people least able to adapt to the changing market conditions with its new technologies and skill requirements will be further marginalized (UNDP, 1996: 103). This is directly applicable to the growing marginal population of the region.

The global environmental issues will surely represent in the future one of the main factors of interdependence between the North and the South, and by the same token, a space for negotiation[6] between the industrialized and the developing countries. By contrast, in many other aspects the techno-economic revolution facilitates an ever-increasing autonomy of the advanced countries with regard to the world in development and the planetary level.

It is clear that any loss of autonomy by the Latin American countries in defining their production, consumption and distribution patterns, and increasing concentration of power in transnational corporations, would bring with it an additional weakening of the feedback between economic activities and ecological deterioration[7]. This could accentuate a tendency toward the overexploitation of some natural resources, the sub-utilization of others, and the externalization of ecological costs from the large organizations toward the region.

A scenario that raises concerns is that the new techno-economic paradigm as is now unfolding could lead to certain disequilibrium between structures of production, gearing even more production toward exports and toward the demand of minoritary high-income sectors, with pressures to generate new demands and re-

[6] For example, one of the negotiation arguments (Gallopín, 1990b) could be directed to the international opening of the access to the new technological developments, to favor the change of the processes of industrialization of the developing countries, as a prerequisite to reduce the global ecological impact associated with growth. The argument has logical validity, if it is considered that today's developed countries are fundamentally those that consumed the planetary ecological potential, and that the current degradation of that capital will restrict the possibility of growth for the developing countries (if they are constrained to use the traditional paths of "dirty industrialization"). The importance of wide availability of new technologies is recognized in Agenda 21 (Chapter 34), but little has been accomplished.

[7] This feedback is essential for the stability of the interactions environment-development (Gallopín, 1980).

duce the useful life of durable goods, thus increasing the production of wastes[8] and the marginalization of large sectors of population.

The orientation of production toward non-essential consumption goods and the obvious explosive tendency toward the increase of supply and diversity of durable consumer goods contribute to generate an indefinitely growing pressure on the environment and scarce resources diverted to non-essential uses[9]. This is more so considering that the trends do not favor a transition toward collective modes of consumption of the goods and services that allow it, but rather they exacerbate individual consumption, multiplying the number of units necessary to satisfy the demand.

A current trend appears to be the decentralization of industrial production, accompanied by centralization in the control of knowledge generation[10]. In the case of microelectronics, the investments of transnational companies in the region would be those dedicated to the realization of progressively less remunerative tasks and with smaller technological importance, often adopting the form of "enclaves" without linkages to the rest of the local productive system. In the area of materials, the apparent directions of change are the geographical relocation of the production of traditional materials in search of comparative advantages in the cost of energy, or to take advantage of savings in transport costs and the flexibility granted by the proximity to the source. Another direction of change is the growing diversification of the plants in the developed countries in the area of the new materials, which are more sophisticated and appropriable.

The main issue is to avoid the type of localization of industries and other productive activities that ignore the local ecological constraints and the environmental adequacy of the localization of activities, with the consequent worsening of environmental problems. To avoid a trend toward the relocation of industries with high polluting potential toward the developing countries, norms of environmental protection should be included in the treaties of international trade. It is of course possible that some ecosystems of the region could be used by big organizations as space for testing new technological developments with high environmental risk, or to explore comparative advantages of the germplasm or of the local ecosystems[11].

[8] This refers to wastes associated with consumption. As for production wastes, they could possibly diminish due to improvements in input efficiency facilitated by the new technologies.

[9] On the contrary, the production of basic goods has a natural ceiling determined by the satisfaction of the population's fundamental material needs.

[10] What led Celso Furtado to anticipate the possibility of a tele-guided destiny for Latin America (Furtado, 1984).

[11] This is not mere speculation. High technology has already been added to the list of well-known cases of pharmaceutical experimentation using the human population of the region (experimental birth-control methods, new drugs, etc.). The Wistar Institute of the U.S., with funding provided by private organizations (Laboratory Rhone-Merieux, Laboratory Transgene, Rockefeller Foundation), clandestinely carried out an experiment in 1986 in emplacements of the Pan American Health Organization in the locality of Azul, Province of Buenos Aires, Argentina. The experiment consisted of the inoculation to cattle of a new genetic recombinant rabies vaccine, obtained by genetic engineering. This was the first test in the world of that vaccine under field conditions. The experiment was hidden from the Argentinean government and its sanitary authorities, and, according to public accusations, both the workers who manipulated the inoculated cows and consumed their milk without pasteurizing, and the population of Azul (who consumed it pasteurized and marketed) were not informed. The experiment was interrupted by the Argentinean sanitary authorities when its existence filtered openly. The case caused a scandal in the U.S. (symptomatically, the public commotion was much weaker in Argentina). See *Revista Humor* No. 186, 187, 190 and 191, years 1986/1987, Buenos Aires.

It seems clear that the technologies and production patterns generated by the large organizations of the industrial countries cannot be expected to spontaneously adapt to the needs and potentialities of the countries of the Latin American region. This implies that the new imported technologies could be poorly adapted to the ecological cycles of the local ecosystems.

Another macro effect that can be expected from the exogenous determination of technology in Latin America is the potential for a lack of "sensitivity" of the structure of production toward the endowment of natural resources in the countries of the region, generating tendencies to the application of excessive pressures on some resources, and simultaneously to the neglect or sub-utilization of others. The rationality of the big transnational companies, as well as their capacity to mobilize capital in the planetary space, could induce levels of renewable natural resources use exceeding ecological regeneration rates, leading to the degradation of the productive ecosystems and their abandonment when their profitability becomes inferior to that of alternative places on the planet. The pressure to export and to compete internationally can result in strong stimuli to produce in inappropriate lands, as well as generate an internal competition with the land dedicated to the production of basic food crops.

The fundamental input for the new techno-economic paradigm is science, increasingly integrated into technology, the type of science that is more directly linked to the requirements of industrial societies. The WTO considers knowledge as private property instead of as the patrimony of humanity, and it favors the patenting of germplasm and living organisms. All these factors contribute to decrease the adaptability of the technologies to local potentials and ecological restrictions (except for those that are specifically designed to be programmed and adapted).

The widening of the income gap between the advanced countries and those of the region, and the structural tendency to the imbalance of the regional external sector, suggests a possible relaxation of the norms of environmental and ecological protection and an accentuation of the current tendency to the overexploitation of the productive ecological base for purposes of export. Those trends, combined with social tensions due to growing technological unemployment and regressive income distribution, are inducing so-called "war economies," abandoning the environmental (and social) objectives of development. On the other hand, it is possible that some regional trade agreements would stimulate a relative homogenization of environmental and social protection criteria. The risk is, however, that the homogenization of standard be made "downward" rather than "upward," restraining the growth potential of the region. As mentioned before, the combination of international mobility of capital and free trade of products stimulates an international standards-lowering competition (instead of increases in efficiency) in the name of reducing costs in order to attract capital (Daly & Goodland, 1994).

Other sources of concern are the tendencies to technological unemployment, which could lead to increasing marginilization and might even end up reverting, in some countries, the current net migration from the rural to the urban areas, with ecological consequences on the rural environment. In addition, the tendencies for

the polarization of income within countries could favor the increase of ecological deterioration associated with poverty, as well as that associated with over-consumption. Finally, the increase of the "vertical" connectivity between the global and the local associated with globalization could have unpredictable consequences. It appears that in many cases the growing integration of the world population to the markets increases dependence from factors increasingly distant from local control (Gallopín, 1994).

Currently, small peasant production is sensitive to distant factors operating through subtle channels. An increase in the U.S. interest rates can trigger policy changes across and along the developing world (because the costs of serving the external debt are linked to international interest rates). Many of those policies directly affect the life of the small producers, particularly the subsistence peasants. Their changing activities will also have environmental consequences and thus become part of the environmental impacts of the operation of the international financial system. Maletta (1988) analyzed several causal chains operating at different scales in the case of peasant agriculture in the Andean region.

From the environmental point of view, the consequences of the insertion of peasant producers into the market may vary drastically depending on the "economic rationality" of the producer[12].

There is another phenomenon associated with globalization and technology that has very deep systemic implications: in hierarchical systems (those containing components and processes that operate at different levels of aggregation and space and time scales) the lower-level subsystems operate faster (at a smaller time scale) than the subsystems and processes belonging to the macro level. Globalization is leading, on one hand, to the local systems becoming more and more connected to the global system; and on the other hand, due to the operation of a global network of telecommunications in combination with new concentrated decision-making systems operating at the planetary scale (particularly transnational companies), the dynamics of the global level is becoming faster, in several dimensions, than the dynamics of the lower levels (Gallopín, 1991). The consequences of this unusual phenomenon are theoretically rich, but largely unpredictable.

It is also difficult to anticipate the environmental impacts associated with the general redefinition of comparative advantages because of the possibility of emergence of new unsuspected advantages, and the probable multiplication (and increased volatility) of the number of factors that define comparative advantages.

[12] In a case-study in the Argentinean province of Chaco (Gallopín & Barrera, 1980) it was possible to verify the coexistence of two economic rationalities in the same geographical space. Most of the producers tried to maximize the rate of profit (capitalist rationality); the subsistence producers, however, sought to maintain constant total family income (rural rationality), a phenomenon originally detected by A. V. Chayanov in Russia (Chayanov, 1925). As a consequence, the rural capitalist producers intensified their exploitation (increasing the environmental impact) as a response to an increase in the price of their products, and diminished their activities in the opposite case. The subsistence producers reacted in inverse form; they increased the exploitation of the land (and their self-exploitation) when the prices went down, in an attempt to maintain their total income. Thus, both types of producers had opposite behaviors, both perfectly rational in the context of each objective function.

The reduction in the relative weight of wages in the new techno-economic paradigm could reduce the importance of the comparative advantages of cheap labor, affecting the prospects of the countries that based their growth on that factor. In the short term, however, globalization may result in a North-South labor competition, stimulating a tendency toward labor-intensive products and processes (Daly & Goodland, 1994). The reduction in the ratio of raw materials to product, and substitution of materials, would affect more directly the countries that based their process of capital accumulation on their mineral or forest resources. The new technologies (and particularly biotechnology) are already affecting the traditional agricultural producers (in the North as well as in the South), transferring profits and the control of production and commercialization to the big chemical and pharmaceutical transnational companies and the big trading companies. Increases in agricultural yields in the advanced countries (facilitated by the new technological developments) are reducing the soil and climatic comparative advantages, closing traditional markets for agricultural products of Latin America, and increasing international competition for those products from the industrial countries.

New Comparative Advantages?

Several comparative advantages could arise in the countries of the region, with different environmental consequences. The range includes the advantages related to the access to sources of cheap energy, those associated with the reduction of costs of transport because of the proximity to the sources of natural resources, those of localization granted by permissive environmental or sanitary legislation (a somewhat perverse advantage), and those of exploitation of the local ecological or climatic conditions or components, among others.

In ecological terms, this changing mosaic of comparative advantages in the countries of the region could lead to a major increase in the pressure of exploitation upon fragile or remote ecosystems currently untouched, the abrupt valorization of particular ecological elements or functions, and the devaluation of others, the installation of new biological forms and even ecosystems in the region, etc. In absence of social regulation, these phenomena can result in the overexploitation and degradation of the regional ecosystems, and in the loss of the traditional comparative advantages that could be associated with them.

The overall ecological prospects that can be inferred in this regional scenario are somewhat discouraging, although there exist some isolated positive aspects. Yet somewhat paradoxically, the *technical* potential for a sustainable management of the ecosystems, for the control, monitoring, and minimization of environmental pollution, for the adaptability of the plants and technologies to the local social and ecological conditions, for a spectacular increase in the production of satisfiers of human needs, for the diversification of uses of ecological resources, and for ecologically sustainable development, is probably higher today than in any moment of the past.

However, unless Latin America adopts active and sustained strategies—which are endogenously defined, and shared among social actors and countries—to carry out the necessary social, economic, and technological structural changes, the mentioned technical potential is likely to materialize only in the most advanced countries. Otherwise Latin America faces the danger of concentrating the perverse effects of the techno-economic revolution[13].

Although the analysis presented in this section concentrates on the possible regional ecological effects of the high technologies, the impact of the diffusion of technologies already existing (modern) and of the change of products should not be underestimated. Both phenomena are directly linked to economic globalization. The recent history of Latin America shows impressive shifts of products and technologies in the agricultural sector. This indicates that the ecological effects of the new technologies in Latin America will not replace those of modern and "traditional" technologies, but rather they will be added to them, at least during the next decades.

Analysis of Alternative Scenarios

The multiplicity of interlinked factors makes it impossible to provide a detailed prediction of the future environmental impact of globalization on Latin America. It is, however, feasible to explore future trajectories representing alternatives that seem plausible on the basis of the information now available.

In this spirit, a prospective analysis was carried out, based on simple simulation models of the ecosystemic transformations associated with land use in each of the 18 major life-zones represented in Latin America. The time-horizon considered was 50 years, beginning in 1980 (Gallopín, 1992, 1995; Gallopín & Winograd, 1995).

Within each life-zone annual land transformations are simulated as simple functions of land use, the general properties of the life-zone, and the selected scenario. Within each life-zone the following categories are distinguished:

"Natural": undisturbed areas with primary vegetation, but also including areas that have been perturbed in the past and today have a vegetation similar to the original one; "Altered": modified by human activities (forestry, shifting agriculture, ranching, etc.) with coexistence of portions of the original ecosystem and secondary vegetation, and including fallow from shifting and peasant agriculture; "Agricultural": areas annually sown and harvested, including permanent and annual crops and non-traditional plantations (e.g., coca and marijuana); "Grazing": areas with natural or artificial pastures, currently used for ranching; "Plantations": areas re-

[13] Even the optimistic analysis of Pérez (1986), who explicitly emphasized the new opportunities, referred mainly to the possibility of opening new free spaces for medium and small companies, to the technical potential for the improvement of production, the possibilities for decentralization, for new degrees of freedom, the diversification and adaptability potential, etc. But all this in a space dominated by the giant companies. She, too, signaled the unavoidable necessity of new development strategies for the countries of the region.

forested for forest exploitation or watershed protection; "Wastelands": areas with severe human-accelerated erosion and desertification processes with irreversible changes in their structure and function (it excludes the natural deserts); and "Urban": urbanized areas (essentially cities).

Two basic socioeconomic scenarios were defined by the whole region: the reference scenario and the sustainable scenario.

The reference scenario implies the partial continuation of the economic stagnation of the 1980s, followed by a moderate increase of regional economic growth. The development patterns remain the same but with a growing influence of globalization and of transnational companies upon the economy. The new technologies enter in the region exogenously. There is no significant move toward the implementation of environmental and sustainability policies. The emphasis of agricultural production is on cash crops for export, and secondarily on crops for internal consumption. The reference scenario also assumes a gradual reduction in the advance of the agricultural frontier in tropical areas, and a general intensification of land use.

The sustainable scenario contains an emphasis on endogenous decision-making by the region[14], and it includes policies to improve income distribution, implementation of active scientific, technological, and environmental strategies including a move against resource-intensive and toward knowledge-intensive growth (Chichilnisky, 1994), and development of new systems of agricultural production. The main emphasis of the agricultural production is on crop diversification for internal consumption, and only in second place, on cash crops for export.

The general characteristics of the two scenarios appear in Table 1.

Table 1. General hypothesis in the scenarios for the simulation runs.

Variable	Reference scenario	Sustainable scenario
Demographic growth	2.2% in 1980 to 1.2% in 2030	2.2% in 1980 to 1.2% in 2030
Production	0.5%/year	the range of 0.5 to 1.2%/year
Average growth of per capita agricultural yield	1%/ year	Within the range of 1.5 to 2.0%/ year
Animal carrying capacity (animal units)	From 0.6 UA/Ha in 1980 to 1.2 UA/Ha in 2030	From 0.6 UA/Ha in 1980 to 1.5 UA/Ha in 2030
Annual harvested area	65% of the agricultural area in 1980; 75% in 2030	65% of the agricultural area in 1980; 85% in 2030
Land-use allocation	Emphasis on export crops; secondarily, in crop diversification for internal consumption and for export	Emphasis in crop diversification for internal consumption and export; secondarily, in export crops

Source: Gallopín & Winograd (1995).

[14] Sometimes called "self-reliance": this denotes a capacity to make autonomous decisions, and it does not necessarily imply autarchy.

Although the scenarios were not designed specifically to simulate the effects of economic globalization, it is clear that the reference scenario represents a more passive attitude of the region toward globalization, while the sustainable scenario implies a more active and dynamic attitude.

The comparison of the calculations under the two different scenarios allows us to illustrate the potential impact of globalization (together with other variables) under either a passive or an active attitude of the region.

Given the simplicity of the models in comparison with the complexity of the ecological and social processes that are unfolding in the region, and the inherent uncertainties in the available primary and secondary data, the results proposed should be taken as indicative and not as definitive numeric results or attempts of detailed prediction. Some of the results have been revised based on later data (Winograd, 1995a), but the changes do not change the overall findings.

The detailed results of the simulations for each life-zone per decade may be consulted in Gallopín (1995a), Gallopín and Winograd (1995), and Winograd (1995). Here only the general results for the whole region are presented (Fig. 1).

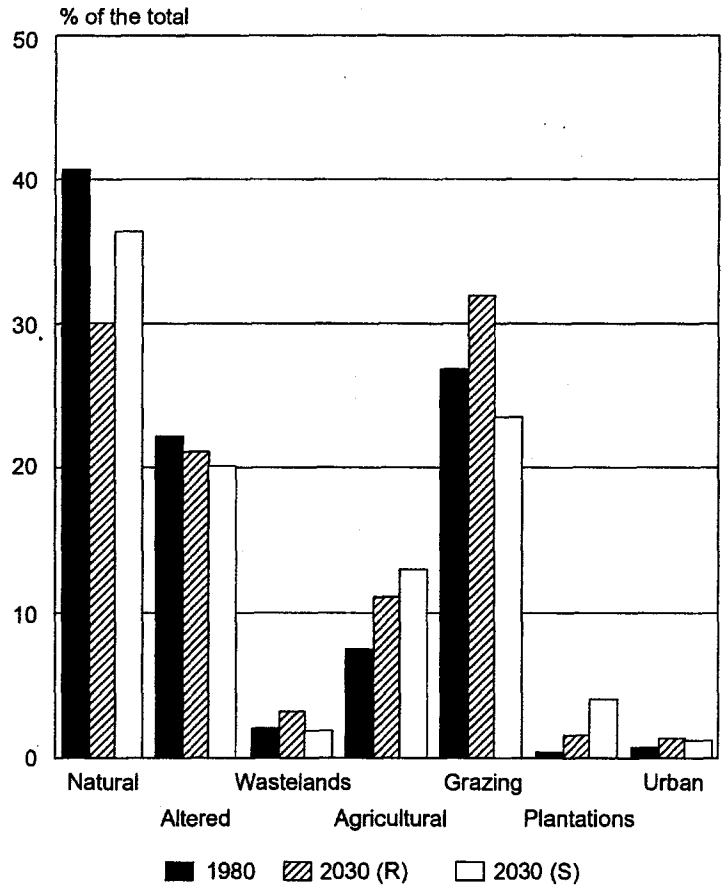

Figure 1. Surface under different categories in 1980 and 2030 under the reference scenario (R) and under the sustainable scenario (S). Source: Gallopín (1995a).

Reference ecological scenario

For the whole region the results imply the transformation of 5 million hectares per year (as an average for the 50 years' runs) of virgin and semi-virgin ecosystems. A fraction of 78% of this surface will come from the tropical areas, 19% from the subtropical areas, and only 3% from the temperate areas. As much as 45% of this transformed area will become agricultural (30% under shifting agriculture, 15% under permanent agriculture); 30% will be used for grazing, and 22% for forest exploitation.

Two major processes drive a large part of the dynamics: (1) the advance of the agricultural frontier, translating into a decrease of natural ecosystems and the growth of agricultural, grazing, and altered areas and (2) the intensification of land use which, in the dry zones, increases the wastelands at the expense of the altered ecosystems, and in the humid zones increases the area of altered ecosystems, within which subsistence agricultural activities intensify.

The total surface of altered ecosystems in the region diminishes because in many life-zones the stocks of land are being exhausted, leading to the intensification of land use instead of territorial expansion.

In this scenario the following environmental problems related to land use stand out:

Soil erosion, originated in deforestation, inappropriate agricultural techniques, overgrazing, and overexploitation. It will particularly affect the tropical and subtropical mountain rainforests and the subtropical rainforests of Central America, the Andean countries, and Brazil. To a lesser degree, the Argentinean pampas will continue to suffer from erosion.

Watershed degradation, due to deforestation and dam construction. It will affect mainly the tropical and subtropical mountain and lowland rainforests in Central America, the Andean countries, parts of South America, Brazil, and Mexico, as well as the temperate rainforests of Chile and Argentina.

Floods, due to watershed degradation, deforestation, and natural processes. They will mainly affect the tropical and subtropical mountain and lowland rainforests 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 cyclic droughts. It will advance mainly in the Patagonian steppes, the Puna, the dry tropical forests, the tropical and subtropical desert shrublands, and the temperate thorn scrublands in the Andean countries, Brazil, Argentina, Chile, Peru, Mexico, and Central America.

Agricultural pollution will continue in many of the cultivated lands in the whole region, and agricultural, industrial, and urban pollution will increase in the deltas and mangrove forests of Central America, the Caribbean, and parts of South America.

Firewood deficit will continue increasing in most of the ecosystems. The shortage of firewood due to deforestation and overexploitation of the forests will affect more than 50 million people in the arid areas and the Andean highlands in the next 30 years.

Sustainable ecological scenario

Under the endogenous scenario, the region is capable of satisfying the agricultural, livestock, fishing, and forestry internal requirements in a sustainable manner within the considered time-horizon of 50 years after 1980, with a substantial surplus for exports.

Three major processes account for a large part of the dynamics in this scenario: (1) Emphasis upon productive rehabilitation of deteriorated and altered ecosystems (which cover 22% of the total land area), because it represents the most realistic strategy for dealing with many of the complex tropical and subtropical ecosystems; (2) Impulse to integrated rural production systems (agriculture-animal husbandry-forestry-aquaculture) whenever they are appropriate; and (3) Active pursuit of integration of the new technologies into traditional and modern technologies.

Besides the quantitative differences with the pattern derived from the current trends, the qualitative changes in the modality of rural production imply a drastic reduction of the ecologically degrading processes previously defined.

For the whole region those figures imply the transformation of 2 million hectares per year of virgin and semi-virgin ecosystems (most of them in tropical areas). Protected areas represent 35% of the remaining natural ecosystems. Altered ecosystems will cover 20% of the area, the same figure as in the reference scenario. However, in this case most of the altered lands become productive (14% in sustainable forestry and 6% under rehabilitation). Cultivated lands increase to 13% (7% under intensive agriculture, 3% under agroforestry, and 3% under shifting cultivation). Grazing lands decrease because of increments in carrying capacity (18% is under intensive and semi-intensive grazing systems, and 7% is integrated with forestry). As a consequence of the rehabilitation and restoration activities, wastelands are reduced to half their initial surface.

An unplanned positive effect of this scenario is that, due to the strong emphasis on reforestation and agroforestry, by the year 2030 about 64 million hectares would have been reforested (mainly in the altered areas). This represents 14% of the world area that was estimated by Sedjo (1989) to compensate, if afforested, the excess atmospheric carbon generated by human activities. Note that the estimated current emissions of biotic origin (mostly deforestation) by the region represent between 8 and 10% of the world total (Gallopín & Winograd, 1995).

The ecological, technological, and economic feasibility of this scenario is argued in detail in Gallopín and Winograd (1992, 1995).

The reference scenario suggests the type of environmental consequences associated with land use that an unrestricted and unregulated opening of the economies in the context of an absence or widespread weakness of environmental (and

social) policies would have. This weakness characterizes the general situation of the region at the present time. The environmental problems would affect critically the economies and the societies in several countries of the region.

The sustainable scenario shows that, from the ecological and technological point of views, it is possible to change direction toward a much more desirable long-term situation, without too large direct economic costs[15].

The main unknown lies in the political feasibility of this scenario, since it goes against all the recent tendencies in the region and of the macroeconomic forces loosened in the last decades.

However, it should be taken into account that the current trends are clearly unsustainable, both ecologically and socially. According to some analyses, they may also be unsustainable in economic terms (The South Centre, 1996; Chichilnisky, 1996). It is therefore necessary to look for alternatives to the current trajectory.

Strategic Elements for Sustainable Development in Latin America and the Caribbean

From the analysis of the simulation models as well as of 21 real-life case studies, and a systematic evaluation of environmental opportunities and constraints at the regional level (Gallopín, 1995), the following elements of strategic importance for the sustainable development of Latin America and the Caribbean stand out:

- The analysis of current trends in the region clearly shows that the prevailing pattern of development is ecologically unsustainable and therefore not viable in the long term.
- There are no important ecological constraints (at the level of the region as a whole) for sustainable development, nor for the conservation of the areas required to maintain the essential ecological functions and services. However, in some countries there exist important ecological restrictions (such as shortage of arable lands), as well as clear environmental complementation, and therefore intra-regional cooperation will be essential.
- At the moment lack of technologies is not a critical obstacle for the sustainable development of the region (in the sense of representing a bottleneck at the regional level)[16]. This does not negate the need to fill the existing gaps of knowledge of appropriate management of some ecosystems.
- The new and emerging technologies can play a very important role for both environmental and general sustainability. Ecological analysis allows the identifica-

[15] The necessary direct investments related with land use would amount to less than 4 billion dollars per year for a 50-year period (Gallopín & Winograd, 1992). These annual costs represent 0.3% of the GDP of the year 1993 for Latin America and the Caribbean.

[16] Today there exist management techniques that are economically, socially, and ecologically sustainable for ecosystems as varied as the tropical humid forests, the tropical dry forests, the tropical montane forests, the Puna, the dry temperate shrublands, the temperate humid forests, Patagonia, etc. (Winograd, 1995; Gallopín & Winograd, 1995).

tion of broad regional priorities for research and development (R&D), taking into account the major ecological opportunities and constraints for development (Gallopín, 1995a). Many of them are absent from the current official priorities set by the scientific systems of the countries of the region.

- Latin America and the Caribbean are a region of high ecological, social, and productive heterogeneity. Different social actors and production types coexist in dissimilar environments. A strategy based on *technological pluralism* (complementary use of traditional, "modern", and high technologies) is essential for sustainable management of heterogeneity.
- *Productive pluralism* (the coexistence of different types of rural production systems, integrated through local, national, and regional policies) represents a more appropriate alternative than productive homogeneity from the point of view of sustainability of development.
- In terms of environmental sustainability the concept of *technological blending* (constructive integration of new and emerging technologies into traditional or modern technologies) assumes particular importance, requiring new forms of organization and an integral strategy for technological innovation and diffusion.
- The domain of application of the new sophisticated technologies is not confined to the "modern" (essentially urban-industrial) sector of the economy. These technologies can play a very important role, given the current context of the region, in the generation of new solutions to problems such as critical poverty, using science and high technology to develop simple, but new and effective technological solutions accessible to the poor, or in the reformulation and revaluation of native technologies used extensively in the region. This implies using high technology to develop solutions of "sophisticated simplicity."
- An important strategic principle is that of the integration among the different areas of the new technologies. It is often assumed that the field of application of biotechnology is limited to agriculture or the pharmaceutical industry, and that the field of application of information sciences is the services and industrial sectors. The integration among areas of new technologies can facilitate very important synergies (for example, in peasant agriculture; Gallopín, 1995a).
- Due to the multiple interlinkages among factors associated with globalization, from the speed and turbulence of changes to the unpredictability of many of them, the development of strategies directed to create a generic social and ecological capacity to respond to changes in a flexible, adaptive, and proactive form will be critical for the region. This general capacity may be equally or more important than specific measures implemented to confront particular challenges.
- An important strategic principle to cope with the growing uncertainties and the lack of sufficient resources to address all possible negative impacts of globalization is to try to develop "*tie-in strategies*" whenever possible. The concept, proposed by Schneider (1989) in the context of global climatic change, is also valuable with reference to the environmental impact of economic globalization. It implies giving preference to those actions directed to avoid or to adapt to

negative changes (or to benefit from positive changes) of economic globalization, that will still provide clear social and ecological benefits even in the case in which the anticipated changes do not materialize (or other unexpected phenomena occur[17]).

Conclusions

Latin America is changing in the context of major global trends. These include, on the negative side, an enormous foreign debt, an increasingly regressive distribution of income, fragile economic growth, a population in continuous growth, and increasing environmental deterioration. On the positive side, there has been a reduction of inflation, a reactivation of economic growth, elimination of military dictatorships, and growing regional economic cooperation. The changes taking place in Latin America today diverge from its recent historical trajectory, and lead to an uncertain future.

The current situation seems to represent an "explosion of novelty." Globalization, the Knowledge Revolution, and the social and economic impacts of the diffusion of the new technology will probably operate as triggers of global and regional changes, with significant social, economic, cultural, and environmental consequences. The resulting new directions in principle could lead to a worsening but also to an improvement of the situation in relation to past trends. In particular, the ecological future of Latin America, in terms of natural resources as well as of habitability, will depend on the social options adopted in the region in the turbulent context of the current world situation.

The ecological future of Latin America is directly linked to the large social options of the region more than it is to the search of new knowledge and new techniques for ecosystem management, although those are also necessary.

Several socioeconomic scenarios leading to alternative futures of the world and region are open. In each one of them it is possible to identify possibilities for the improvement of the management and conservation of the environmental resources. The opportunities and restrictions vary strongly between the different scenarios.

The countries of Latin America need to define and implement new development strategies allowing them to incorporate the opportunities implicit in the economic transformations and the new technologies without paying enormous social, economic, and ecological costs. In other words: Latin America must implement its own "knowledge revolution", shifting away from resource-intensive sectors and forms of production, into knowledge-intensive products and technologies.

However such strategies, in order to be viable, must be socially, economically, and ecologically sustainable in the long term. In economic terms, new forms of

[17] The effect of reduction in carbon emissions in the sustainable scenario described above is a good example. Reforestation and rehabilitation of degraded lands, besides contributing to mitigate global climatic change, have social and environmental value by themselves. Other things being equal, they are therefore preferable to actions that would be useful only if the phenomenon of global warming is really confirmed.

property rights for knowledge are needed if innovation and knowledge-intensive sectors and products are to flourish. The aim is to achieve a society having as basic attributes participation of the population in the creation and diffusion of knowledge and decisions, increased equity in the access to knowledge, and an intrinsic compatibility with its environment. This is a much bigger challenge, and of different nature, than developing economic competitiveness at the international level.

These new national and regional development strategies will have to be solidly based on science and technology, with priorities and goals established by the countries of the region. This is indispensable due to the fact that the knowledge-intensive sectors are those that contain most of the dynamics of the world economy today, and in many ways characterize the current globalization process.

The analysis presented here shows that within this context, trade liberalization may be desirable. In the context of resource-intensive industrialization, however, liberalization is not necessarily or automatically beneficial for all countries, and is certainly not a recipe for sustainable development[18]. This contrasts with the position of the international organizations that maintain that economic globalization will be beneficial for the South and that developing countries should therefore accelerate their total integration in the global economy through an extensive and fast liberalization based on resource extraction and exports, and the enhancement of the role of the market, reducing the function of the state to the maintenance of an environment appropriate for the flowering of business and the functioning of competitive markets.

From the environmental and social points of view, it appears that the countries of Latin America should carefully define policies for selective integration to the world market, instead of a fast unconditional opening of the economies.

Besides the inherent difficulties to the definition of the strategic integration required in different countries of the region, it is obvious that the current international tendencies represent a strong obstacle for any strategy endogenously defined (particularly for the poorest, but also for the strongest countries). However, even within the limited degrees of freedom allowed by the current constraints, it should be possible to adopt strategic directions favoring an orientation toward a more sustainable development in the region.

When the currents are strong and turbulent, there are at least two possible strategies: that of the transatlantic ship, whose power and robustness confront the frenzy of the elements, and that of the kayak, whose agility allows it to negotiate the fast waters on the basis of know-how and high capacity of reaction. The required skills and the actions appropriate to drive the two vessels are very different. It is possible that the countries of Latin America and the Caribbean should concentrate on the kayak metaphor at the national level, and in the transatlantic metaphor at the

[18] Some analysts even maintain that globalization and the liberalization policies, and the dismantling of the state, have failed in the industrial countries as well as in the emergent Asian economies, and that the fast growth of the latter was due to the application of policies precisely opposed to those recommended by the advocates of total liberalization (The South Centre, 1996). The IMF recognized, after the crash of the Asian markets in 1998, that the liberalization models have been pushed too far in Asia.

regional level (or even the extra-regional one, leaning on strategic alliances and real international cooperation).

In synthesis:

- Globalization is a multidimensional process that greatly exceeds the economic dimensions of free trade and the neoliberal position.
- While markets are an important economic institution and an engine of growth, an unrestricted opening of the economies to the international market is not by itself conducive to sustainable development. The free play of market forces can spontaneously generate asymmetries and inequalities, and under current conditions is unable to guarantee ecological sustainability.
- Some of the effects (both positive and negative) of globalization and of the opening of the economies are already detectable and are being documented.
- Globalization exhibits an essential ambivalence with potentially very positive and negative potentials. Therefore it is necessary to guide the globalization processes according to criteria of strategic importance.
- The globalization process should be associated with ethics, responsibility, and a governance system. The possibility that the global system falls into a scenario of generalized "barbarization" (Gallopín & Raskin, 1998) may otherwise be realized.
- The environmental sustainability of development poses specific questions for the strategies to cope with globalization (for example, the role of the different time horizons in economic decisions and in ecological processes).
- The current situation in Latin America and the Caribbean vis-à-vis the globalization process is weak. Under those conditions, the possible strategies are:
    - To simply drift with the currents (which seems to be the present attitude). This, for the reasons previously presented, could be suicidal. At best it can only benefit a minority, excluding most of the population of the region.
    - To navigate creatively: the strategy of the kayak—not synonymous with letting go, taking advantage of the force of the flows but at the same time seeding the germs of the desired future. This is possible only if a long-term vision is adopted, a systemic and multi-causal perspective, directed to create a society intrinsically compatible with its environment. It implies measures coordinated in space and staged in time directed to give fruit at different time horizons (institutional in the short term, educational in the long term, etc.)[19].
- And above all, more than to try to tighten all nuts and bolts, it is necessary to strengthen the societal and ecological sources of renewal, and the generalized societal capacity to respond to change, even to unexpected change.

[19] A third strategy would be to try to change, from Latin America and the Caribbean, the global system—the transatlantic boat. However, this is probably unfeasible. If possible at all, it would depend on the capacity of the region to establish alliances with other international actors, and in the future development of solid regional cooperation.

Economic globalization, in combination with the end of the Cold War and the potential of the Knowledge Revolution, makes possible a qualitative jump in the history of the human civilization. This promise, however, may not be fulfilled, and the growing marginalization of large population masses in the South (and also in the North) anticipates a conflictive future.

It seems clear that there are no separate solutions, one for the North and one for the South. A global solution must be obtained that integrates the needs of the North and of the South, and leads to rapid economic progress and to the creation of new technology while fostering the conservation of the world's precious natural resources. A solution must be found that integrates the needs of the present and the future.

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