ECOLOGICAL PROSPECTIVE OF SOUTH AMERICA

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INTRODUCTION

It is a great honor for me to be invited to address you in this meeting.

My intention is to share with you some of the results of a four-year study on prospective of Latin America. Those may be useful in providing some broad perspective for the South American Riverway System (SARS) Project. Here I will be emphasizing results of direct relevance to South America.

The results I will discuss, and indeed the SARS Project itself, should be considered in the context of the unfolding of major driving forcing that are shaping the future of South America:

- Demographic growth
- Urbanization
- Globalization and Transnationalization
- Environmental Degradation
- Technological revolution
- Social Polarization
- Global Climate Change

The unfolding of those forces in the context of the historical trajectory and the current natural, socioeconomic, and cultural endowment of the nations of South America could result in qualitatively different futures for the region in the next decades; some of those possible futures are quite dismal, but some imply real quantitative and qualitative progress.

The project "Ecological Prospective for Latin America" was implemented by a team of scientists under my coordination (Gallopín, 1992, 1995). We considered in the analysis two of the contrasting futures, concentrating in the ecological and technological dimensions. This analysis was articulated with a broader project ("Technological Prospective for Latin America") addressing in addition social, economic and political factors (Herrera et al, 1994).

To my knowledge, the project on ecological prospective is the first analysis of the ecological future of a region in relation to the technological revolution, and using major ecosystems as units.

The major objective of the project was to explore the ecological and technological feasibility of an environmentally sustainable scenario, as well as the consequences of continuing with "business-as-usual", taking into account the new opportunities and challenged afforded by the so-called "new technological wave", "Third Industrial Revolution" or "Techno-economic Revolution".

The name new technological wave denotes the complexus of new and emerging technologies, led by microelectronics and information technologies, including also biotechnology, nanotechnology, new materials and new sources of energy. This wave of innovations is having major economic, cultural, political, social and environmental impacts, contributing strongly to the turbulence and speed of change at all scales from local to global.

The technological analysis concentrated along three lines:

- Identification of the potential direct ("technical") effects of the new technologies.
- Exploration of potential indirect ("societal") effects of the new technologies within the prevailing scenario.
- Mathematical simulation models and future scenario analysis.

POTENTIAL DIRECT EFFECTS OF THE NEW TECHNOLOGICAL WAVE

For each type of new technology, the major potential direct impacts were identified. For example, the area of microelectronics was defined as including computation, information processing, artificial intelligence and telecommunications, as applied in services, industries, agriculture, organization management, and management of complex processes; automation and robotics in production and services; and telemetry and resources detection, and anticipation of events. Two of the important attributes of those technologies in terms of possible effects on basic components of the social and economic structure are their potential for highly efficient decentralization and conversely their potential for information (and thus, power) centralization.

An illustration of the possible effects in rural environments is represented by changes associated to the feasibility of managing complex agro-ecosystems through computer models and information systems, and the possible reversal of the current net population flow from the rural to the urban areas (if high levels of urban unemployment are generated by automation and robotics).

Possible effects in urban environments include, e.g., possible changes in the comparative advantages of large cities in relation to intermediate and small ones, both for enterprises and for the population.

POTENTIAL INDIRECT EFFECTS OF THE NEW TECHNOLOGICAL WAVE

Indirect effects are much more difficult to identify; as in the case of direct effects, some could be beneficial and others detrimental.

A number of the indirect impacts may be negative unless active endogeneously defined policies for the incorporation of technological change in the countries of the region are defined and implemented. Some of the detrimental impacts, (as arising from the logic of the process as it is currently unfolding, and under the current passive attitude of South America), have already been documented in their initial phases. Those include:

- loss of autonomy of the countries of the region to define their production and consumption patterns.
- transfer of the thought process abroad
- widening of the income gap
- technological unemployment
- regressive income distribution
- concentration of power in the large organizations of the more advanced countries
- structural imbalance of the external sector of the regional economy

On the other hand, the new technological wave provides new opportunities for sustainable development, if creatively approached. For instance, the new technologies make possible (and efficient) new operational modes associated to such terms as "flexible manufacture", "production on demand", "stock minimization". These allow for increasing delinking of the scale of plant from scale of market, and of productivity from scale of plant (making obsolete in many cases the concept of economy of scale). All of this implies profound changes in the nature and volatility of comparative advantages.

There are features of the new techno-economic paradigm which may lead to the loss of some of the traditional comparative advantages of South America. For instance the reduction of the relative weight of labor and labor costs may result in the loss of the comparative advantages based on cheap labor; material substitution and dematerialization may lead to the loss of the comparative advantages on mineral and other natural resources endowment; and biotechnology and the increased sophistication of agriculture in industrial countries may minimize the region's edaphic and climatic comparative advantages.

On the other hand, other comparative advantages may become relevant for South America, such as:

- access to cheap sources of energy
- reduction in transportation costs due to the neighborhood to the location of natural resources (or to the SARS)
- utilization of highly skilled labor
- exploitation of local ecological or climatic components
- exploitation of local empirical knowledge
- radication because of permissive environmental or sanitary legislations (a perverse comparative advantage)

Ecologically, this changing pattern of comparative advantages in the countries of the region could generate risks of severe increases in pressures upon fragile or remote spaces or ecosystems currently untouched, the sudden valorization of particular ecological elements or functions (and the loss of value of others), and the introduction of new biological organisms or even exotic ecosystems.

In the absence of social regulation this could lead to over-exploitation and degradation of regional ecosystems (and loss of associated comparative advantages), but under intelligent policies, new opportunities for sustainable development could be generated.

The discussion above has concentrated on the impacts of the new and emerging technologies. On top of that, it should be considered that large ecological impacts are already occurring in South America due to the difusion of the prevailing "modem" (i.e., the postwar technological wave) technologies and due to impressive shifts in areas of production (e.g., the expansion of soja crops).

As a consequence, it must be recognized that in South America three technological revolutions coexist in various combinations:

- the agricultural revolution

- the industrial revolution (postwar paradigm)

- the information revolution (the new technological wave)

Large numbers of people in the region still do not have access to the benefits of the industrial revolution, let alone the new technological wave.

SIMULATIONS AND SCENARIOS

The ecological analysis was carried out for the 18 major ecosystem types of Latin America. Mathematical simulation models were implemented for each ecosystem; each year, land shifts between seven categories (natural, grazing, agricultural, plantation, altered, wasteland, and urban) at rates associated to human activities and spontaneous processes of regeneration. The models calculate surfaces under each categories, and annual flows of land between categories. The values of the flows were estimated for each ecosystem and each human activity on the basis of the available literature and expert opinion.

The simulations were run from 1980 to 2030. Two basic socio-economic scenarios were defined: the "reference" scenario (business-as-usual) and the "sustainable" scenario. For each human activity and each ecosystem, the rates of land transformation differ according to the scenario considered.

The **reference scenario** implies the partial continuation of the stagnation of the 80's, followed by a moderate increase in economic growth. The patterns of development are fundamentally unchanged, with an increasing influence of transnational companies and globalization of the economy; the new technologies enter the region under exogenous determination; South America maintain its current passive attitude. No strong environmental policies are implemented.

Under the reference scenario, the simulations indicate (for the whole of Latin America) that (as an average for the 50 years) about 6.2 million hectares are transformed per year (of which 5.5 million hectares are deforested). In terms of origin, 78% of that transformed area comes from the tropics, 19% from the subtropics, and only 3% from the temperate areas. Most of this transformed land will be used for permanent agriculture, ranching and urban uses (55%); about 25% will be used under shifting agriculture, and 20% represents exploitation of the forest (part of it moves into ranching and shifting agriculture).

In the reference scenario, two major processes drive the changes:

- The advance of the agricultural frontier, resulting in a decrease of the natural ecosystems and growth of the agricultural, grazing and altered areas, and,

- The intensification of the use of the land, which, in the dry zones, increases wastelands at the expense of the altered ecosystems, and, in the humid zones, increases the extents of altered ecosystems, within which subsistence agricultural activities intensify.

Some of the ecological consequences of the evolution of the reference scenario are:

- Advance of the agricultural frontier, resulting in the loss of forest resources and possible extinction of between 15% and 35% of the existing species within the next 40 years.

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

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

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

- Decertification, associated to overgrazing, excessive extraction of fuelwood, and cyclic droughts, 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, and Peru.

- 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 South America.

- The deficit of fuelwood will increase in most of the ecosystems. Scarcity of fuelwood due to deforestation and overexplotation of forests will afflict more than 50 million persons living in the arid zones and the Andean plateaux in the next 40 years.

The **sustainable scenario** represents an attempt to follow an endogenously - determined (not isolationist or autarchic) development path. It implies a better distribution of wealth, the implementation of national and regional environmental policies, an active scientific and technological strategy, social and economic reforms, and the development of new rural systems of production.

The simulations under the sustainable scenario suggest significant improvements in relation to the reference scenario. Three major processes command the dynamics in this scenario:

- Implementation of S&T and economic policies emphasizing the productive rehabilitation of deteriorated and altered ecosystems (which cover 22% of the total land area) (the most realistic strategy for dealing with many of the complex tropical and subtropical ecosystems)
- Implementation of policies favouring integrated rural production systems (agriculture-animal husbandry-forestry-aquaculture) whenever appropriate
- Active implementation of policies directed to the integration of the new technologies into traditional and modern technologies.

A set of new and existing forms of rural production systems is included in the sustainable scenario (Table 1).

STRATEGIC ISSSUES

From the analysis of the simulated trajectories, as well as from the research on case studies and the regional assessment of environmental constraints and opportunities, a small set of basic strategic issues for environmentally sustainable development of South America relevant to science and technology policy emerged:

- No overriding regional ecological constraints for sustainable development (including food production), and for the conservation of areas needed to maintain essential ecological functions and services are evident.
- There is no critical lack of available technologies impeding the sustainable management of the South American ecosystems (in the sense that they represent a bottleneck at the regional level).
- New and emerging technologies can play an important role; the ecological analysis allows the identification of broad regional priorities for R&D, taking into account the major ecological opportunities and constraints for development.
- The principle of technological pluralism (complementary use of traditional, "modern" and high-technology) is essential.
- Technological blending (constructive integration of new and emerging technologies into traditional or modern technologies) should be an important component of the strategies.

- Productive pluralism, with the coexistence of different major types of agriculture, integrated through sub-national, national and regional policies, is a better alternative than productive homogenization.

SOME SPECIFIC R&D ECOLOGICAL PRIORITIES

Scientific research

a) The study of the functioning of the South American natural ecosystems including their responses to human actions and natural perturbations. Many of the ecological studies in the region are highly descriptive, shedding little light upon ecosystem dynamics, evolution and resilience limits, and particularly about sustainable alternative management schemes.

b) The study of the altered, perturbed and degraded ecosystems, as well as the stabilized neo-ecosystems which have been generated by man-made transformations, in order to identify appropriate management, restoration or rehabilitation techniques. Those new ecological configurations do not necessarily have low productivity; in many cases they offer new potential resources.

c) The comparative study of the concrete forms taken locally by the relationships between society and nature in South America. Those studies are essential for the identification of realistic and acceptable solutions to the problem of ecological degradation, by taking into account both the ecological dynamics and the rationality and conditions of the social actors.

d) The study of the interactions between major ecosystems of the region, which are likely to result in effects taking place at long distances and with long time-lags. This includes aspects such as the regional effects of the transformation of the Amazon basin, the relationships at the continental level between the Andean range as the great donor of water, sediments, nutrients and species, and the lowlands which receive, accumulate and distribute materials and energy; the regional or sub-regional impacts of the growing re-design of the hydrological systems; the impact of changes in land use upon climatic catastrophes across national boundaries, etc.

e) The study of the possible ecological modifications induced by global climatic changes upon the ecosystems of the region and the human activities, in order to anticipate the necessary preventive and corrective measures.

Technological research

Biotechnology: emphasis on development of sustainable food- production systems (both large and small-scale, including prominently peasant agriculture), and sustainable management of renewable natural resources adapted to the local environments. Sustainable exploitation of the regional germplasm. In some countries where mining is important, biometallurgy may be a priority.

Computation: emphasis on education, on micro-computer endogenously developed expert systems for rural communal units (for medical diagnosis, agricultural management, etc.), for planning of resource development, and for management and administration of complex diversified systems of production, commercialization and distribution.

Telemetry: emphasis on natural resources detection and evaluation, monitoring of erosion, crop condition, pollution, forecasting of weather and natural disasters, monitoring of the amount, condition and trends of the national renewable natural resources stock.

Telecommunications: emphasis on access to information (regarding prices, products, weather, pests, alternative agricultural management methods, etc), on education, participation, decentralized inter-connection, tele-diagnosis of problems and maladies, emergency plans of alert, etc. Development of efficient systems for linking remote and isolated areas.

New sources of energy: emphasis on energetic self-sufficiency of rural communities, benefiting from local conditions (wind, biomass, hydropower, sunshine). Development of small-scale energy systems.

New materials: utilization and improvement of locally available mineral and biological materials for home-building, tools, roads, dams, etc., and for export.

CONCLUSIONS

I would like to finalize by sharing with you some of the conclusions of this analysis, particularly those which may be of potential interest to the SARS Project.

- We are living at a time of breaking of the historical trends. The crisis (not only economic, but also social and environmental) is not only a threat but also an opportunity (at least in the sense that it is forcing societies to explore new paths as alternatives to current unsustainable trajectories).

- The issue of dynamic interactions between ecosystems in the region will become increasingly important; changes in some components or areas can reverberate far away. For instance:

- flows of sediments, water and nutrients from the continental highlands to the lowlands are resdistributed far away by the hydrological systems; those patterns could change dramatically in the SARS is implemented.

- the loss of hydrological regulatory capacity in the upper basins, due to deforestation and soil erosion, could result in increasing floods as well as water shortages in the lower basins.

- Changes in evapotranspiration and water cycles in Amazonia (which recycles half of the rainfall internally) due to deforestation and changes in land use may affect other ecosystems in the region, as well as change the regional (not only the global) climate.

- The increasing scarcity of agricultural land due to land degradation and population growth may trigger massive national and international migrations in South America.

- The SARS itself would link previously unconnected systems.

Those processes would intensify functional interlinkages and create new ones. This means that new forms of planning will become necessary, as well as new forms of cooperation between the countries of South America (e.g., joint management of subregional biogeochemical cycles).

All of that points out to the need for new active policies and strategies in South America to incorporate the opportunities imbedded in the new technological wave without paying immense social, economic and ecological costs. This is a much greater challenge than just achieving "competiveness".

The new strategies must be strongly supported in Science and Technology, with goals and priorities defined by the South American countries themselves. This is necessary due to the powerful science-intensive, high-technogical dimension of the current wave of planetary socio-economic and political restructuration, and also in order to harvest the large potential benefits of the new technological wave.

Our study indicates that this is ecologically and technologically feasible. Preliminary estimates suggest that it is also economically feasible. Is it politically feasible? This is a function of political and social will.

Thank you very much.

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Table V. Major types of sustainable rural systems proposed for Latin America (source: Gallopín 1995)

AGRICULTURE

1. Modern, capital-intensive agriculture. Located on the lands with higher comparative ecological advantages (fertile and stable soils, optimal climate, good irrigation potential). Not necessarily in the form of large monocultures. It includes diversified crops, biological control of pests, crop rotation, and soil conservation.

2. Peasant agriculture. It requires the implementation of structural reforms and technological innovations. Production directed to satisfy local food requirements as well as yielding cash products of high unit value made possible by special opportunities provided by local ecological conditions. Multipurpose integrated or mixed farming widely adopted. Mainly labor intensive, as well as intensive in technologies appropriate for diversified and small-scale production. Technological blending very significant.

3. High-technology diversified agriculture . Directed to the selective exploitation of local genetic resources for food, medicine, industry, etc. It implies the development of new, efficient technologies for diversified ecosystems.

4. Indigenous farming systems. Respecting cultural diversity so that indigenous communities can maintain their lifestyles and integrated production systems if they so choose.

MEAT PRODUCTION

1. Modern intensive livestock-raising. Capital-intensive animal husbandry, in herds or in barns, and intensive raising of wildlife with high food or commercial value.

2. Extensive livestock-raising. It implies a modernization and rationalization of the current extensive ranching, and includes the harvesting and use of native species and wildlife management. Most current subsistence and nomadic pastoralism would be transformed into this activity or, alternatively, into peasant agriculture.

3. Modern and high-technology wildlife management and harvesting. It implies the management, domestication, and harvesting of wildlife in captivity, semicaptivity, or wilderness, for the production of meat, fur, fine wool, skins, and hides for internal consumption and for export. Major candidates are chamelids, capybara, otter, alligator. Under good management, they can produce higher economic yields than cattle.

FORESTRY

1. Integrated forestry. Carried out by companies and cooperatives linking distributed households. Based on the sustainable management of natural and altered forests, mainly in the tropical rainforest zone, and including the rational use of most species (not just a few, as is the current practice). The products, for internal consumption and export, include timber, agglomerates, hardboard, paper pulp, wood flour for animal feed, chemicals, raw materials for the plastics industry, fertilizers, soaps, charcoal, fuelwood, and hunting and fishing products.

2. Recollection forestry. An artisan forestry, socially organized and provided with scientific research inputs; mostly located in the forests, savannas, and shrubby semideserts. It complements peasant agriculture, with communal organization of zones of extraction. Products, according to the local ecology, could include palm sprouts, rubber, mushrooms, nuts, and palms.

3. Productive plantations. Run by companies or cooperatives in tropical rainforests and dry tropical and subtropical forests with scientific research inputs regarding local fast-growing species. Mainly for the production of paper, fuelwood, charcoal, and timber.

4. Protective reforestation. Important for watershed and highland protection; directed to restore ecological regulation of floods, and reduce erosion and the silting of reservoirs.

FISHERIES

1. Intensive marine industrial fishing. Confined to open seas, managed by companies or large cooperatives. Mainly directed to internal consumption and export, exploiting a diversity of species.

2. Modern marine artisan fishing. In the coastal zones. It implies rescuing and improving existing techniques, using many species. It requires research and technical assistance (mainly to reduce post-harvest losses). Produce directed to internal consumption (assuming changes in the current patterns of consumption) and export.

3. Marine aquaculture. In the coastal zones, estuaries, and fishponds. It implies setting priorities for the management of local species and the protection of estuaries as breeding grounds. Production is for internal consumption and export.

4. Modern freshwater artisan fishing. Similar to its marine counterpart, but directed essentially to internal and local consumption.

5. Freshwater aquaculture. In dams, fishponds, etc, is similar to its marine counterpart, directed to internalconsumption and export.