REPORT ON THE LATIN AMERICAN AND CARIBBEAN REGIONAL WORKSHOP ON SCIENCE AND TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

Santiago, Chile, 5-7 March 2002

ECLAC

SUMMARY OF DISCUSSIONS AND CONCLUSIONS

Based on the discussions of the Task Forces held at the Workshop, the contributions of the Drafting Group which convened immediately afterwards (J. Carrizosa, R. Dagnino, S. Díaz, A. Elizalde. G. Gallopín, J. Rabinovich, J. Sarukhan and H. Vessuri) and subsequent editing and completion by G. Gallopín.

CONTENTS

BACKGROUND

In October 2000, two dozen scientists, drawn from the natural and social sciences and from across the world, convened at Sweden's Friibergh Manor, near Stockholm, to explore the intellectual questions underlying a transition to sustainability that will require the emergence and conduct of a new field of scientific and technological inquiry—sustainability science. The Workshop explored this issue from three perspectives:

- **Core Science Questions:** What are the core scientific questions and issues that must be addressed in the decades ahead that will form the foundations for sustainability science and technology,
- **Research Strategies:** What research strategies will be required to enable the scientific inquiry and facilitate the research to address these core questions of sustainability science, and
- **Institutions and Infrastructure:** What innovations and changes will be required to more fully enable the institutions and infrastructure essential to the conduct of sustainability science and technology.

Box 1. Core scientific questions identified at Friiberg:

- How can the dynamic interactions between nature and society--including lags and inertia--be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
- How are long-term trends in environment and development, including consumption and population, reshaping nature--society interactions in ways relevant to sustainability?
- What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?
- Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?
- What systems of incentive structures--including markets, rules, norms, and scientific information--can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?
- How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?
- How can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?

The workshop participants concluded[1] that the world's present development path is not sustainable and that efforts to meet the needs of a growing population in an interconnected but unequal and human-dominated world are undermining the Earth's essential life-support systems. The extraordinary complexity of the challenges that lie ahead is suggested by today's emerging interactions among global environmental changes and the profound transformations underway in

[1] Kates, R.W. 2001. "Sustainability Science" *Science* 292, 641-642.

social and economic life. These include such diverse alterations of the earth as climate warming, land transformation, and loss of biological diversity, together with social transitions including a population that is growing more slowly, while aging and urbanizing; an economy that is globalizing while increasing both wealth and inequality in the face of persisting poverty; and a system of resource utilization that in the energy, manufacturing and agricultural sectors is making more with less even as it increases its overall demands on the earth to unprecedented levels.

One of clearest issues to emerge was the need to initiate a world-level dialogue that would take into account the specific features of the different regions, which have different social, economic, cultural and ecological realities. This led to the recommendation that workshops should be held in different regions of the developed and developing world in order to consider these differing realities and points of view.

As a result of the Friiberg meeting and other activities, an international Initiative on Science and Technology for Sustainability (ISTS)[2] was created. This is coordinated by an international group of scientists and academics that are committed to pursuing sustainable development.

Further to the recommendations of the Friiberg meeting, a number of regional workshops have taken place. The first was the workshop for Africa, which was held in Abuja, Nigeria, from 13 to 15 November 2001; the Asian workshop was held on 4 and 5 February in Chiang Mai, Thailand; and the European workshop from 27 February to 1 March in Bonn, Germany. The Latin American event that is the subject of this report was the fourth regional workshop. The North American workshop was held on 25 and 26 March in Ottawa, Canada.

In May 2002 another workshop will be held, this time to integrate and summarize the key messages from the different regional meetings and other issues covered in the framework of ISTS.

Although the ISTS is conceived as a continuing process of dialogue and consolidation, one of the immediate milestones on the horizon is the World Summit on Sustainable Development, which will take place in September 2002 in Johannesburg, South Africa. Steps are being taken to present the main conclusions reached thus far at this world event.

[2] See http://www.sustsci.harvard.edu/ists for further information.

OBJECTIVES: THE CHALLENGE POSED TO SCIENCE AND TECHNOLOGY BY SUSTAINABLE DEVELOPMENT

The meeting was convened to initiate a process of reflection and exchange of ideas and experiences concerning the challenges and opportunities posed by the quest for sustainable development, from a Latin American and Caribbean perspective.

The results of this intense and condensed discussion among science and technology (S&T) professionals from different disciplines and orientations, drawn from different countries of the region, are expected to be of particular interest to: (a) institutions that conduct research and development (R&D) activities (universities, public and private research institutes, etc.); and (b) institutions that define and implement science and technology policies, or promote or finance R&D (ministries or departments of science and technology, national scientific and technological research committees, private enterprises, foundations, etc.). In addition to these two specific categories, the deliberations of this workshop may be of interest to the general public, and to politicians and other decision-makers who are concerned about sustainable development in the region.

The initial question requiring to be answered in the framework of this meeting was: in what way, if any, does sustainable development pose S&T challenges that differ from other major challenges of our times, such as globalization, economic competitiveness, and so on?

In many instances, it is becoming clear that the predominant approach in S&T is exhibiting major shortcomings. This in no way relates to attacks to science and technology that have come from certain hostile quarters, but rather reflects constructive criticism and warnings that have arisen within the scientific community itself.

Although recognizing that major advances due to specialization within a number of disciplines have contributed to improving the quality of life of millions of human beings, it is becoming clear that in a significant number of important cases, the very success of compartmentalized scientific approaches has led to the aggravation of the environmental and development problems they set out to resolve.

A number of processes have played a part in this. One of these is the fundamental uncertainty introduced both by our limited understanding of human and ecological processes and the intrinsic indeterminism of complex dynamic systems (including human components, man-made infrastructure and artificial objects, and natural components) that comprise the subject of sustainable development, and by the myriad of human purposes and choices.

In addition, the current historical context exhibits major differences to the relatively recent past. On the one hand, the world is moving through a period of extraordinary turbulence and volatility reflecting the economic, cultural, social and political processes associated with globalization. In addition the speed and magnitude of global change, the increasing connectedness of the social and natural systems at the planetary level, and the growing complexity of societies and of their impacts upon the biosphere, result in a high level of uncertainty and unpredictability.

On the other hand, current trends are proving to be ecologically and socially unsustainable. In recent years millions of the region's inhabitants have slid into poverty and live in deteriorated environmental conditions.

In this respect, problems and situations have become increasingly complex in recent decades. The main reasons for this include:

Ontological changes: human-induced changes in the nature of the real world are proceeding at unprecedented rates and scales and are resulting in growing connectivity and interdependence at many levels. The molecules of carbon dioxide emitted by fossil fuel consumption (mostly in the North) combine with the molecules of carbon dioxide produced by the burning of forests (mostly in the South) to force global climate change; an economic crisis in Asia reverberates across the global economic system affecting investments in countries far away.

Epistemological changes: changes in our understanding of the world related to the
modern scientific awareness of the behavior of complex systems, including indeterminism, self-organization and emergent properties.

Changes in the nature of decision-making: in many parts of the world, a more participatory style of decision-making and government is gaining ground. This, together with the widening acceptance of additional criteria such as the environment, human rights, gender, and others, as well as the emergence of new social and economic actors such as non-governmental organizations and transnational corporations, has increased the number of dimensions used to define issues, goals and solutions and hence augmented the complexity of decisions.

In short, increasing complexity and connectedness mean that the components of problems are not nearly as easy to separate as they once were. Development and environmental problems must therefore be approached not only as complex problems *per se*, but also as inseparable and mutually determined.

This represents an exceptional challenge to science and technology, particularly to the analytical compartmentalization of disciplines, which represents the bulk of activities and priorities of current S&T systems in both north and south.

The proposals of ISTS, and of this regional workshop on science and technology for sustainable development, are motivated primarily by the need for a holistic or systemic approach to sustainable development problems, together with the associated epistemological, methodological, strategic and institutional implications for science and technology. The chief aim of the workshop was to develop a regional perspective on the challenge and to scale the definition of the problem down from a global to a regional level, taking into account the specific features, problems and opportunities of the region.

The focus of this workshop lay in the questions: How can science and technology contribute to sustainable development in Latin America and the Caribbean? What characteristics are required by a Science and technology for Sustainable Development (STSD)? One of the strategically and politically important aspects of the current period in our history is the overlapping of economic, ecological, cultural, political, social and demographic processes generated by the intersection of globalization with growing global ecological interdependence. Unlike other eras, today it is virtually impossible for any country to delink itself from the world economic system, nor, obviously, from the global ecological system. One of the implications of this is that there can be no segregated solutions for the north and the south. Either a solution is found that encompasses everyone, or there can be no solution worthy of the name. The *agendas* of the north and south, however, can and should be different, given the different conditions that prevail from one region to another.

Sustainable development is the name given to the quest for such a solution, in which *development* is understood to be the genesis and unfolding of qualitative potential – not just the pursuit of quantitative growth – and *sustainability* covers the ecological, economic, and social [3] dimensions.

It is becoming increasingly clear that sustainable development requires the coordination of measures at the local or micro level (at which many of the problems are manifested and solutions are put into practice) and the macro – national and international – level (policies, agreements, economic instruments which help to create an environment that is conducive to and supportive of micro actions). This means that the quest for common sustainable development requires the participation of all peoples in an effort of mutual cooperation, and work at multiple scales ranging from local to global. It was proposed to work along two complementary lines to deliberate the contribution of Latin America and the Caribbean to science and technology for sustainable development: (1) to consider the specific features of the Latin American and Caribbean region in terms of obstacles to and opportunities for STSD; and (2) to contribute to the global dialogue a Latin American and Caribbean perspective, not only on the region's problems, but on global problems and the universal issues of science and technology for sustainable development.

[3] Broadly defined, including also the cultural and political dimensions.

The subject of is this workshop was therefore the *role of science and technology as a contribution to sustainable development, from a Latin American and Caribbean perspective, focusing on the challenges (and opportunities) posed by sustainable development to science and technology*. Clearly, not all sustainable development problems have a technological solution; in fact, the deep-rooted ecological and social unsustainability of world development patterns reflect more the asymmetries of economic, political and military power that characterize our time, rather than technical or demographic factors; however, the deliberations of the workshop concentrated on those sustainable development issues in which science and technology may play an important role.

The workshop did not conceive of science and technology for sustainable development (STSD) as a new science or a new technology, but as a reorientation of scientific and technological research towards the great challenges of sustainable development.

The workshop proceedings were conducted along four main lines:

1. Core scientific questions. What key knowledge is required for science to make an effective contribution to sustainable development? What core scientific questions need to be answered?
2. Methodological and conceptual challenges. What challenges does the problem of sustainable development poses to the criteria and method of science and technology?
3. Research strategies. What research strategies may be employed and on what scale in order to address the core questions defined?
4. Institutional innovations. How can scientific and technological institutions be better organized to develop research strategies, including cooperation between countries and sectors?

There is a clear logic to the choice of these lines of questioning, as the content of the core questions undeniably influences the methodological and conceptual challenges, which in turn affect research strategies; while the requirement for institutional innovations will depend on the response to all of the above.

CRITICAL KNOWLEDGE REQUIRED (CORE SCIENTIFIC QUESTIONS)

The participants of the workshop analyzed the core scientific questions presented in Box 1. It was concluded that these were legitimate and sufficiently broad to discount any limitation to their applicability in the Latin American region. Their very generality, however, detracts from their ability as a basis from which to directly derive a working agenda adapted to the specific features of the region. In general they were also perceived to lean markedly towards the natural sciences. In consequence, it was proposed that, for the purposes of application in Latin America, a greater emphasis should be placed on ethical, social, economic, cultural and political aspects and on different visions of the world.

The strategy adopted was to classify priority sustainable development issues (problems/opportunities) as a prior step to identifying key knowledge-needs (or knowledge gaps) for moving towards the solution of the problems or taking advantage of the opportunities.

Specific features of Latin America and the Caribbean

Although sustainable development is a global challenge, there is good reason for developing a specific agenda for Latin America and the Caribbean, because of the particular features of the region, which include:

- Increasing levels of extreme poverty and sharp contrasts of inequity and social marginalization.
- Increasing concentration of the population in cities. This trend increases demand for resources and energy and exacerbates the loss of cultural identity, marginalization and social inequity.
- A form of integration into the globalization process that leaves the countries seriously vulnerable in terms of competitive capacity.
- The planet's greatest biodiversity, but one of its highest loss rates due to the conversion of natural ecosystems.
- Secular problems of land tenure and accreditation of rural properties, which hamper conservation efforts and the sustainable management of natural ecosystems.
- An agricultural frontier that is expanding faster than anywhere else in the world.
- The world's largest concentration of fresh water.
- Low rates of societal participation in decisions that affect a country's natural, social and economic capital.
- Severely limited skilled human capital at the tertiary level, which restricts the capacity to deal with social and economic development problems.

Critical knowledge needs

What is the key knowledge needed to promote the long-term ecological, economic and social sustainability of development in the region? Although new critical knowledge is needed in all areas, in many cases we already possess enough basic knowledge to approach the path of sustainability more closely than we are doing at present. The largest difficulty lies, perhaps, in how to put that knowledge into practice.

The knowledge required to solve these problems relate to a range of areas and disciplines. In general, this knowledge concerns the study of society-nature interactions.

The following are some of the areas in which new knowledge is required:

- How to eradicate poverty in the region, and how to do it in a sustainable manner (without replicating the unsustainability of the development patterns that prevail in Latin America and the Caribbean today).

- Identification of the political, economic, cultural and technical obstacles to the application of the already available appropriate scientific and technical knowledge for sustainable development (the political economy of unsustainability).

- The real (market and intangible) value of ecosystemic services (including their differential value for different sectors of society). If we had a clearer picture of what the ecological services that ecosystems provide to society are really worth, many practices that appear to be justifiable from an economic point of view would no longer be perceived as such (the expansion of the agricultural frontier in the Southern Cone, for example).

- What factors represent a threat to biological diversity (genetic, species, functional, landscape, etc.) and what levels of degradation are acceptable in that they allow an adequate response time for adaptive management to steer the situation towards sustainable use or conservation?

- The ecosystemic and ethical values of diversity. In other words, how many and which species can be lost, and what else do we lose when we lose biodiversity? What are the ecosystemic services of biodiversity?

- What are the costs in terms of diversity, ecosystemic services, availability of water and biogeochemical cycles of the carbon-sequestering plantations that have been proposed within the framework of global measures to mitigate the effects of greenhouse gas emissions?

- How can we guarantee the viability of rural agricultural systems on which the maintenance of genetic diversity depends?

- It is necessary to recover and systematize traditional or indigenous practices and technologies for the sustainable use and management of natural resources and environmental services as tools of STSD.

- Most local and global environmental problems derive from the environmental impact of demand for energy and resources by each individual. In consequence, it is vital to learn how to induce positive behavioral changes in order to implement sustainable development models, including also the behavior of public and private decision-makers. Social sciences, philosophy and especially social psychology are key disciplines in the quest for solutions to this problem.

- It is necessary to identify gaps in legislation regarding the protection and the sustained and economically attractive use of natural resources, and to develop mechanisms to ensure compliance with existing legislation.

- It is necessary to generate predictive regional models and scenarios, based on more realistic suppositions than current ones, including the distorted nature of globalization in Latin America and the Caribbean (for example, the fact that in many countries the destruction of ecosystems is more closely related to the international market than to domestic pressures).

- Study of asymmetries between the rural environment and the large cities, with an emphasis on demands for resources.

- How can the region attain a model of sustainable agriculture that is also competitive at the world level? Consider, for example, the expansion of arable farming at the expense of natural vegetation in Latin America and the Caribbean, leading to the destruction of ecosystemic services, the expulsion of small producers and the concentration of land ownership.

- How can the subsistence agriculture practiced by millions of poor farmers in the region be transformed into sustainable rural agriculture?

- How can existing, technically appropriate solutions be made economically competitive in the conditions that prevail in our countries?

- We need to understand how economic and distributive trends are related to energy, matter and the biological cycles of the environment, at different scales (local areas, water basins, regions, etc).

- Research is needed to improve our understanding of the thresholds, limits and vulnerability of each country's priority ecosystems, in accordance with their resilience and carrying capacity.

- How can scientific and technical knowledge be mobilized to achieve new forms of integration into the global economy, by viewing technological innovation as a contribution to sustainable development? We need to seek opportunities to link dynamic sectors with the practice of sustainability.

- Determinants of ecological, economic and social vulnerability (and resilience) of the region's socioecological systems. This is a key area of interdisciplinary work in Latin America and the Caribbean.

- Means to transform ecological heterogeneity –a feature of many of the region's ecosystems– from an obstacle to production into an opportunity, by designing new systems of marketing and reporting that will guarantee a sufficiently regular delivery of products to the final consumer.

- Management of technological and productive plurality, by combining, when appropriate, cutting-edge, modern and traditional technologies.

- Sustainable and coordinated management of the major biogeochemical cycles in the region that cross political boundaries (such as the water cycle in the Amazon, supranational hydrographic basins, shared ecosystems, etc.).

METHODOLOGICAL AND CONCEPTUAL CHALLENGES

STSD poses substantial methodological and conceptual challenges, which refer not only to specific methodologies for obtaining necessary key knowledge, but also to the very methods and criteria of S&T.

Epistemological challenges

Sustainable development calls upon science and technology (science particularly) to re-examine a number of epistemological issues, including the unit or units of analysis to be used, the issue of integration, and the criteria of truth.

The recognition that human (social, economic, etc.) activities and the environment are coupled and therefore mutually determined systems (as well as strongly non-linear, complex and self-organizing) leads to the conclusion that the main unit of analysis of STSD must encompass the total coupled system or "socioecological system" (defined at the scale appropriate for the problem considered) and the associated processes.

An integrated approach to research and to the management of these systems for sustainable development is therefore required. This integration may have several facets (among disciplines, between science and policies, between understanding and action, among spatial-temporal scales, among quantitative and qualitative factors, and among science and other forms of knowledge).

In the research sphere, integration implies the adoption of a systemic approach (the scientific study of wholes) and an inter-disciplinary –or even trans-disciplinary– research style.

Lastly, whether –and how– the criteria of falsification for rejecting hypotheses are applicable to STSD is a question that needs to be re-assessed. Research frequently focuses on narrow and quantifiable aspects of problems, an approach which overlooks potential interactions between the components of complex biological systems of which humans are part.

Ockham's razor, the heuristic scientific principle which states that "one should not increase, beyond what is necessary, the number of entities required to explain anything", is still valid in a complex systemic world, but the definition of "necessary" may require to be drastically expanded in order to encompass the linkages between the object under study and other parts of reality.

Interaction with other knowledges

As modern science has evolved, its powerful conceptual structures for understanding the natural world and its historical relation to economic and political intervention have contributed to the exclusion of other sources of

knowledge patrimony of marginalized segments of society, be they indigenous, rural, poor or ethnic minorities.

In recent decades, other forms of knowledge have begun to impinge upon different areas of scientific research, particularly when it concerns controversial scientific and technical subjects that have clear public dimensions. Examples from public health research suggest that social movements can participate in distinctive ways in scientific activity, while at the same time the link with science has a significant influence on these movements.

We lack, however, a comprehensive framework regarding the multiplicity of local knowledges that could be used as inputs for scientific research and have thus far remained largely unknown to research systems as potential sources of innovation. The key knowledge generated by the “lay expert” is often contextual, partial and localized, and has not been easy to translate or integrate into a more scientifically manageable conceptual framework.

Although the affirmation of the right to cultural difference has increasingly won legitimacy and is accepted as politically correct, scientific ignorance (and in fact almost always condemnation) of traditional knowledge is still widespread. Science and technology for sustainable development are not exempt from the epistemological debate.

In this respect, it is proposed to seek areas in which scientific research and non-scientific knowledge in relation to specific subjects may overcome their profound differences to exchange concepts and empirical knowledge. Science for sustainable development creates historic opportunities to use inputs from other forms of knowledge, by exploring the practical, political and epistemological value of traditional/local knowledge as an the under-utilized resource.

Decisions that are taken in the workplace, S&T research laboratories, health care, legislation forums etc, should include all the stakeholders in the subject being researched, particularly when they will be adversely affected by the outputs of science and technology.

The incorporation of lay experts in the processes of public decision-making and the research agenda is not an issue of more democracy. It makes good sense in terms of using the expertise that is available, even when it is found in unexpected places.

Methodologies for conducting scientific/technological activities in relation to sustainable development

Methodologies relating to supradisciplinary[4] approaches

Sustainable development can be approached from many different disciplines, but none of these alone can provide an answer to the main problems of sustainable development. Moreover, a multidisciplinary team can contribute little if the experts from each discipline limit themselves to producing a technically correct vision of their own specialty, and lack the ability or willingness to combine their knowledge with that of other disciplines. The step from the multidisciplinary to the interdisciplinary (or trans-disciplinary) level requires the development of team work and methodologies articulating different sciences (and even different areas of expertise within the same science). In terms of their application to sustainable development-related disciplines, these methodologies are still in their infancy and need to be developed within a Latin American and Caribbean perspective, taking its idiosyncrasies into account.

Methodologies relating to prediction of events and situations

The interdisciplinary approach, especially in relation to sustainable development, tends to involve long term time horizons. There is also a conflict between the time scales of sustainability and political decision-making, which means that methodologies for anticipating problems need to be strengthened. In this respect, scenario-building, mathematical modeling and trend studies are examples of methodological proceedings that should be put to good use. These require large volumes of data and historical information, however, which are rarely available in Latin America and the Caribbean. It is therefore a priority to develop methodologies which can be used to conduct quantitative and predictive evaluations and which are useful and reliable even when data is limited.

Methodologies relating to monitoring and impact indicators

Given that human activity has a cumulative effect on natural resources, studies should be based on the evolution of a range of sustainability indicators. It is therefore necessary to identify the most crucial sustainable development indicators and monitor them over the long term. In Latin America and the Caribbean it is particularly important to monitor biodiversity, the great underground water reserves, and the arable soils in the zone of expansion of the agricultural frontier.

Methodologies for the rigorous processing of qualitative variables

Many of the variables and processes that are important for sustainable development are by nature qualitative (e.g. cultural and political factors). In many cases, although the variables and relations are quantifiable in principle, in

[4] This term is used as a generic denomination for multidisciplinary, interdisciplinary and trans-disciplinary approaches, without entering into the current debate on the definition and usefulness of each.

practice it is very difficult to arrive at an estimate of the corresponding values. It is therefore essential to develop scientific methodologies of qualitative analysis which are logically rigorous, verifiable and reproducible.

Methodologies relating to kinds of knowledge

The Latin American and Caribbean region is home to a wealth of traditional/local knowledge. Scientific knowledge and other kinds of knowledge are potentially complementary. Indigenous and rural knowledge is the result of many centuries – and sometimes millennia– of accumulated wisdom on how to use and live alongside natural resources. For the Latin American and Caribbean region it is important to develop methodologies to integrate this knowledge into conventional scientific/technological systems.

It is worth pausing to consider that first modernization and now globalization, with their push towards cultural homogenization, are rapidly eliminating the region's traditional capital of accumulated empirical knowledge. This amounts to a genuine loss of "socio-diversity", which is dying out in parallel with biodiversity.

Methodologies for establishing priorities, monitoring and evaluation of S&T

S&T institutions in the region have a weak capacity to communicate with political decision-makers, which must be reinforced. In order to improve this relationship it is necessary to identify new methods to communicate the opportunities and threats scientists identify. Comprehensible models and simple and realistic indicators are needed for political decision-makers and for non-experts who can participate and help in monitoring. The development of methodologies for "Science-Policy" dialogue is another important strategy. This will make it possible to strengthen public participation in the identification of priorities and the assignment of resources on the science and technology agenda. In this respect, it is also important that research methods should include means to identify priorities and conduct follow-up and evaluation in conjunction with other actors or referents in the problem, including representatives of affected local communities, dissemination experts, other scientists, etc.

RESEARCH STRATEGIES

- The design of strategies should be based on prospective studies, assessments of regional capacity, research agendas driven by the needs of users and strategies to promote changes in attitudes. In this respect, research strategies must be comprehensive and must provide the opportunity to implement models for the analysis of complex systems and the use of modern tools.

- Strategies should be integrated at the national and regional levels, in order to promote:
  - Frameworks for the discussion and analysis of problems;
  - Reinforcement for existing mechanisms of integration, while promoting new mechanisms when necessary.
  - The development of programs to put these strategies into practice.

- It is also necessary to distinguish levels (different referents and different social actors), geographical zones and thematic areas. Different agendas exist (local, national, regional and global) for different referents. Working on the basis of long-term perspectives and different levels of referents poses operational and financing challenges and affects political implementation in a number of ways. It is essential to be aware that, depending on the relevant unit of analysis, a multiplicity of scales exists. Whenever possible, strategies should not be delineated by institutional or geopolitical boundaries, but by those determined by the dynamics of processes and systems. Units of analysis must vary to take into account the characteristics and complexity of processes.

- It is essential to mobilize scientific and technological know-how in order to identify and achieve alternative forms of integration into the world economy, using technological innovation as a contribution to sustainable development. Opportunities must be sought to link the most dynamic sectors of the economies with the practice of sustainability. In this respect, it is particularly important to deal with the issue of intellectual property.

- Any strategy must take into account the effect of the reduction of the role of the State on research. There is a need to design options to secure financing for knowledge generation in order to preserve biological and cultural wealth and monitor and control the appropriate use of resources. Proactive public policies are needed to enable the development of S&T for sustainability.

- Efforts should be made to overcome the structural limitations arising from the fact that only a small percentage of young people enter higher education. It is strategically essential to expand human capital, especially at the skilled level, and to develop an institutional infrastructure for that capital. The use of strategies suited to the local situation could mitigate the brain-drain problem.

To bring this about, among other solutions, it is important to promote the formation of national and international networks involving a variety of actors and disciplines, in order to make the best possible use of human resources and infrastructure. In this sense, horizontal cooperation must be encouraged in order to share the knowledge that is generated among sectors and countries that suffer from comparable problems.

- Civil society and its organizations should be engaged in all the phases of scientific research that affect them or is pertinent, from the conception of the project and the definition of objectives, rationale and expected outputs, to the enjoyment of the benefits resulting from the research. This will require a combination of research and societal learning, including elements of collective action, innovative public policies and broad social experimentation. It is essential to work with all social groups to understand how they develop their know-how and conduct social practices. In this context, mechanisms should be created to report on the social relevance of scientific and technological research and to secure the transfer and return of knowledge to all the actors involved.

- The major issues that define the particular features of Latin America –poverty and biodiversity– call for the design of special strategies. An alliance-building cognitive effort is required in order to understand and address poverty, inequity and the violence that it generates, together with the regional distortions of the democratic system and the resulting asymmetries in power distribution, against the backdrop of the region's rich biogeophysical environment. This means working jointly with the different disciplines that are engaged in generating economic, political, technical and cultural proposals which constitute alternatives to the dominant model, such as research into the effectiveness and efficiency of different energy uses in order to guarantee an energy system that is sustainable and accessible to the whole population, or research into markets which could capitalize on the region's biodiversity (such as the production of rubber in tropical forests, cacao with certificates of origin, etc.) and other comparative advantages that mitigate the adverse effects of globalization, such as global environmental services.

INSTITUTIONAL INNOVATIONS

This section revisits many of the elements discussed previously, especially those of a methodological and conceptual nature, and seeks to encompass them in the framework of institutional design for sustainable development.

By way of introduction, it should be noted that the innovations needed to make institutions involved in implementing R&D and human resources activities, and in development, planning and management, more consistent with the points discussed in the previous sections would imply a significant turning point in their history.

Historically, in Latin America and the Caribbean the research community has shaped and channeled the structure, organization and operation of these institutions to a much greater extent than occurs in the developed countries, and has naturally done so in keeping with the values that it views as most important. In fact, the structurally peripheral nature of the Latin American and Caribbean region has lead to a situation in which production activities in general (with the exception of agriculture and health care) do not demand locally generated know-how in the way that the industrialized countries' sectors of production do.

In the advanced countries a social network of actors (industrial enterprises, state bodies, the military, organized social movements, agricultural producers, etc.) which has been tightly and comprehensively woven over many decades, influences scientific and technological activities by means of an array of "signals" as to what is and is not relevant, required, and cost-effective there. In Latin America and the Caribbean the social network of actors (emitting agents) is very fragile and more loosely woven and patchy than in the advanced countries, which means that the research community tends to be influenced more by what is desirable by its peers outside the region. The result is that the research agenda of Latin American and Caribbean institutions does not adequately reflect the knowledge needs for the region's development

The particular research needs of sustainable development exacerbate this distortion. In order to remedy this, in addition to completing and reinforcing the social network of actors and channeling their signals, it is important to act jointly with the receiving agents (institutions involved in S&T) to amplify that signal and decodify it using methodologies for strategic innovation management that will enable the institutions of the Latin American and Caribbean region to meet the S&T needs of sustainable development in a more satisfactory manner. A number of pitfalls, ranging from voluntarism to paternalism, must be avoided in the pursuit of joint action on both social demand and scientific and technological supply.

The changes needed require methodologies for the strategic management of innovation which, by helping to establish a new institutional culture, will make it possible to optimize existing potential for innovation and to help S&T activities

gain the impact needed to contribute to sustainable development. Three sets of methodologies have been identified:

The first set is intended to make the the research agenda reflect, through the identification of priorities and opportunities, current and anticipated knowledge demand arising from production activities related to sustainable development. It is essential that this set should include at least three of the actors who are directly involved with R&D activities: researchers, public innovation policy managers and the private sector (both business and non-governmental organizations).

The second set of methodologies concerns the identification of the potential users of the results of research, in order to engage them in the design and development of projects. Users will then be supportive of the activities of the institutions and ensure that the research outputs have a better chance of being used effectively.

The purpose of the third set of methodologies is to increase internal efficiency and the capacity for establishing relations between institutions and with S&T decision-making bodies and other agencies. The methodologies needed to accomplish this include: the identification of problem situations, definition of key actions, identification of crucial areas of governance, recognition of actors and flows related to the generation and use of knowledge and power (inter- and intra-institutional), Situational Strategic Planning (SSP), structural analysis, scenario-building, etc.

Most of the methodologies mentioned have yet to be used in public institutional innovation in S&T, although they have been used to some extent in private organizations and in other public policy spheres. Some of the methodologies are in the process of development throughout the world, including Latin America and the Caribbean. A small number of others have already begun to be employed in institutions in the region. For this reason, a necessary activity –and one that is relatively easy to implement– is to produce an analytical inventory of the methodologies mentioned here, which could be made available to Latin American S&T institutions to aid the process of institutional innovation for sustainable development.

It should be emphasized that institutional innovations are important to ensure the viability of the objectives proposed in the other aspects of sustainable development analyzed in this report.

Scientific and technological institutions need to undergo a renovation in order to be able to respond to the problems identified within the framework of sustainable development.

This renovation must include, in addition of what it was already said:

- Adequate lines of financing.
- Efficient mechanisms to mobilize funds.
- Inter-institutional coordination.
- Training on the STSD approach in institutions that manage, promote and raise funds for science and technology.
- Generation of effective institutional channels to transmit social demand for science and technology to the relevant agencies.

The generation of knowledge for sustainable development requires efforts that transcend national borders and institutional and financial mechanisms that can operate at a supranational level. Sources of funding that are stable and reliable over time are also crucial for scientific and technological research activities. This, in turn, requires an entity (a fund or program) to be responsible for mobilizing and assigning resources. This does not necessarily mean creating new institutions, but making better use of those that already exist.

Financing

It would be advisable to create a Latin American and Caribbean Research Fund for Sustainable Development, to support research projects, technological development and projects implementing sustainable development strategies.

These funds should be used to encourage projects that are open to international competition, and which place a high value on cooperation among institutions and work groups from different disciplines and countries of the region. Cooperation should be encouraged between social groups, sectors of production and academics.

The institution administering the funds must be independent of the institution(s) responsible for implementing projects, in order to avoid conflicts of interest.

Among other avenues of funding to explore, the following are worthy of consideration:

- Fixed contributions from the governments of the region, preferably in the form of pledges complemented by means of additional contributions. These could be used to create an endowment to guarantee the sustainability of funding.

- Funds created within financial agencies based or operating in the region, which would allocate a portion of their net income to this purpose.

- Charges for the provision of environmental services and the use of natural resources by net importers of environmental space.

Rules and priorities

- To alter the "rules" of funding assignment and national research competitions so that interdisciplinary or trans-disciplinary projects in the area of sustainable development can be admitted and adequately classified.

- To develop mechanisms to promote and assess long-term research projects. The current system is incompatible with this type of project.

- To propose subjects that bring together efforts, funds and institutions at the regional level in areas such as biodiversity, water and alternative energy. Today the region's institutional networks are still weak.

- Join regional and subregional efforts to create networks for the production and transmission of sustainability know-how.

- In general, design coordination with the private sector (associations of producers, committees, business) to reflect the relevant objectives. For example, generate research which enables the certification of private-sector production activities.

- Ensure that existing knowledge reaches the institutions and groups responsible for making decisions, as there are no systemic channels for this purpose at the present time.

Participation

The participation of other social actors, in addition to S&T professionals, at the different phases of the scientific and technological research process and in related decision-making, can be crucial for a number of reasons:

Ethical reasons. The undeniable right of the sectors affected to participate in decisions that have a bearing on their wellbeing (such as the installation of a nuclear or chemical plant in their area).

Political reasons. It is essential to guarantee society's control over R&D outputs, particularly those that have an impact on health and the environment.

Pragmatic reasons. In certain cases (e.g. new agricultural technologies, new health treatments), it can be especially important to encourage the social groups who are the intended beneficiaries to have a sense of ownership over the scientific and technological knowledge. For this it may be essential to engage these groups at the R&D phases in order to incorporate their interests and perceptions into the process.

Epistemological reasons. The complex nature of the sustainable development problematique, in which biogeophysical and social processes usually overlap, often makes it necessary to consider the different perceptions and objectives of the social actors involved. Also, it is increasingly clear that it is important to combine empirical knowledge built up by traditional farmers, other cultures and ethnic groups, etc. with modern scientific and technical knowledge (the constructive combination of diverse types of relevant knowledge).

From the foregoing it can be concluded that it is not necessary or appropriate to broaden participation in all cases and for all phases of R&D; the kind and degree of participation is a question to be analyzed in relation to each particular problem and context.

The specific recommendations made at the workshop included the following:

- Greater societal control over the outputs of research, through the creation of channels for citizen participation in research funding and orientation.

- An active participation by the scientific community in the creation of mediation forums for sustainable development problems, whose complexity requires the reconciliation of conflicting and disparate interests.

- Promotion of societal involvement in research (i.e. research action). Participatory research involving all the social actors and points of reference in cases where it is appropriate.

- Combination of research with societal learning that includes elements of collective action, innovative public policies and social experimentation. This means working with all the social groups in order to understand how they build their knowledge and social practices.

- Build capacity in the institutions involved with the implementation, promotion and management of R&D in the above mentioned methodologies, in order to promote the institutional change required to contribute to sustainable development.

CONCLUDING REMARKS

- Clearly, not all the sustainable development problems of the Latin American and Caribbean region can be resolved by means of science and technology. However, S&T have much to contribute in many cases, and the ability to generate and use them is increasingly a key economic factor in today's world.

- Sustainable development far transcends the environmental sphere and the challenge to science and technology is therefore much greater than simply incorporating environmental considerations into development. The socioecological system has to be approached in its totality, encompassing its social, economic, institutional and ecological dimensions. No less important and complex is the need for the design and implementation of comprehensive policies based on new knowledge and S&T potential. This was stressed in a number of different ways in several of the workshop's conclusions.

- The challenge that sustainable development poses to science and technology in the region is real and serious. In Latin America and the Caribbean it is necessary not only to reinforce (and in some cases rebuild) scientific and technological capacity to boost growth and economic competitiveness, but to do so while redirecting a large fraction of efforts towards the generation of a new scientific and technological capacity: science and technology for sustainable development.

- There is no established STSD tradition in either north or south. It is therefore necessary to create it, which represents an opportunity for international cooperation.

- Although a number of groups can be found in Latin America and the Caribbean that propound interdisciplinary studies, it is necessary to move beyond rhetoric and implement effective measures to make the training of human resources, allocation of funding, and setting of R&D priorities conducive to the understanding and resolution of sustainable development problems in the region.

- The above implies much more than defining priority issues. A serious approach to the challenge posed by sustainable development to science and technology has major repercussions at the level of theory and methodology, the practice of scientific and technological research, the definition of research agendas and the organization and operation of institutes that research and promote science and technology.

- This report analyses some of the implications and makes recommendations to the scientific and technological community and to institutions that generate and promote scientific and technological research.

- It is important to bear in mind that the STSD challenge, while by no means trivial, represents an area of action that is both feasible and accessible for the region, unlike other scientific and technological challenges which require very expensive and sophisticated equipment, or a critical mass of researchers and resources. The challenge is technically and economically manageable for the region.

- In this respect, the Latin America and the Caribbean region already possess a substantial knowledge base. Although there are crucial information gaps, in many cases the main obstacle to progress in sustainable development is ignorance of knowledge and techniques that are already available. In parallel with research to generate new knowledge, it is therefore also urgent and necessary to improve the availability, dissemination and integration of existing relevant knowledge.

- Another key point is that STSD refers to a type of knowledge that must be generated endogenously in the region. This knowledge cannot be taken "out of the shelf" from other countries or from the stock of universal knowledge.

- We cannot, however, ignore the serious structural obstacles in the region that hinder scientific and technological development, and which set Latin America and the Caribbean apart from the industrialized countries.

- Given the overlapping and complex nature of sustainable development problems, in many cases (though not all) it may be necessary to seek the participation of different sectors and coordinate different sources of knowledge (not only different scientific disciplines, but also the perspectives of civil society, indigenous groups, business, politicians, etc.) in the science and technology endeavor.

- This represents a major scientific and technological challenge, because it is essential to ensure that this coordination is not perceived as an attempt to justify lack of scientific and technological rigor, which could gravely damage the weak scientific and technological system in Latin America and the Caribbean. A serious and far-reaching scientific analysis of systems is required. In addition to material and energy phenomena, this must include an irreducible variety of perspectives and knowledge sources, and even of intentions and objectives.