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## EDUCATION, SCIENCE, TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES, COOPERATION AND CAPACITY-BUILDING

## Science for sustainable development

## Report of the Secretary-General

SUMMARY

The present report covers issues related to science for sustainable development, as discussed in chapter 35 of Agenda 21. The report focuses on the experiences of national Governments, the United Nations system, other international organizations and the scientific community in implementing science-related policies and programmes at the national, regional and international levels (paras. ___). Based on this analysis, priority issues have been identified within the four programme areas for which specific actions need to be taken (paras. ___). Several policy recommendations to encourage and promote those actions are presented (para. ___).

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# INTRODUCTION

1. The multi-year thematic programme of work adopted by the Commission on Sustainable Development at its first session identified chapter 35 of Agenda 21, 1/ "Science for sustainable development", for review by the Commission at its third session, in 1995. The present report provides a basis for the forthcoming discussion of the Commission on how to encourage and support national initiatives and strengthen international cooperation with a view to enhancing the contribution of science to sustainable development, particularly in developing countries.

2. The analysis of the report covers the four programme areas of chapter 35, namely:

(a) Strengthening the scientific basis for sustainable management;

(b) Enhancing scientific understanding;

(c) Improving long-term scientific assessment;

(d) Building up scientific capacity and capability.

3. The report focuses on the experiences of national Governments, the United Nations system, other international organizations and the scientific community in implementing science-related policies and programmes at the national, regional and international levels. Based on this analysis, priority issues have been identified within the four programme areas for which specific actions need to be taken by national Governments, with the support of international organizations and major groups, in particular the scientific community. Several policy recommendations to encourage and promote those actions are presented for consideration by the Commission.

4. Linkages have been established to the extent possible with other cross-sectoral chapters of Agenda 21, in particular chapters 31, "Scientific and technological community", 34, "Transfer of environmentally sound technology, cooperation and capacity-building", 36, "Promoting education, public awareness and training", and 37, "National mechanisms and international cooperation for capacity-building in developing countries".

5. The report benefited from the consultative process during the inter-sessional period, which involved the United Nations system, governmental and non-governmental organizations and the scientific community, in particular the International Council for Scientific Unions (ICSU). An inter-agency consultation was convened by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Paris, 24 and 25 March 1994), with the participation of United Nations bodies and organizations, including the Food and Agriculture Organization of the United Nations (FAO), the World Meteorological Organization (WMO), the United Nations Industrial Development Organization (UNIDO), the United Nations Environment Programme (UNEP), the United Nations Centre for Human Settlements (Habitat), the Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, the United

Nations University (UNU), the Economic and Social Council for Western Asia (ESCWA) and the Economic Commission for Africa (ECA), other international organizations, such as the Organisation for Economic Cooperation and Development (OECD), and scientific institutions, in particular ICSU. The inter-agency consultation agreed on the outline for the report and its major contents.

6. Extensive use was made of information provided to the Commission by national Governments, the United Nations system, governmental and non-governmental organizations, and research and development institutions. Contributions from individual experts were also taken into account. Reference is made to recent relevant publications by, for example, UNESCO, UNIDO, FAO, WMO, the United Nations Development Programme (UNDP), the United Nations Conference on Trade and Development (UNCTAD), the World Bank, OECD, ICSU and the Third World Academy of Sciences (TWAS).

## I. ASSESSMENT OF THE CURRENT SITUATION AND TRENDS RELATED TO SCIENCE FOR SUSTAINABLE DEVELOPMENT

### A. The role of science in achieving sustainable development

7. The policies and programmes being developed and implemented by national Governments, the United Nations system and other intergovernmental organizations have emphasized the key role of national scientific capacities and capabilities for achieving sustainable development objectives. It is not an exaggeration to assert that without science there can be no sustainable development. A critical mass of scientists and engineers is needed in developing and developed countries alike for the development, adaptation and use of environmentally sound technologies and production systems. Science is the basis for sustainable agricultural and industrial development, as well as for meeting the world's increasing energy demand.

8. Effective actions to ensure a sustainable future for human society on Earth need to be based on the assessment of the impact of human activities on natural systems and the well-being of people. To understand the impact of human activity on the environment and, subsequently, to identify appropriate solutions, a solid knowledge is required of the functioning of ecosystems and their interrelations with human society. Thus, policy-making for sustainable development centres around extremely complex questions for which interdisciplinary scientific information from both the natural and social sciences is needed to find viable and long-term solutions.

9. Scientific research conducted during the last 30 to 40 years has led to the understanding that there are limits to the healthy functioning of life-support systems. That understanding has been instrumental in moving towards the concept of sustainable development. A major challenge for science, on the eve of the twenty-first century, is to deepen this understanding of the functioning of the overall Earth system through further investigation of boundaries or limits within which development can take place. It will also be necessary to determine the rates at which those limits will be reached. Both questions require intensive research in order to improve the forecasting capabilities needed to

design sustainable development strategies. Buying time to do that research is one of the most important rationales for applying the precautionary principle.

10. At present, many developing countries, in particular the least developed ones, lack even a critical mass of qualified scientists in the relevant disciplines. Without an endogenous scientific capacity and infrastructure, development is impeded. These countries are not in a position to carry out the scientific work needed and to apply the science needed for addressing their environment and development problems. These countries are also unable to participate actively in international Earth system research programmes and in international conventions dealing with the global environment. Only a strong science education programme can ensure such a critical mass of scientists, beginning in primary school and continuing through secondary school to graduate and post-graduate research and training.

11. Recent publications by UNESCO, UNDP, the World Bank and UNCTAD conclude that there are three crucial factors associated with economic development: science, technology and education. Their studies show that there is a relation between investments in science and education and the growth of gross national product (GNP) in countries showing rapid economic growth. The correlation between science and the growth of GNP highlights the important role of science in furthering the societal goals of economic growth and environmentally sound and sustainable development.

12. The information available from countries, including those submitted by national Governments to the Commission, indicate that very few countries have taken specific measures in direct response to chapter 35 of Agenda 21. In a number of countries, however, scientists have been included either in their personal capacities or as ex officio representatives of national scientific institutions in the national coordination mechanism (national commission/ national council for sustainable development).

13. Developing countries generally consider both internal and external brain drain to be a most serious problem in relation to science for sustainable development. While provisions ensuring the equal treatment of women in national science policy and scientific institutions already exist in a large number of countries, it appears that there have been no specific measures taken in this respect in direct response to chapter 35 of Agenda 21.

## B. Intergovernmental processes

14. Two intergovernmental processes have been launched recently that are specifically dedicated to supporting science for sustainable development in developing countries and to sensitizing governmental decision makers at the highest possible level to this need.

15. The first process was initiated by the Prime Minister of Pakistan, who invited heads of State and their representatives to endorse the establishment of a Commission on Science and Technology for the South (COMSATS). Forty-nine countries were represented at the first meeting of COMSATS (Islamabad, 4 and 5 October 1994), which was chaired by the Prime Minister of Pakistan. The

objective of COMSATS is to provide political and economic support for major initiatives related to scientific capacity-building. In this vein, COMSATS endorsed the aim of creating 20 centres of excellence in the South as the frontier areas of science related to sustainable development, and established the Network of International Centres of Excellence in the South, with headquarters in Islamabad. COMSATS called for enhanced North-South and South-South cooperation in order to achieve self-reliance and adequate endogenous scientific capacity in the South. The COMSATS Technical Assistance Fund was established, with Pakistan contributing Rs 30 million (equivalent to US$ 1 million).

16. The second process, the Presidential Forum on the Management of Science and Technology for Development in Africa, was initiated by a regional non-governmental scientific organization called the Rand Forum. The Presidential Forum met for the first time in Maputo, in 1993. The second Presidential Forum was held in July 1994 and was attended by 16 heads of State or their representatives, who endorsed the establishment of an African Foundation for Research and Development. The meeting reaffirmed its support for the periodic sessions of the Presidential Forum as a major endeavour to sensitize the African geopolitical and geo-economic leadership to the crucial role of science-led development.

17. Specific scientific issues and activities were addressed in the context of the conventions on biological diversity, 2/ climate change 3/ and desertification 4/ aimed at promoting technical and scientific cooperation; research and development; scientific and technological capacity-building; and the establishment of intergovernmental scientific and technological advisory bodies.

18. The Global Conference on the Sustainable Development of Small Island Developing States (Barbados, 26 April-5 May 1994) recognized the important role of science and technology by including in its Programme of Action, 5/ a separate chapter (chap. XIII) on this issue. Moreover, within the topical chapters on such subject areas as climate change, sealevel rise, natural and environmental disasters, and management of wastes, the need for a strong scientific basis was emphasized.

## C. United Nations system and major international scientific organizations

### 1. Main activities in relation to the four programme areas of chapter 35 of Agenda 21

#### (a) Strengthening the scientific basis for sustainable management

19. By including this programme area in chapter 35 of Agenda 21, the United Nations Conference on Environment and Development (UNCED) recognized that development and natural resources management will be sustainable only if it is based on sound science, using the best scientific knowledge available and with continued research to improve the knowledge base. In this respect, with the support of international organizations, as appropriate, countries need to:

(a) Collect, analyse, interpret and disseminate scientific data and information related to the broad areas of sustainable development as defined in Agenda 21, and develop and apply science-based policies, resource management systems and technologies;

(b) Generate through science new knowledge that is relevant for sustainable management and policy-making, in particular through interdisciplinary research.

20. While these are tasks for industrialized and developing countries alike, the gap between them is widening. Many developing countries, particularly in Africa, lack the necessary scientific manpower and infrastructure. The bodies and organizations of the United Nations system, including the World Bank, have a long tradition of supporting programmes and activities in developing countries aimed at strengthening the scientific basis either in particular sectors, such as food, agriculture, fisheries and forestry (FAO), industry (UNIDO), health and sanitation (WHO), agrometeorology and operational hydrology, weather and climate forecasting and services (WMO), or for broader scientific inquiry in the basic engineering, social and environmental sciences (UNESCO, UNU). The regional commissions have also developed programmes focused on strengthening science as related to development in the developing countries. ICSU has mounted a programme dedicated to strengthening scientific capacities in developing countries related to global change research.

(b) Enhancing scientific understanding

21. This programme area of chapter 35 stresses the need to:

(a) Carry out research programmes in order to better understand the carrying capacity of the Earth as conditioned by its natural systems, such as the bio-geo-chemical cycles, the atmosphere/hydrosphere/lithosphere/cryosphere system, the biosphere and biodiversity, the agro-ecosystem and other terrestrial and aquatic ecosystems;

(b) Develop and apply new analytical and predictive tools in order to assess more accurately the ways in which the Earth's natural systems are being increasingly influenced by deliberate and inadvertent human actions, demographic trends, and the impact and consequences of those actions and trends;

(c) Integrate the physical, economic and social sciences in order to better understand the impacts of economic and social behaviour on the environment and of environmental degradation on local and global economies.

22. The international research programmes needed to understand the Earth system, its carrying capacity and the mechanisms governing its life-support systems, are now by and large in place. These programmes, which involve United Nations bodies and organizations as well as other international organizations, include the International Geosphere-Biosphere Programme (IGBP) of ICSU; the joint WMO/UNESCO/ICSU World Climate Research Programme (WCRP); Diversitas, a joint programme on biodiversity of the International Union of Biological Sciences (IUBS), the Scientific Committee on Problems of the Environment (SCOPE) of ICSU and UNESCO; the Global Atmosphere Watch (GAW) of WMO; the International

Hydrological Programme (IHP) of UNESCO; and some others. The agro-ecosystems and the terrestrial and aquatic ecosystems are the subject areas of scientific activities of FAO and UNEP, as well as the major focus of UNESCO's Man and the Biosphere (MAB) Programme. The lithosphere is the subject of the International Geological Correlation Programme (IGCP) jointly sponsored by the International Union of Geological Sciences and UNESCO.

23. The relevant organizations, based on decisions of their governing bodies, have also started to develop comprehensive global observation systems for the major components of the Earth system, such as the Global Climate Observing System (GCOS) sponsored by WMO, UNEP, the Intergovernmental Oceanographic Commission (IOC) and ICSU; the Global Ocean Observing System (GOOS) sponsored by IOC, WMO and ICSU; and the Global Terrestrial Observing System (GTOS) sponsored by UNEP, UNESCO, FAO, WMO and ICSU.

24. Progress has been made in the integration of natural sciences and socio-economic research at the national, regional and international levels. That progress, however, appears to be proceeding more slowly than anticipated. The Human Dimensions of Global Change Programme (HDP) has been launched by the International Social Sciences Council (ISSC). Another encouraging example is that UNESCO's Man and the Biosphere (MAB) Programme has been reoriented since UNCED to further enhance its interdisciplinary function and to include a major focus on the links between economics and natural resources research.

25. A distinction needs to be made between international scientific undertakings dedicated to Earth system research on global environmental issues, such as climate and biodiversity, and the need to integrate environmental science in other major fields of science, such as agriculture and health. Significant progress has been made during the last few years in this respect. An example is the integration of a sustainable agriculture component into agricultural research as well as into the work of the international research centres of the Consultative Group on International Agricultural Research (CGIAR), which are co-sponsored by the World Bank, FAO and UNDP.

(c) Improving long-term scientific assessment

26. The primary objective of this programme area is to provide assessments of the current status and trends in major developmental and environmental issues at the national, subregional, regional and global levels. These assessments need to be based on the best available scientific knowledge in order to develop strategies for achieving sustainable development.

27. At the international level, the main scientific assessment programme under way is that of the Intergovernmental Panel on Climate Change (IPCC) sponsored by WMO and UNEP. IPCC has proven to be a valuable tool for Governments. Based on its scientific assessments, IPCC has proposed various response strategies to counter the potential impacts of climate change. As the IPCC interfaces efficiently with the international scientific community, its framework could serve as a model for similar assessment panels on environment and development. Other important scientific assessments being coordinated by the scientific community include assessments for stratospheric O3 (WMO and UNEP), for greenhouse gases (WMO/GAW), and for marine pollution (Joint Group of Experts on

the Scientific Aspects of Marine Pollution (GESAMP)). The UNCTAD Advanced Technology Assessment System addresses technology-related issues of sustainable development.

28. Over the past few years, a large number of statistical publications and reports on the status of environment and development have been launched and continue to gain prominence. In this regard, important contributions are being made, for example, by UNDP, UNESCO and UNEP, as well as by non-governmental organizations, such as the World Resources Institute and the World Conservation Union. Several agencies are developing indicators for sustainable development, including on the basis of cooperation.

(d) Building up scientific capacity and capability

29. The primary objective of this programme area of chapter 35 is to improve the scientific capacities of all countries, in particular the least developed countries, in order to enable them to fully participate in the generation and application of scientific research concerning sustainable development. Traditionally, scientific and technological capacity-building in developing countries has been an area accorded high priority by United Nations bodies and organizations. Accordingly, efforts have been reinforced and capacity-building programmes reviewed to better address the new paradigm of linking environment and development.

## 2. Enhancement of inter-agency cooperation

30. Inter-agency cooperation and coordination in the field of science has been enhanced since UNCED through the efforts of the ACC Inter-agency Committee on Sustainable Development (IACSD) and its two subcommittees on oceans and coastal areas and on freshwater resources. The establishment by IACSD of the task-manager system was of crucial importance in this respect.

31. The United Nations bodies working with UNESCO as task manager for chapter 35 have agreed to set in motion a process of enhanced cooperation and coordination focused on the implementation of this chapter. The group has agreed that the first step towards this goal is more efficient exchange of information, followed by increased quantity and quality of joint activities, and the development of joint programming where appropriate. The ultimate objective is to eliminate overlap, to pool expertise and resources and to concentrate international action on the priority areas of common concern.

32. At its 1994 substantive session, the Economic and Social Council addressed the division of labour and improvement of coordination within the United Nations system in the field of science and technology. It was concluded that as an immediate focus for coordination and joint action in science and technology at the inter-agency level, organs and organizations of the United Nations system should give particular attention to (a) science and technology policy and planning capabilities at the national level; (b) the sustainable use of natural resources; (c) new technologies, including biotechnology; and (d) education and human resources development.

33. Several major initiatives have already been taken since UNCED to enhance cooperation between relevant United Nations agencies. A number of these initiatives also involve major international scientific organizations, as well as major national organizations that are geared towards international cooperation in scientific fields related to sustainable development.

34. UNEP, in partnership with UNESCO, ILO, UNIDO and a number of universities, has developed a series of training programmes for cadres of ministries of environment of developing countries in the field of environmental management, which involve both the scientific and ecological foundations of environmental care and modern management tools, such as simulation models and resources accounting. The ultimate objective of the United Nations system is for developing countries to develop and run national and regional training courses in direct response to their needs.

35. A novel collaborative venture, Project 2000+: Science and Technology Education for All, has been launched by UNESCO to address the priority area of scientific capacity-building and science education, with an emphasis on developing countries. The objective of Project 2000+ is to ensure scientific and technology literacy for all children, youth and adults throughout the world. Project 2000+ is based on partnerships between a group of major intergovernmental organizations and agencies and non-governmental organizations that have special concerns and responsibilities in the field of science and technology education and research. Its Steering Committee includes UNESCO, UNICEF, UNDP, UNEP, the World Bank, the Commonwealth secretariat, ICSU, and several international non-governmental bodies grouping associations for science and technology education.

36. The World Climate Programme (WCP), for which WMO plays an overall coordinating role, is another example of enhanced inter-agency cooperation and, to some extent, integration of activities by a number of United Nations bodies and ICSU. In 1993, a special intergovernmental meeting on the theme "Climate agenda" was held to determine the WCP response to UNCED. At this meeting, the sponsors of WCP (WMO, UNEP, UNESCO/IOC, FAO and ICSU) were asked by the Governments represented to draw up an integrated proposal to Governments indicating programme and budget requirements for the next several years according to the four main thrusts of the WCP: climate services for sustainable development, studies of climate impact assessment and response strategies to reduce vulnerability, new frontiers in climate science and prediction, and dedicated observation of the climate system. The socio-economic benefits of climate research for member States will also be addressed. An integrated proposal will be presented to the governing bodies of the sponsoring institutions in 1995.

37. The World Bank has indicated its willingness to support another international initiative promoted by developing countries in specialized fields and in centres of excellence. This initiative is designed to establish strategic links among the agricultural, environmental, basic and engineering sciences. The project will identify 20 centres of excellence in various regions of the South that will promote capacity-building in science and technology according to the priorities of each region and with the commitment of Governments in the region. Each regional or international centre is expected to

encompass a network of national centres aimed at training scientists and promoting research and development. The regional centres will form a global network. The backbone of the international network will be the international agricultural research centres of CGIAR (co-sponsored by the World Bank, FAO and UNDP). Other intergovernmental organizations with major science programmes, such as UNESCO, UNIDO and WMO, would also be invited to participate, as well as major scientific non-governmental organizations, such as TWAS.

38. Another example of recent efforts to enhance international cooperation related to science and Agenda 21 is the newly launched pilot project entitled Global Forum for Sustainable Development Research and Capacity Development (Bellanet). Bellanet (named after Bellagio in Italy) aims to promote and achieve efficient information exchange, more concerted efforts and concrete collaboration among a broad range of donors and actors, including intergovernmental organizations, bilateral donors and foundations in the field of research and development for sustainable development in developing countries. This initiative has been developed by IDRC (Canada), the MacArthur Foundation, the Rockefeller Foundation, SAREC (Sweden), and the World Bank, on the basis of consultations with other United Nations agencies and bilateral donors. The project includes specific provisions to ensure relevance and linkages of Bellanet with Governments and the scientific communities in the developing countries.

## D. Financing of science for sustainable development

39. Consistent with the relevant decision of the Commission on Sustainable Development taken at its second session, the in-depth discussion on the financial aspects of science for sustainable development was part of the overall discussion on financing the implementation of Agenda 21 that took place in the context of the Inter-sessional Ad Hoc Open-ended Working Group on Finance (New York, 6-8 March 1994). In the context of the present report, the financing of science for sustainable development is considered as it is directly related to the priority issues discussed in the report. The financial implications of research and development in relation to the sectoral issues to be discussed by the Commission at its third session are not addressed.

40. There are considerable financial implications associated with the measures to be taken to implement chapter 35 of Agenda 21. The financial responsibility of Governments with regard to science is significant. Developing country Governments need to consider long-term investment in science education a high priority, on the premise that such investment will unlock a vast human capital that has been underexploited to date: the intellect of present and future generations. At the same time, developing country Governments need to increase the financial resources devoted to science and technology, particularly with regard to research and development.

41. Financing for science for sustainable development is being provided primarily at the national level through national and provincial governments, industry and business, as well as by foundations and sometimes by non-governmental organizations. In most countries, the data available does not distinguish between the financing of research and development in general and the

financing of science for sustainable development in particular. As stated in UNESCO's World Science Report, published in 1994, many industrialized countries spend about 3 per cent of their GNP on research and development activities. In developing countries, the figure in most cases is significantly below 1 per cent. This demonstrates that there is a great shortfall of funds needed for increased scientific capacity-building in developing countries, in particular in the least developed countries.

42. Financial support to developing countries in the field of science is provided by a number of bilateral donors. The limited availability of funds for research assistance and training in specialized scientific fields, however, has become a particular concern. With the shrinking overall volume of development assistance funds and with acute emergencies in developing countries on the increase (e.g., in Somalia and Rwanda), it is becoming more and more difficult to defend aid budgets for long-term capacity-building for research. There is a need to reach agreement among donors of research assistance on the measures that must be taken to safeguard resources for essential purposes; to agree on common programmes; and to seek synergy and increased efficiency.

43. Relevant bodies and organizations of the United Nations system, including the World Bank and intergovernmental regional banks, continue to be another major source of financial support for scientific activities and scientific capacity-building in developing countries. In addition to the financial means provided for this purpose, a number of United Nations bodies and organizations, including FAO, UNESCO, UNIDO and UNEP, have spent a considerable share of their regular programme funds on supporting programmes and activities related to science for sustainable development and scientific capacity-building in developing countries.

44. Given the serious lack of resources and qualified personnel in the least developed countries, a realistic short to medium-term strategy for building scientific and technological capacity to manage the transition to sustainable development would be to concentrate on subregional measures rather than national ones. Subregions usually tend to share several common characteristics that facilitate a more rational and efficient use of resources, including qualified staff. Subregional efforts also have greater potential for creating local capacity in the short to medium term than regional (continental) and international programmes. Examples of subregions are East Africa, southern Africa, West Africa, and the Caribbean. Frequent contacts between scientists from developing and industrialized countries is a precondition for rapidly disseminating and applying new scientific and technological methods. At relatively low cost, much can be achieved in practical terms by providing funds for scientific visits and meetings, electronic communication, access to data banks etc.

45. Two recent important initiatives have been taken to enhance the funding of science and technology for sustainable development in developing countries, in particular in Africa. The first initiative is the above-mentioned creation of the COMSATS Technical Assistance Fund; the second is the creation by UNESCO of the International Fund For Technological Development of Africa. UNESCO has already contributed US$1 million as seed money to the Fund, as a mark of its commitment to the technological development of the African region. The Fund is

aimed at supporting science and technology for sustainable development in Africa, in particular at promoting intensive interaction between national scientific and engineering institutions and local industry.

46. The financing of international scientific programmes, in particular those of an intergovernmental nature, such as the World Climate Research Programme (WMO, IOC of UNESCO and ICSU) or the International Hydrological Programme of UNESCO, is again primarily provided by national Governments. Governments naturally give priority to financing the national activities feeding into these internationally mandated and coordinated programmes. Hence, it is generally more difficult to raise the funds needed for the international coordination efforts within each programme and for true international cooperative activities, in particular those supporting developing country participation in these activities. Governments should realize that internationally coordinated scientific programmes need to have sufficient international core funding in order to work efficiently as true programmes.

47. In conclusion, a major obstacle to initiating essential activities for implementing the objectives of chapter 35 of Agenda 21, in particular in developing countries, is the lack of funds allocated to science and science education. The Commission may wish to address appropriate measures to increasing financing for priority actions at the national level related to science for sustainable development, in particular scientific capacity-building in developing countries, and to formulate recommendations addressed to multilateral and bilateral donor agencies and Governments, as well as specific funding mechanisms, such as the Global Environment Facility (GEF).

## II. STRATEGIC ISSUES CONCERNING SCIENCE FOR SUSTAINABLE DEVELOPMENT

48. The overview of the four programme areas of chapter 35 of Agenda 21 that has been provided above, as well as the subsequent review of the status of implementation of the objectives of that chapter, demonstrates the need for broad action at the national, subregional, regional and global levels. Strategic issues for which there is a need for priority actions are:

(a) Capacity-building in science, with particular relevance to the needs of developing countries;

(b) Strengthening international scientific cooperation;

(c) Improving communication of science;

(d) Enhancing the application of science.

## A. Capacity-building in science, with particular relevance to the needs of developing countries

49. An integral part of development and environment planning in developing countries should be provision for capacity-building, in particular in the least developed countries. Radical measures should be taken by Governments in developing countries, particularly in Africa, in the following areas: general science education and training; enhancement of the status of science; science in national development plans; and training in specialized fields and interdisciplinary approaches. While these questions are of greatest relevance for the developing countries, they are also of strategic importance for the developed countries and the economies in transition.

50. Developing countries are approaching the end of the twentieth century with a monumental challenge to their survival and long-term development. Perhaps the greatest challenge facing humankind is how to provide adequate amounts of food, water, raw materials and energy for a projected world population of between 8 and 10 billion by the year 2020, which will call for an enormous response. For example, most people agree that world food supplies will have to more than double over the next 30 years. To achieve the requisite increases in the productivity of resource use in a sustainable way calls for new integrated systems of knowledge. Today, biotechnology and information technology are providing some of the solutions, as well as pointers to the future. But more creative work on new integrated systems is required. Above all, greatly increased investment in science and technology will be necessary.

51. The ability of developing countries to meet this challenge will depend on their ability to participate in and benefit from the scientific and technological revolution that is rapidly unfolding in the developed countries. The new forces of modern science and technology, if harnessed properly and applied in accordance with each country’s particular socio-economic and cultural circumstances, offer immense possibilities for solving many of the complicated problems that are currently impeding economic, social and environmentally sound and sustainable development in the developing countries. For example, recent advances in tissue cultures, genetic engineering, biotechnology and biometeorology could be instrumental in increasing agricultural productivity, reversing land degradation and conserving biodiversity in the ecologically fragile zones of the South. The challenge is, therefore, for developing countries to master modern science and technology as part of the movement towards sustainable development. This should be achieved by first building up their indigenous capacity and then transferring the technology and know-how needed to maximize productivity.

### 1. General science education and training

52. Building indigenous capacities calls for the strengthening of science education at all levels. The fundamental importance of literacy for all is now recognized by developing countries. A similar emphasis and commitment needs now to be given to science education, which is the starting point for building a sound technology base. Science education should begin at the primary school level, when attitudes and behaviour are shaped. This needs to be understood as

a strategic issue requiring action during the next decade, particularly in terms of funding for scientific equipment in schools and universities, and for restructuring secondary and higher education systems, especially in the fields of mathematics and other basic sciences and technical training.

53. The four basic sciences - biology, chemistry, mathematics and physics - are indispensable for understanding, applying and developing all branches of science and technology within the context of sustainable development. Higher education and research in the basic sciences need to be strengthened, in particular in the least developed countries, with special emphasis on the infrastructure required, i.e., laboratories (including equipment, instrumentation, electricity and water supplies, and consumables), libraries and other basic facilities.

54. Among the basic sciences, biology and chemistry attract more students and practitioners than physics and mathematics. For instance, in sub-Saharan Africa, the output of postgraduate physicists and mathematicians is very low, as a result of which even the essential replacement of retiring university teachers is in jeopardy. Therefore, special attention should be paid to promotion of postgraduate and research training in physics and mathematics in the least developed countries.

### 2. Enhancement of the status of science

55. The classical brain drain of scientists can be avoided only if the status of scientists, scientific institutions and the government bodies responsible for science and technology improves. In many countries, particularly in the developing world, scientists, scientific institutions and government agencies responsible for science have a low priority in society in general and on governmental agendas in particular. To change this situation, the following steps should be taken:

(a) Provide adequate salaries and other incentives for scientists;

(b) Provide adequate financing for scientific institutions, including universities, especially with respect to scientific instruments and equipment;

(c) Set up or strengthen professional scientific associations and other means of reinforcing the scientific and technological community in order to improve quality through peer review and raise the self-confidence of scientists;

(d) Provide leadership at the highest level - when appropriate by the head of State - to national bodies charged with formulating and implementing science and technology policy;

(e) Promote public understanding of the role of science for sustainable development;

(f) Give emphasis to fully utilizing the talents of women and to their career development.

### 3. Science in national development plans

56. Strategies, policies and plans should exist at the national level, and, as appropriate at the subregional and regional levels in order to ensure the development of scientific capacity and the management of science. Recognizing that science and technology are essential for both economic (including industrial and agricultural) development and for the protection of the environment, increasing numbers of Governments now integrate science and technology into their national development plans. It is recommended that Governments follow that approach whenever feasible.

57. Most smaller countries do not possess economies of sufficient scale to allow for a national scientific infrastructure of the scope required to address national needs. One solution to this problem is for countries to cooperate at the subregional or regional levels to share institutions of higher learning and advanced research and development. Pooling the resources of countries with similar problems is more cost-effective than trying to develop national institutions.

58. National science plans should also promote strong linkage between universities and research institutions, on the one hand, and national industries and agriculture etc. on the other, so that scientific knowledge and information finds its way into the productive sectors. Measures should be taken to make the private sector of national economies invest more in the development of science.

59. Women and men from all regions of a country and belonging to all its various ethnic groups need to be mobilized to participate in national science and technology efforts. Because some of a country’s most valuable natural resources may be found in remote areas, often known only to groups on the fringes of society, the inclusion of such groups is essential. Governments need to be sensitized to the importance of involving such groups, which might sometimes require administrative restructuring. Non-traditional partners for scientific activity, such as the military, can also be engaged in national and regional efforts for sustainable development.

60. The brain drain of specialists from developing countries to industrialized countries is a well-known problem that requires urgent action. Existing research and training institutions, particularly those in critical areas such as food security, soil erosion, deforestation and desertification, energy supply and tropical diseases, need to be upgraded in order to provide the necessary conditions for scientists to carry out research. In each subregion, there should be at least one centre of excellence in each of these critical fields.

61. Another measure to alleviate the brain drain is for Governments in the South and international and bilateral donor organizations to establish in developing countries research and training centres in key areas of frontier science and high technology, such as molecular biology, biotechnology, informatics and new materials. If a number of well established and competent institutions can reach the standards of international excellence, it will be possible to retain scientists in their countries of origin.

### 4. Promoting interdisciplinary approaches and use of new technologies

62. The science addressed in chapter 35 is intended to provide the knowledge base for sustainable development and must therefore be designed to cover all facets of the complex problems of environment and development as they appear at the global, regional, and local levels. Traditional disciplinary research is inadequate, because in that approach only part of a problem is treated in isolation from other interrelated parameters. Disciplinary scientific work needs to be complemented by interdisciplinary research involving the basic and engineering sciences, environmental sciences, economics, demography, and other social and human sciences.

63. The role and impact of human activity within the natural environment needs to be the focus of research relevant to sustainable development. In the past, humans were seen as separate from the natural environment. What is needed is to recognize that humans are an integral part of ecosystems and to understand the interrelationships that affect humans and the natural resource base.

64. Research intended to study those interrelationships needs to be problem-oriented, i.e., to focus on specific problems of resource use and management as they appear in real life. Scientists from different disciplines need to design research programmes together with planners, managers and local populations to plan, execute and follow up research work. This kind of scientific endeavour requires new organizational structures of research and science at the national level. Such science needs to include prospective studies in order to improve the ability of the sciences to predict the likely consequences of human activity and the changes over time that can be expected in the Earth's natural and human systems.

65. The use of new information and communications technologies has far-reaching implications for science related to sustainable development. It is now possible to better manage massive amounts of data, such as satellite data, in order to track global conditions and trends. Technologies such as GIS and sophisticated computer modelling are important tools for carrying out research on the whole Earth system in order to understand the interactions among the atmosphere, the biosphere, and the geosphere at a global level. New technologies also allow for rapid, frequent and low-cost interaction among scientists around the world. Scientific research and capacity-building related to sustainable development need to take further advantage of the new opportunities offered by such technologies.

### 5. Training in specialized fields

66. Despite considerable efforts, many developing countries, in particular the least developed countries, do not yet possess a critical mass of trained personnel in specialized fields and in interdisciplinary approaches related to sustainable development. Efforts must be increased to train specialists in many specific areas of science, including those in the topical chapters of Agenda 21 (chaps. 9 to 22). Many countries do not have adequate training facilities at universities or other institutions to prepare scientists to carry out research

related to development and policy-making. Specific attention needs to be given to the development of such facilities.

67. The recycling of materials and energy is the foundation on which sustainable development rests. The relatively new science and technology of recycling in the modern sector is virtually non-existent in most developing countries. Policies, strategies and resources are needed urgently to put this new science in place in education, application and research within the specific contexts (geographical, ecological, climatic, resources, population, education levels, etc.) of the developing world.

68. An understanding of specific scientific and engineering disciplines is crucial in the era of recycling. Such disciplines include thermodynamics, the self-organization and reorganization of biological systems, the management of cities as closed-loop systems and waste management techniques. The social sciences also have an important role to play in this context and there is a large body of research findings on low-cost participatory approaches to environmental management in third world cities and rural areas.

69. A problem shared by developing and industrialized countries alike is that most current training programmes and institutional structures are sectoral and disciplinary and do not address the complex interactions among people, natural resources, technology, environment and development. This constitutes a major challenge in the training of a new generation of scientists, engineers and other experts, who need to have appropriate interdisciplinary insights and knowledge if they are to tackle complex issues and pave the way for scientifically sound policy decisions. In this connection, it is particularly urgent to initiate training programmes and institutional infrastructures that respond to sustainable development objectives and can provide support to the implementation of Agenda 21. The United Nations system should act as a catalyst for providing technical support to such innovative interdisciplinary capacity-building activities.

## B. Enhancing international scientific cooperation

### 1. Strengthening existing international scientific programmes

70. Science related to environment and sustainable development needs, by definition, to be based both on national scientific programmes and activities and on international scientific cooperation. In many fields, such as ocean sciences, climate research, and research on the functioning of the Earth system and its carrying capacity, the generation of new knowledge is not possible without international scientific cooperation. And without this knowledge, as stated above, sustainable development cannot be achieved. Hence, it has become a strategic issue for Governments to support international scientific observation and research programmes.

71. National plans and investment in science should further global environment and developmental observing systems and should strengthen internationally coordinated scientific programmes on environment and development involving

relevant United Nations bodies and major international scientific bodies. Major emphasis should be given to national activities that contribute to global observation and research undertakings. Special efforts need to be made to increase the participation of developing countries and their scientists in international scientific undertakings in the field of environment and development.

72. The strategy followed to date in designing and implementing major international research and observation programmes has proved to be sound in principle and feasible in practice. This strategy is based on two principles:

(a) The programmes are based upon collaboration among the relevant United Nations bodies and one or more international scientific non-governmental organizations. In this way, scientific quality and objectivity, as well as policy-making relevance, is ensured.

(b) Scientists from participating countries design the international coordinating framework or research agenda together, in cooperation with a high-level international scientific steering committee. Nations then integrate the programme framework into their national research and observation activity. In this way, countries are part of coherent synergistic international programmes and networks that not only advance knowledge in the interests of all but also utilize more efficiently scarce human and financial resources, keeping duplication to a minimum.

73. For this strategy to work best, countries need to participate actively in the preparation of the framework (i.e., the observation and research agenda) as well as in its implementation.

### 2. Emerging issues for international scientific cooperation

74. Many subject areas related to environment and development have already significantly benefited from international scientific cooperation. However, there are several emerging interdisciplinary subject areas that are not yet adequately addressed by specific scientific programmes at the international level. Two of these areas were identified by the inter-agency consultation convened by UNESCO in its function as task manager for chapter 35 of Agenda 21: environmental economics and indigenous knowledge.

75. As to environmental economics, chapter 35 recognizes that increased international cooperation is needed for interdisciplinary research linking economics and the natural sciences. Chapter 2 refers to the development of economic theories linked to macroeconomic policies conducive to sustainable development, as well as to trade and debt issues in the context of environment and development.

76. Current methods for assessing different environmental values, such as option and existence values, are not yet universally agreed upon. International scientific cooperation is needed to develop the methodologies that will take into account different cultural and socio-economic situations. Other issues in environmental economics will also clearly require international scientific

cooperation, because national experiences have to be shared between countries and regions and will have to be adapted to suit national or regional needs and circumstances.

77. The range of issues at the interface of environment and economics, important in both industrialized as well as developing countries, and the scientific inputs necessary to address them, are too broad to be covered by any single institution. Cooperation between the international community, including the United Nations system, and universities, the private sector, research institutions, NGOs and Governments is essential.

78. Through centuries of living close to nature, indigenous or local peoples throughout the world have acquired an immense knowledge of their environment and its natural resources. Living in and on the richness and variety of complex ecosystems, they have an understanding of the properties of plants and animals, the functioning of ecosystems and the techniques for using and managing them that is particular and often detailed. In many developing countries, rural communities rely on locally occurring species for many - sometimes all - foods, medicines, fuel, building materials and other products. Equally, the knowledge and perception of the environment of local people and their relationship with it are often important elements of cultural identity.

79. Recent years have seen a growing appreciation of the existence of these two systems of knowledge for managing natural resources and the environment: one based on indigenous people's knowledge, and a second based on so-called western scientific knowledge. Using the two systems in a complementary fashion provides a powerful tool for achieving and managing sustainable development.

80. Indigenous knowledge received a great deal of attention during the preparations for UNCED and references to its importance are found in all the UNCED agreements, including the Convention on Biological Biodiversity and the Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, 6/ as well as in several chapters of Agenda 21. Within that perspective, several initiatives have taken shape over the last two or three years. They include the World Wide Fund for Nature (WWF)/UNESCO/Royal Botanic Gardens at Kew Initiative on People and Plants, which promotes ethnobotany and the sustainable and equitable use of plant resources. A number of projects within the World Decade of Cultural Development focus on the links between culture and resource use. Several FAO activities are rooted in local knowledge of natural resources, including its programmes on community forestry and on non-wood timber products. Traditional medicine is among the programmes of the World Health Organization (WHO). At the non-governmental level, the Indigenous Knowledge and Development Monitor produced by the Centre for International Research and Advisory Networks, serves as the international community of people who are interested in indigenous knowledge.

81. In terms of possible future action, Governments should take steps to record and apply indigenous knowledge in promoting participatory approaches to natural resources management and to the equitable and sustainable use of resources. Various bodies within the United Nations system should be encouraged to examine the current profile of indigenous knowledge in their programmes relating to

environment and development, and explore ways and means of reinforcing such profiles. Steps might also be taken for ensuring coordination of these activities and making better use of existing information, and for improving access to sources of information through such means as preparing various handbooks on particular subjects (e.g., ethnobotany) which could be subsequently made available on computerized networks and updated on a regular basis.

## C. Improving communication of science

82. A critical but often neglected link in making effective use of science for sustainable development concerns communication. While science is indispensable for sustainable development, it can have an impact only if it is communicated to various non-specialist user groups in a language and form that can be understood and used.

83. At present there is a serious gap between the producers of scientific information and the users of such information, including policy makers, teachers, the media, non-governmental organizations, and other groups that play a major role in taking action towards sustainable development. The information on which decisions and actions are based is sometimes too sectoral to be relevant to complex real-world problems, out of date, partial to a particular geographical or cultural perspective, or driven by emotional reactions or interpretations.

84. What is needed is to ensure that the most recent and comprehensive information is collected, synthesized and made available in appropriate forms, depending on the particular needs of each target user group. The interpretation and language appropriate for a policy maker will differ from what is most effective for a teacher or for the general public.

85. In order to close this producer-user gap, the scientific and technological community needs to recognize that, for research to be used to solve the problems faced by society, the communication exercise described above must be considered an integral part of the research process. Scientists should be encouraged and indeed rewarded by their universities and research institutions to commit their time and energy to this communication work. At the same time, society needs to convey its requirements to the scientific community in order to mobilize the resources that science can bring towards finding solution to those problems.

86. Scientists need to work hand in hand with communicators, educators, journalists, and others who have the professional skills to assist in the effective transfer of technical information to non-specialist users of that information. Professional educators and communicators also need to take the initiatives of working with scientists to improve the content and relevance of their work concerning environment and development. Another need is the development of on-line information systems for various aspects of sustainable development (e.g., sustainable agriculture and rural development) in order to ensure easy access by managers and decision makers to high-quality and up-to-date scientific information.

87. Governments need to understand the importance of ensuring that scientific knowledge and information is tapped for decision-making. Governments should play an active role to help close the communication gap and to provide adequate financial support.

88. The need to address this communications challenge is also taken up in chapter 31 of Agenda 21, "Scientific and technological community" and chapter 36, Promoting education, public awareness and training.

## D. Enhancing the application of science

89. Once new scientific information becomes available, it needs to be channelled quickly towards application by Government, industry and other economic sectors. To achieve this goal, close relationships must be fostered and, where absent, created between universities and research institutions on the one hand and business, industry and agriculture on the other. It is within the agricultural sector that such linkage has been developed most effectively so far. Extension services in some countries convey the results of agricultural research to farmers within one to three years.

90. Business and industry should strive to systematically absorb scientific findings. Success in this area can best be achieved through research undertaken on a collaborative basis between research universities, other research institutions and industry. Since sustainable development depends to a large extent on an evolutionary process of the world’s "industrial metabolism", it is encouraging to note that in several branches of industry new opportunities for successful competition are being recognized. Science must support industry in its effort to design cleaner products and to devise cleaner production processes in response to environmental risks.

91. Intensive interaction and cooperation needs to be developed between national scientific, engineering and technology centres and institutions, on the one hand, and local and national industry on the other. In this vein, different types of partnership and cooperation between industry and universities need to be explored, including continuing education programmes for industry staff, industrial in-service training and apprenticeships for university students, consultancy services by universities and research institutions, research contracts to carry out research work on behalf of private or public-sector industries and the establishment of cooperative research centres. Such collaboration, which implies certain ethical rules and regulations, has become an integral part of the technological achievements of several regions in the world. This approach should be applied elsewhere in order to enhance science and technology in general and science for sustainable development in particular.

## III. PROPOSALS FOR ACTION BY THE COMMISSION ON SUSTAINABLE DEVELOPMENT

92. The Commission on Sustainable Development may wish to consider the following proposals:

(a) Governments, with the support of international organizations, are encouraged to exchange information concerning the impact of the lack of scientific capacities and capabilities on achieving sustainable development objectives in developing countries, in particular the least developed countries, and to make this information available to the Commission;

(b) Governments of developed and developing countries, the United Nations system, and other relevant international organizations should accord high priority, including within cooperation and partnership arrangements, to specific activities aimed at enhancing the scientific capacities and capabilities of developing countries, e.g., through scientific education, enhancement of the status of science, improved integration of science in national development policies and plans, increased training in specialized fields and promoting interdisciplinary approaches;

(c) Governments that are members of COMSATS are encouraged to take efforts towards implementing the main objectives agreed upon by COMSATS, including:

(i) Providing political and economic support to major initiatives in capacity-building for science in the South;

(ii) Establishing a network of international centres of excellence in the south;

(d) Recognizing that in many scientific fields related to sustainable development, such as climate change, the human dimensions of global environmental change, the global hydrological cycle, the assessment of freshwater resources, and oceans and regional seas, the generation of new knowledge needs enhanced international scientific cooperation, Governments, international organizations and the scientific community should join efforts towards:

(i) Developing global environment and development observing systems;

(ii) Strengthening and, where necessary, expanding existing international scientific programmes to ensure coordination and high-quality science;

(iii) Increasing the participation of developing countries in these international scientific programmes;

(e) Governments, the industrial sector, and science and technology institutions, including universities, should enhance their cooperation at the national level as an effective way to strengthen both science for sustainable development and environmentally sound and sustainable economic - especially industrial - development;

(f) In addressing the need for increased financing to implement activities in the identified priority areas, in particular activities related to scientific capacity-building in developing countries, Governments of developed countries may consider:

(i) Increasing the amount of funds dedicated to the projects aimed at providing the scientific basis for the four portfolios of the Global Environment Facility;

(ii) Providing increased financial support to activities aimed at interdisciplinary training and the development of interdisciplinary research and development facilities, including in the context of the UNDP Capacity 21 programme;

(g) Governments of donor countries and multilateral and bilateral donor agencies should be encouraged to financially support:

(i) The International Fund For Technological Development of Africa, in order to support innovative programmes and projects intended to promote intensive interaction between scientific and engineering institutions and local industry in Africa;

(ii) The COMSATS Technical Assistance Fund for establishing a network of international centres of excellence in the South.

## Notes

1/ United Nations Conference on Environment and Development in Rio de Janeiro, 3-14 June 1992, vol. I, Resolutions Adopted by the Conference (United Nations publication, Sales No. E.92.I.8 and corrigendum), resolution 1, annex II.

2/ See United Nations Environment Programme, Convention on Biological Diversity (Environmental Law and Institutions Programme Activity centre), June 1992.

3/ United Nations Framework Convention on Climate Change (A/AC.237/18 (Part II) and Add.1 and Add.1/Corr.1).

4/ United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (A/49/84/Add.2), annex, appendix II.

5/ Global Conference on the Sustainable Development of Small Island Developing States, Bridgetown, Barbados, 26 April-5 May 1994 (United Nations publication, Sales No. 94.I.8 and Corrigenda), resolution 1, annex II.

6/ United Nations Conference on Environment and Development ..., resolution 1, annex III.

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