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REPORT ON SCIENCE AND TECHNOLOGY INFRASTRUCTURE AND POLICY IN SELECTED MEMBER AND ASSOCIATE MEMBER COUNTRIES OF THE CDCC

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Executive Summary

A methodology of documentation and Internet-based literature review, telecommunications contact and consultations with science and technology practitioners in the region was used in this qualitative review.

The research revealed that the region possesses an extensive institutional science and technology (S&T) infrastructure in agriculture, inherited from the colonial period. That infrastructure is at present understaffed and programmes are not coordinated regionally. The study recommends that decisions at the political level need to be made on either capitalizing on and increasing expenditures aimed at building up the existing infrastructure or allowing the capability to continue to dissipate.

In the non-agriculture areas there are research and development (R&D) institutions in the larger territories as well as a growing network of Bureaux of Standards. These institutions together with the Tertiary Institutions provide the major S&T infrastructure in the region. The University of the West Indies (UWI) as the single largest repository of R&D infrastructure and S&T human resources has a special role in any S&T policy framework for the region.

The region belongs to the internationally recognized grouping of Small Island Developing States (SIDS). The SIDS Programme of Action and the outcome of the recent United Nations Meeting on SIDS in Mauritius are therefore of special significance to the region.

The region shares some of the salient features of SIDS, i.e:

(a) The marine environment;

(b) An endemic shortage of trained human resources;

(c) Special, though fragile, biodiversity; and

(d) Significant tourism industry.

There are, however, features of the region which set it apart from other SIDS. These include:

(a) Relatively higher levels of education than most other developing countries;

(b) Proximity to North American markets and culture and the demonstration effect of that proximity on life styles, including a familiarity with S&T; and

(c) Access to the biological resources of the tropical rain forests in Guyana and Suriname.

The study identifies that the Caribbean is in an excellent position to develop a global 'knowledge-niche' in the science, technologies and systems for the management of the Exclusive Economic Zones (EEZ) of SIDS. The study further identifies Information and Communication Technology (ICT) as a key area of knowledge for achieving the 'knowledge-niche' identified above and also for overcoming the human resource deficit.

Based on the region's access to its SIDS biodiversity and that of the tropical rainforest, biotechnology is identified as an area of 'knowledge production' in which the region can develop specialized market niches. The example of Cuba in medicine and agriculture can be emulated.

The application of science, technology and innovation for deepening the integration of local production into the tourism product is also discussed. It is emphasized that it is not enough merely to become able in the use of existing technology. The region must become so intimately familiar with the science that we become 'knowledge producers' in specialized facets of the technologies.

To achieve any or all of the identified opportunities, the study finds and firmly recommends that the human resource base will have to be completely reoriented towards an emphasis on science, technology and innovation, through education, training, retraining and S&T 'aculturization'. The S&T culture has to be inculcated from the primary school level. Programmes have to be devised where children can learn by playing with science and technology and acquire the culture of problem-solving through innovation. All the resources of the region capable of influencing and managing change will have to be marshalled for the most fundamental restructuring of the societies. Without such change, however, the region's future will always be on the margins of progress.

In the context of S&T policy, the study identifies the Caribbean Council for Science and Technology (CCST) as having a seminal role and points to the recommendations of the CARICOM Ministers with responsibility for S&T that the organizational structure of the CCST be strengthened. The findings of the study support the recommendations of the Draft Framework Policy for S&T in the Caribbean recently produced by the CCST.

In seeking a Way Forward, the study recommends that the region be cognizant of its constraints in science and technology and therefore should be cautious in its ambitions. It identifies six initial steps with which to start on the Way Forward but which will constitute a major S&T policy agenda for the region.

1. INTRODUCTION AND STUDY DESIGN

1.1 Introduction

The economic advancement of societies has always been fuelled by technological choice. In the broadest sense, this statement has held true from prehistoric to modern times. Prior to the twentieth century, however, changes in technology were so slow as to make technology almost a constant in the economic equation. In the latter half of the twentieth century technological change had become so rapid that the intimate relationship between technological choice and economic progress became inescapable. A feature of the phenomenon of rapid technological change experienced in the last century has been the strengthening relationship between developments in technology and discoveries in the field of science. The linking of science to technology and of technological choice to economic growth may very well be the defining benchmark of the twentieth century which was one of the most remarkable periods in human affairs.

The harnessing of knowledge through science and the managing of technological choice for sustainable human progress will concomitantly be the defining signposts of the twenty-first century. In the context of characterizing advances in science and technology as the acquisition of knowledge leading to innovative solutions, products and services, the world is said to have moved into a knowledge economy and science and technology are now usually linked with innovation (science, technology and innovation) in the new paradigm. Any nation or group of peoples which intends to exist and prosper in this century – and beyond – has, as a matter of urgent national business, to build the infrastructure and systems to assimilate knowledge and to create, innovate and utilize technology. These attributes will be at the nexus of sustainable human development for the future.

For small States in the developing side of the world the situation will be one of survival as increasingly powerful groups compete for increasingly scarce resources.

1.2 Background

Most of the States of the Caribbean either participated in the 1979 United Nations Conference on Science and Technology (UNCSTD) or are signatories to the Vienna Programme of Action on Science and Technology. Since then efforts, which can be generally characterized as spasmodic, have been made to establish policy structures for the integration of science and technology into the development process. Attempts at science and technology policy formulation in the subregion have varied widely and the results of these attempts have been equally varied. Almost all the territories have experimented with councils for science and technology and science and technology issues continue to be on the agenda of regional and national consultations.

In 1981, the CCST became operational based on the decision of the Caribbean Development and Cooperation Committee (CDCC) – which is an advisory body to the Economic Commission for Latin America and the Caribbean (ECLAC). The objectives of the CCST were:

(a) To implement CDCC objectives by designing and executing appropriate joint scientific and technological projects, and also advise the CDCC and its member countries on scientific and technological issues requiring attention;

(b) To identify institutions that could participate in the projects, and establish the mechanisms for cooperation;

(c) Where no relevant institutions exist, to propose measures for the implementation of particular projects;

(d) To devise procedures for the effective dissemination of the results of Caribbean research and development projects, and their application in member countries; and

(e) Generally, to promote the establishment and strengthening of appropriate national and Caribbean organs and mechanisms for science and technology development and application. There are at present 14 member countries of the CCST, namely, Antigua and Barbuda, Belize, Cuba, Dominica, Grenada, Guyana, Haiti, Jamaica, St Kitts and Nevis, Saint Lucia, St Vincent and the Grenadines, Suriname, Trinidad and Tobago and the United States Virgin Islands.

In 1984, the CCST at the request of the Caribbean Community (CARICOM) Ministerial Subcommittee on Science and Technology coordinated the preparation of an S&T Policy and Plan for the CARICOM region. That policy document was approved by the CARICOM Heads of Government in 1988 and focused on initiatives that could be taken to the regional level, but recognized the need for national policies and plans. Between 1987 and 1992 the CCST organized a series of national consultations on S&T in the "small economy" member States. The consultations were intended to make recommendations for the organization, policy and programmes for S&T at the national level.

In the last decade, however, there has been a definite falling off in the interest of S&T in the CARICOM region. Not much attention has been directed at S&T at the national level, with the exception of Jamaica, which established a Science Advisor in the Office of the Prime Minister and as recently as February 2005 completed a six-year Strategic Plan for its National Commission on Science and Technology, and Trinidad and Tobago, which established a Ministry of Tertiary Education, Science and Technology and a Science and Technology Sub-Committee on its Vision 2020 Task Force.

At the regional level, the CARICOM Ministerial Subcommittee on S&T appears to have been replaced by a Task Force on ICT. Since 2000, the CCST has been working on a new S&T policy for the Caribbean.

Since the latter half of 2004 there has been a resurgence of interest in S&T in the subregion. This seems to have coincided with the completion of preparations to participate in the

United Nations International Meeting to Renew the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States which was held in Mauritius in January 2005. The renewed interest might well have also been driven by:

(a) A fuller appreciation of the opportunities which technology, particularly ICT, offer for overcoming some of our endemic development constraints, as SIDS;

(b) The sobering realization that merely to survive in the globalizing world required that our societies become, in the future, much more intimately competent in science and technology than we have been in the past; and

(c) The deepening commitment of governments to achieving the United Nations Millennium Development Goals (MDGs) and the growing realization that achievement of the goals is inextricably linked to the use of knowledge and the application of appropriate technology.

Caribbean policy makers are reconsidering the need for S&T policies which will help to address the challenges and responsibilities that lie ahead. The institutional mechanisms to both develop and implement such policies are once again the focus of attention.

1.3 Study design

The research approach was qualitative. The countries selected for review were among the CARICOM member States. CARICOM is the largest group of countries in the CDCC. A methodology of documentation and Internet-based literature review, telecommunication contacts and consultations with representatives of S&T institutions and the S&T community in the subregion was used to access the S&T infrastructure and the S&T policy interventions, ongoing and proposed. The objective of the review is to promote discussions on S&T among stakeholders in the CDCC subregion.

2. SCIENCE AND TECHNOLOGY INFRASTRUCTURE

Science and technology infrastructure in the region is largely located in R&D and tertiary institutions. S&T capability also exists within industry but is not as yet significant enough to be considered in a review of national resources.

2.1 Research and development

The research and development infrastructure of the subregion is evidence of laudable efforts by individual territories to respond to the need for an indigenous S&T capability which can at least comprehend the modern S&T milieu and hopefully glean some benefits for the State.

2.2 Agriculture

Export agriculture has been the dominant economic activity in the subregion for most of its recent history. Not surprisingly, therefore, the subregion, which at one time housed the world famous Imperial College of Tropical Agriculture (ICTA), has significant agricultural R&D infrastructure. In spite of the emergence of tourism, mining (including petroleum), manufacturing and services as important sectors of economic activity, expenditures on research and development in agriculture continue to be higher than in all other sectors. R&D activities in agriculture are undertaken by:

(a) Ministries responsible for agriculture and fisheries;

(b) National commodity institutions;

(c) Other national bodies;

(d) Subregional commodity institutions;

(e) Regional institutions; and

(f) International institutions operating in the subregion.

2.2.1 Ministries of agriculture and fisheries

The following is a sampling of the larger research and development centres in Ministries of Agriculture and Fisheries in the CARICOM region:

(a) <u>The Bahamas</u>
Central Agricultural Station, Nassau
Agricultural Research Centre, North Andros.

(b) Barbados
Research and Development capability in Agricultural Engineering, Agronomy, Plant Protection

(c) Belize
Central Farm Research Station

(d) Guyana
National Agricultural Research Institute

(e) Jamaica
Department of Science, Technology, Research and Development

(f) OECS
Agricultural research in the Organisation of Eastern Caribbean States (OECS) is carried out mainly by the Caribbean Agricultural Research and Development Institute (CARDI) – a regional institution

(g) Trinidad & Tobago
Central Experiment Station

Although there usually is a fisheries section in most ministries of agriculture, it is usually not given as much prominence and attention as agriculture. Nevertheless, fisheries sections are involved in significant projects related to conservation of fishing stocks, and the management and planning of fisheries development.

The large numbers of vacancies in ministries of agriculture suggests that professionals are not strongly attracted to jobs with national agricultural research and development institutions.

2.2.2 Produce Chemist laboratories

Agricultural produce laboratories were established with British Overseas Development Assistance (ODA) in the countries of the OECS to provide the services of a produce chemist for technical assistance to agriculture. This initiative has not been too successful but some continue to function in Grenada, Dominica, Saint Lucia and St. Vincent and the Grenadines.

2.2.3 National commodity institutions

(a) Sugar Cane Feeds Centre (mainly beef production) – Trinidad and Tobago

(b) Guysuco Agriculture Research and Development Division (sugar cane) – Guyana

(c) Guysuco Other Crops Division (non-sugar cane crops) – Guyana

(d) Guyana Rice Board – Research and Extension Division – Guyana

(e) San Roman Experiment Station (sugar cane) – Belize

(f) Citrus Research and Education Institute – Belize

(g) Toledo Rural Development Project (rice) – Belize

(h) Sugar Industry Research Institute – Jamaica

(i) Banana Board of Jamaica – Jamaica

(j) Coconut Industry Board – Jamaica

The major commodities of sugarcane and banana traditionally have had an acceptable number of research and development staff for addressing the major problems, with better linkages to other similar research and development institutions. Many of the other commodity institutions e.g. coffee and coconuts, have not been strong national research and development institutions and the research and development efforts have declined over the years as a result of economic pressures on the industries. Some no longer conduct any significant research themselves and critical research in these crops may now be contracted out to other institutions e.g. University of the West Indies (UWI), CARDI.

2.2.4 Other national bodies

Caribbean Industrial Research Institute (CARIRI) – Trinidad and Tobago

CARIRI is involved in R&D on natural products and food and biotechnology technologies.

Institute of Marine Affairs (IMA) – Trinidad and Tobago

The IMA has several research programmes pertaining to the marine environment, including marine fisheries and aquaculture.

Scientific Research Council (SRC) – Jamaica

This institute is not only involved in agricultural research but a significant focus of the work of the Institute is in food technology. Other agriculture-related areas include tissue culture, entomology and microbiology.

2.2.5 Regional commodity institutions

(a) The Cocoa Research Unit of UWI, located in Trinidad and Tobago;

(b) The Windward Islands Banana Development Company Research Station located in Saint Lucia and serving the Windward Islands of Dominica, Grenada, Saint Lucia and St Vincent and the Grenadines;

(c) The Sugarcane Breeding Station located in Barbados and serving the sugarcane growing countries of Barbados, Belize, Guyana, Jamaica and Trinidad and Tobago;

(d) The Caribbean Rice Improvement Network headquartered in Guyana and serving the rice growing countries in the former West Indies (Belize, Guyana, Jamaica and Trinidad and Tobago) and in the wider Caribbean; and

(e) The OECS Fisheries Unit, this subregional unit is now part of the wider Caribbean Regional Fisheries Mechanism (CRFM) headquartered in Belize.

2.2.6 Regional institutions

(a) CARDI, headquartered in Trinidad and Tobago but with research projects, facilities and staff in CARICOM member States in a decentralized system of management; and

(b) UWI Faculty of Science and Agriculture (UWI/FSA), located in Trinidad and Tobago but with a representative located in Jamaica, Saint Lucia (for the Windward Islands) and Antigua (for the Leeward Islands).

(c) The Caribbean Regional Fisheries Mechanism mentioned above.

CARDI and UWI/FSA have the best collection of agricultural research professionals in the Commonwealth Caribbean and they cover most of the wide range of disciplines in agriculture. Many of the staff are well trained with higher degrees and also possess a wealth of experience. In the case of UWI, the professional staff is centralized at St Augustine, Trinidad, while the agricultural professionals of CARDI are distributed throughout the CARICOM member States and carry out on-farm adaptive research. In addition to the staff of the Faculty of Science and Agriculture there were 102 post graduate students registered in 2005, representing a substantial research resource. The Departments of Botany and Zoology at UWI in St Augustine and at the Mona campus, Jamaica, also conduct research on agriculture-related problems.

2.2.7 International institutions

CAB International is an institution which evolved out of the Commonwealth Institute of Biological Control and is located in Trinidad and Tobago.

PROCICARIBE is a network of agriculture research networks, each in specialized areas of research. PROCICARIBE facilitates linkages with institutions of similar research interest in the hemisphere and is organized by CARDI.

The Iwokrama International Centre for Rainforest Conservation and Development. The Iwokrama Centre is located in Guyana and manages 371,000 hectares of tropical rainforest in central Guyana. Its aim is to demonstrate how tropical rainforests can be conserved and sustainably used.

2.2.8 Coordination

A significant amount of research is carried out in agriculture in the subregion but there is very little coordination of efforts even among institutions located in the same territory. Each institution develops its research programmes without reference to other similar institutions. This approach does not promote the maximization of the use of resources. In recent years CARDI has been developing its programmes after consultations with ministries of agriculture in member States. The presence of the Inter-American Institute for Cooperation on Agriculture (IICA) in the subregion also promotes cooperation but only where IICA can exercise influence i.e. via funding. The two major agricultural research institutions, UWI/FSA and CARDI, do not collaborate on an institutional basis and there is limited collaboration among individuals.

2.3 Non-agriculture research and development

In the non-agriculture sectors research and development institutions can be grouped as follows:

(a) Applied research institutions;

(b) Tertiary level institutions; and

(c) Standards bureaux.

The following is a brief review of the major research and development institutions in their groups:

2.3.1 Applied research institutions

Caribbean Industrial Research Institute (CARIRI) - Trinidad and Tobago

CARIRI was established in 1970 by the Government of Trinidad and Tobago with technical assistance from the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organization (UNIDO). The Institute's focus is in food technology, agro-industry, analytical services, engineering, petroleum testing, micro-biology/biotechnology/natural products, environmental services, construction and materials technology.

Scientific Research Council (SRC) – Jamaica

The SRC was established by the Government of Jamaica in 1960 to "foster and coordinate scientific research in the island and to encourage the application of the results of such research to the exploitation and development of the resources of the island." The Council focuses on agro-industry, analytical services, engineering and energy, food science and technology and mineral resources. The Council has recently extended its interest in biotechnology into tissue culture and the testing of genetically modified foods.

Institute of Applied Science and Technology (IAST) - Guyana

The IAST is mandated by the Government of Guyana to lead the development of Guyana's natural resources through the adaptation of appropriate technology. IAST works in agricultural science, agricultural engineering, alternative energy, analytical services, food science, natural products and minerals – including ceramic technology. In the last three to four years, activity of IAST has been drastically reduced.

Institute of Marine Affairs (IMA) – Trinidad and Tobago

The IMA has a mandate to execute research in the following areas: marine fisheries and aquaculture, marine ecology and sedimentology, oceanography, environmental impact assessments and pollution monitoring. The Institute is also active in environmental law and marine environmental education.

International Centre for Environmental and Nuclear Sciences (ICENS) – UWI, Jamaica

ICENS was established by the Government of Jamaica and UWI. Its focus is the application of nuclear energy in geo-chemistry and the development and the use of powerful databases and spatial information systems, which allow for the application of the data across several disciplines.

Centre for Resource Management and Environmental Studies (CERMES) – UWI, Barbados

CERMES was established at the UWI, Barbados, in 1986, with an intake of 20–25 MSc. students a year. The Centre provides a significant research capability in natural (including marine) resource and environmental management.

2.3.2 Bureaux of Standards

While Bureaux of Standards are not major research institutions, they do possess or have access to laboratory facilities to support their work programmes. Those facilities can be the basis of an indigenous R&D capability where none exists and can also participate in a regional science and technology network. Bureaux of Standards exist in the following CARICOM countries: Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts and

Nevis, Saint Lucia, St Vincent and the Grenadines and Trinidad and Tobago. In 2002, the member States established the CARICOM Regional Organization for Standards and Quality (CROSQ) to promote the development of standards and recognition of technical regulations.

2.3.3 Tertiary institutions

University of the West Indies (UWI)

The UWI was founded in 1948 at Mona, Jamaica, as a University College of the University of London, to serve the countries of the English-speaking Caribbean, the Bahamas, British Honduras (Belize) and British Guiana (Guyana). In 1962, Guyana withdrew from full participation and established its own university. In 1960, the second UWI campus was opened in Trinidad with the former ICTA at St Augustine becoming the nucleus of the Faculty of Agriculture. A third campus was opened in Barbados in 1963 and moved to the present site at Cave Hill in 1968. In 1978 teaching for Part II of the BSc. in Hotel and Tourism Management began in the Bahamas as part of the Faculty of Social Sciences (Mona). The University centres in the non-campus countries ensure that the population across the region has access to the educational resources of the UWI. There is also a distance learning facility – UWIDEC, which in 2003–2004 had an intake of 2681 students.

UWI is the region's premier educational institution. Its faculties offer a wide range of undergraduate, masters and doctoral programmes in humanities and education, pure and applied sciences, science and agriculture, engineering, law, medical sciences and social sciences. It is, as well, the foremost science and technology institution in the subregion, with the largest pool of specialized and expert personnel and the greatest stock of research equipment and other facilities.

University of Trinidad and Tobago (UTT)

The UTT was formally established in 2005 to primarily serve the human resource needs of the hydrocarbon and energy-based industries of Trinidad and Tobago. The UTT offers programmes leading to MSc and BSc in engineering and petroleum management as well as **B Eng.** degrees. Technician level training for certificates and diplomas in technology is also offered as well as training at the craftsman level for oil and gas drilling operations.

University of Suriname

The University of Suriname was founded in 1968. During the period 1983 to 1989 significant changes were made in the structure of the University. The present structure consists of the Faculties of Medical Sciences, Social Sciences and Technological Sciences. There are five research institutes:

(a) Centre for Agricultural Research in Suriname (CELOS);

(b) Institute for Applied Technology (INTEC);

(c) Bio-medical Research Institute (MWI);

(d) Institute for Development Planning and Management (IDPM); and

(e) Institute for Social Science Research (IMWO).

University of Technology – Jamaica (UTech)

UTech evolved from the Jamaica Institute of Technology established in 1958 which became the College of Arts, Science and Technology (CAST) in 1959. UTech was formally accorded university status in 1995. The University's academic programmes are modeled in the British polytechnic schools. UTech is structured into the following faculties: business and management; education and liberal studies; engineering and computing; health and applied science. To provide a focus for research and activities at the University, an Office of Research and Graduate Studies has been established.

University of Guyana (UG)

UG was established in 1963 and operates a main campus at Georgetown and a satellite campus at Berbice. Undergraduate diploma and degree programmes as well as Masters programmes are offered at the following faculties: natural sciences; social sciences; technology; agriculture and forestry and at the Institute of Distance and Continuing Education and the School of Professional Development.

University of Belize (UB)

1n 2000, the University of Belize was formed out of the following five institutions: University College of Belize; the Belize Technical College; the Belize Teachers' Training College; the Bliss School of Nursing and the College of Agriculture. The University is structured into the following faculties: agriculture and natural resources; arts and sciences; business; education; engineering and technology; nursing, health sciences and social work

3. SCIENCE AND TECHNOLOGY IN THE SUSTAINABLE DEVELOPMENT OF THE CARIBBEAN

Any analysis of the role that S&T can play in the sustainable development of the subregion has to start with the features which distinguish the subregion. The Caribbean is comprised mainly of SIDS. The constraints to development of SIDS are well documented and the Barbados Programme of Action and follow-up activity, including the United Nations Meeting in Mauritius in January 2005, represent a global response to those constraints. From the perspective of S&T and the Caribbean, the salient features are:

(a) The marine environment;

(b) The endemic shortage of trained human resources;

(c) The relatively higher levels of education than the majority of populations in the rest of the developing world;

(d) The proximity to North America and North American markets and the demonstration effect of that proximity on life styles in the Caribbean;

(e) Biodiversity; and

(f) The tourism product.

3.1 The marine environment

For SIDS, the creation of Exclusive Economic Zones (EEZ) under the Law of the Sea has increased by large multiples of the land mass, the area of the planet's surface for which these States are responsible. For almost all Caribbean countries their marine areas constitute a major natural resource. For some, it is their only natural resource. The management of the EEZ of SIDS presents problems that are peculiar only to those States, i.e. large areas and resource bases have to be managed by few people with limited facilities. The situation is not limited to the Caribbean and it is of great economic significance wherever it occurs. The development of specialized knowledge and the application of appropriate technology are necessary if this particular constraint to the development of SIDS is to be overcome. Non-SIDS do not have the problem and therefore will not be producing the solutions as we have come to expect in other areas of development. SIDS must therefore develop for themselves the systems of management and the technologies for the sustainable development of their land and marine areas and the enlightened exploitation of their living and not-living resources. The networking of scarce human resources and the use of sophisticated technologies to multiply the output of limited human resources and to monitor and manage large surface areas are among the more feasible solutions. The Caribbean is in an excellent position to develop and become a knowledge-producer in a specialized but global, knowledge-niche i.e. the management of the EEZ of SIDS. The additional dimensions of environmental management and natural disaster mitigation serve only to highlight the opportunity.

3.2. The trained human resource deficit

The most prominent feature of the region's S&T landscape is the large and chronic deficit in trained human resources. To address this problem, new and innovative solutions have to be examined. Creative, collaborative mechanisms have to be mobilized. The use of relatively sophisticated technology, such as computer-aided and expert systems, remote sensing, satellite surveillance and spatial information systems, and advanced ICT, will have to be explored for their potential to build critical masses from a very narrow human resource base and to expand the functional range of the trained cadre in place. The first facet of the solution lies in making greater use of existing resources. To this end, networking and more extensive use of ICT can create virtual critical mass which for all intents and purposes can be available anywhere in the region. ICT will be the key to creating this synergy and the political resources of the subregion must be directed to creating the regional and international partnerships and cooperative instruments that will permit the region to make the fullest use of this powerful area of technology.

To further expand the range of capabilities of the cadre of trained individuals in the region, there is the need to broaden and deepen the knowledge and use of advanced technologies such as satellite-based data gathering (e.g. remote sensing), spatial information systems (GIS, GPS), mathematical modeling for resource management and disaster mitigation, and computer-aided systems in management and production. For example, by the use of appropriate expert systems a graduate chemistry teacher in a small island State can be made to function, on the one hand, as a general medical practitioner and, on the other hand, as a chemical engineer; in either case to an extent which will provide an additional capacity in those disciplines. That possibility also broadens the scope and contribution of individuals and reduces the attraction of migration.

In essence the region has to creatively harness available technology to solve its human resource problem. But it is not enough merely to make use of the available technology. The region must become so intimately familiar with the science and the technology that we become a leader and "knowledge–producer" in specialized facets of the technologies.

A second dimension of the solution lies in expanding the trained human resource base through education, training, retraining and S&T "culturization". Orientation of the education system towards an emphasis on science and technology will have to start at the primary school level. Training will have to be greatly expanded at the technical and vocational levels and include the involvement of the private sector. All the resources of the region capable of influencing and managing change will have to be marshaled for what must be the most fundamental restructuring of our societies since the end of colonialization. Without such change, however, the region's future will always be at the margins of progress.

3.3. Comparative advantage in education

The relatively higher levels of education than in other parts of the developing world and its proximity to North America both offer comparative advantages for the development of the

region. The Caribbean is better placed than most SIDS to be able to assimilate and adapt sophisticated technology because of relatively higher levels of education.

In the globalized knowledge economy, competitive advantage in the production of goods and services is almost entirely based on science and technology. Investors seeking to enhance competitiveness establish their operations in proximity to knowledge rather than labour pools, since the cost of labour in today's world provides a relatively small advantage compared to the cost of information. Emerging trends in technology hold very good prospects for small States. Globalization and new technologies have created economic comparative advantage for small-scale decentralized production of a wide range of goods and services. Flexible manufacturing techniques have revolutionized the concept of economies of scale. New industries based on ICT are giving the small business sector an increasing role in modern economic growth, contributing to employment and export development. ICT has made feasible the viability of large producer cooperatives. In these cooperatives, independent small-scale producers with the advantages of low overheads and production flexibility are able to conglomerate their production, achieve economies of scale in common services and acquire negotiating power to deal with their external environments, just as if they were large corporations. These opportunities would be open to Caribbean States when we produce entrepreneurs and knowledge workers in the labour force.

Identification of the S&T needed to realize these opportunities is a first prerequisite to moving forward.

Economic developments are impacting on Caribbean States at an ever increasing pace. To avoid becoming marginalized, Caribbean societies have to achieve the ability to adjust and thrive in such a changing world environment, where science, technology and innovation play the role of prime movers. This requires fostering a culture for identifying and utilizing change. The key to developing that culture is education and training, that is, the correct orientation of the human resource. Effective utilization of science and technology will not be possible until the human resources are developed which are able to utilize technology, create knowledge and innovate.

3.4. Biodiversity, biotechnology and agriculture

The Caribbean region has the advantage that it not only contains the vaunted biodiversity of SIDS, including the second largest barrier reef on the planet, but also access to the biodiversity of the tropical rainforest in Guyana and Suriname as well as the biological resources of coastal low lying States in Belize, Guyana and Suriname.

Commercialization of biotechnology is a global growth industry. The region must therefore at least attempt to exploit its access to the vast biological resources and biodiversity of the tropical zones as well as the unique ecosystems found in SIDS.

The opportunities in biotechnology include improvements in agriculture via bio pesticides and bio fertilizers, in increased production of bio fuels to replace fossil fuels, in medicine and health care, bio remediation of pollution and even in mining.

As far back as 1990, CARICOM Ministers with responsibility for Science and Technology signaled "the importance of biotechnology for significant positive application in the region and support the idea of collaboration among biotechnology institutions". Those sentiments have been reinforced at every conference and symposium held in the region in the last 15 years.

Implementation will, however, require the building of capacity both in institutions and in human resources. Once again the long-term objective cannot be merely to become competent in the utilization of the technology but to be adept at the "cutting-edge" of some special aspects. This has been amply demonstrated in Cuba where achievements in medical biotechnology have become legendary.

The Iwokrama International Centre for Rainforest Conservation and Development in Guyana manages a 371,000 hectare site which is part of the Guiana Shield Frontier Forest, one of the four remaining extensive pristine forested areas left on the planet. Scientists from all over the world are continually working at the Centre. It should be possible to establish a Caribbean Biodiversity Corps of young regional scientists to initially work as counterparts to the international specialists at Iwokrama while becoming reputable specialists in their own right.

A similar regional effort can be mounted to participate in the international programmes which are now examining the environmental constraints and well-known fragility of the ecosystems of SIDS

3.4.1. Agriculture and aquaculture

The region has extensive, though uncoordinated S&T infrastructure and a long history of agricultural education. The S&T infrastructure is larger than such infrastructure in any other economic sector. The region therefore has the choice of either letting this area of economic activity continue to decline and expend less and less on S&T in this area, or to capitalize on the existence of this S&T infrastructure. Build it up with focused objectives to ensure food security in the region and/or create a global exportable knowledge niche in some specialized areas, following the example and lead of Cuba. Outside of Cuba, the work on buffalypso and the Sugar Cane Feed Centres in Trinidad and Tobago, the development of brine shrimp in Jamaica and the work in Guyana of the Iwokrama Centre in forestry and biotechnology are similar examples. Again, outside of Cuba the smaller regional populations have to create the collaborative mechanisms and intensively use ICT to create the critical mass necessary to make any efforts in this policy direction feasible and viable. Examples of such cooperative models exist around the world and in the region. The Caribbean Regional Fishing Mechanism is an example. Since 1997 CARICOM has had the results of a study funded by the Canadian International Development Agency (CIDA) and the Commonwealth Secretariat on a Strategy for Cooperation in the Sustainable Oceans Management and Development in the Commonwealth Caribbean.

3.5. Tourism

The tourism product has emerged as a significant economic sector in the region. It impacts on the lives of almost all of the region's citizens. The S&T implications of tourism have tended to focus on the threats to the sustainability of the natural environment on which the industry depends. There has been some discussion but no real attempts at deepening the local production content in tourism. An example of such deepening that has been discussed is the integration of food production and the supply of goods and services into the tourism industry. The S&T implications of these could be limited to biotechnology for agriculture, health services and environmental management, computer-aided management and the flexible manufacturing systems mentioned before. The provision of real time information on maritime conditions, water quality or fishing conditions would be another area where science and technology can impact on improvements in the delivery of tourism products. Similarly computer simulation and mathematical modeling can be used in managing the mitigation of natural disasters.

4. SCIENCE AND TECHNOLOGY AND INNOVATION POLICIES FOR DEVELOPMENT

While science, technology and innovation (ST&I) are increasingly recognized as very important elements in economic and social transformation, their roles are not generally integrated into the development planning process.

The first proviso of an ST&I policy is that the formulation of S&T policy should not be done exclusively by scientists and technologists. This can be gleaned from perusing any ST&I policy document prepared by scientists. The document usually begins or ends with the lament that the efforts of the ST&I policy formulators are not taken seriously in development planning. That is true, simply because development planners do not see a link between what S&T people wish to have and what development planning is all about. S&T policy should be formulated by development policy makers in dialogue with S&T practitioners. To be taken seriously S&T policy has to be approached from the perspective of development planning, that is, the S&T policy must emerge from the S&T implications of development plans.

The starting point of S&T policy is therefore the development plan. By reviewing the S&T implications of development plans, S&T practitioners can begin a dialogue with planners who will themselves have questions about the S&T options which impact on their plans. The answers to those questions will be the framework for an S&T policy. It is only after several such dialogues that development planners might begin to approach S&T practitioners for inputs prior to starting the planning process.

To integrate S&T into development planning requires organizational mechanisms designed to promote the desire of development planners to talk with S&T practitioners about the S&T implications of their plans and the S&T options available.

4.1. The Caribbean Council for Science and Technology (CCST) Draft Science and Technology Policy for the Caribbean

The CCST has produced a draft Science and Technology Policy for the Caribbean which "provides a framework to guide the choice and judicious application of science and technology for national development … and provides a regional basis and perspective for specific national policies".

The CCST policy framework emerges from a vision of the region as a net exporter of goods and services after a shift to innovative and more knowledge-intensive activities. The development of the human resources and the application of science and technology in a regional context are the pivots on which achievement of that vision turns.

Not surprisingly, the CCST framework places emphasis on the development of the human resource. It recognises that in a strategy for development that is knowledge-based, education and training become even greater in importance as building blocks for the future. There is therefore a need for a greater thrust in science and technology at all levels in the society. Public awareness and education are seen as a first step towards the attainment of this goal.

Looking for models of success, one can recall that in colonial times most primary schools had a "school garden" where once or twice a week male students went into the garden and learned simple agricultural techniques. The girls did cooking and sewing. The colonial administrators instituted this mechanism because they saw that the future of the students was to be agricultural or domestic workers and wanted them to be prepared early. For the students the sessions in the school garden were a welcome break from "classes" and they looked forward to the activity. To begin the process of creating science and technology literate societies the equivalent of a "school garden" in science and technology has to be created in all primary schools. A place where students can "play" with science, learn simple technology and practice the skill of problem solving by innovation. The environment must be a break from classes, a place where students learn from doing, at play.

Importantly the CCST Framework for Science and Technology Policy in the context of incorporating S&T in national economic planning encourages the following:

(a) The incorporation in each economic sectoral plan, the technological requirements to fulfil the goals;

(b) The establishment of appropriate mechanisms for the review and evaluation of the incorporation of S&T into the planning process;

(c) Formulation of a plan for monitoring and advising on S&T implementation strategies; and

(d) Determination, through a process of consultation, of the priorities for selective action related to science, technology and innovation.

The CCST identifies the ineluctable link between science, technology, innovation and national economic competitiveness and urges cooperation and networking between business interests and S&T institutions.

Finally the CCST identifies the following priority areas where the application of science, technology and innovation can produce benefits in the near to medium terms:

(a) Biotechnology in agriculture and the food sector;

(b) Natural resource management and the environment;

(c) Disaster preparedness, construction and environmental management;

(d) Health;

(e) Tourism;

(f) Alternative energy;

(g) Information and Communication Technology;

(h) Standardization and competitiveness; and

(i) Water and waste water management.

The CCST already has a mandate from CARICOM governments. As a basis for initiating the dialogues with the economic planners proposed above, constituent members of the CCST must use their Policy Framework to review and report to their governments on the S&T implications of national development plans and budgets. Those dialogues will eventually achieve one of the major objectives of the CCST, to develop science and technology policies that are meaningful in the context of the national planning process.

5. THE WAY FORWARD

In seeking a way forward, the region needs to be cognisant of its constraints and therefore cautious in its ambitions. Decisions and strong politically-backed choices have to be made in the following key areas:

(a) The development of a science and technology and innovation orientation of the human resource, that is, in education, training and retraining;

(b) Increasing investment in the existing S&T infrastructure in agriculture and building, coordinating and focusing the regional capability into the critical mass for creating innovation and competitiveness in knowledge niche markets such as biotechnology. This will also impact on regional food security;

(c) Taking steps to become intimately and 'cutting-edge' familiar with the use and development of ICT;

(d) Developing the capability to exploit the region's biodiversity and access to the biological resources in its SIDS ecology and tropical rainforests. For example, the developments in biotechnology for health care, medicine and environmental management; and

(e) Becoming cutting-edge 'knowledge-producers' in the area of management systems and technologies for managing and exploiting the EEZs of the SIDS– including tourism; and

(f) In the context of (e) above, develop regional coordinating mechanisms such as the CCST, for the development and application of science, technology and innovation. The CARICOM decision to strengthen the organizational structure of the CCST should be implemented. Development agencies operating in the region should establish a Regional Inter-Institution Coordinating Forum on Science, Technology and Innovation. The Forum will provide for the sharing of information, increase the opportunities for synergy and enhance returns on resources employed by the institutions and governments. Such an intervention would be most timely in the light of regional commitments to integration and the decreasing resource quanta allocated for the region, within the budgets of the bilateral and multilateral institutions.

The initiation of just these initial six steps forward will constitute a major S&T policy agenda for the region and from these initial steps some of the other priority areas as identified by the CCST and other national analyses in the context of the United Nations MDGs will emerge naturally for attention and implementation.

Annex 1

A SCIENCE & TECHNOLOGY POLICY FOR THE CARIBBEAN

Prepared by the

Caribbean Council for Science and Technology (CCST)

24 January 2000
with suggested amendments
Oct. 2001

1. Introduction

1.1 Rationale

A regional policy in science & technology provides a framework to guide the choice and judicious application of science and technology for national development. While it cannot substitute for national policies and actions, it provides a regional basis and perspective for specific national policies. However small a country might be, there are several issues relating to national decisions and choices over which it potentially has only partial control. This potential is improved through some regional cohesion in the decision-making process, and a regional policy framework provides the chance for such integration to be articulated and developed.

The principal value of a Regional Science and Technology Policy is that it affords an opportunity for coherent development initiatives that maximise economic performance while optimising the use of resources and enhancing the social welfare function of our peoples. The creation, distribution and exploitation of knowledge offer a competitive advantage in wealth creation and in improvements in the quality of life. Accordingly, the enunciation of a clear and concise articulated regional S& T policy for the Caribbean is critically important. Such a *Policy Brief* should explore the role of science, technology and innovation in the transformation of the region. Indeed its main focus will be the role of governments in fostering scientific and technological progress for the economic growth of the region and greater social well-being of our peoples. The preferred mechanisms should be based on harmonising national strategies in S& T and creating complementarity. These must also seek to strengthen links between science and industry to the benefit of all sectors in the economy. Many of these efforts may be achieved through networking.

1.2 On the nature and scope of science and technology

Science can be defined as knowledge ascertained by observation and experiment, critically tested, systematised and codified under general principles. Technology can be considered to be the use of knowledge for the production of good arid services to meet the development needs of a population.

Advancement in modern technology is increasingly science-led. At the same time, by providing new modes and instruments of observation and experiment, technology contributes to the advancement of science. Thus, Science and Technology have a synergistic relationship, and for this reason they tend to be paired as though representing a single entity, that is, "Science and Technology" (hereinafter referred to as S&T).

It is important to recognise that S&T is a crosscutting tool, the use of which improves efficiency, quality and productivity. It is essential to most sectors of society, including the wealth-creating areas of agriculture, manufacturing and industry, and natural resource exploitation, as well as the service-oriented sectors of health, transportation, education, communication, and energy. Indigenous research and experimental development work are important in using the methods of S&T to gain a better understanding of the immediate environment and to derive tangible physical benefits therefrom. Equally important are the results

of those scientific and technological activities, which, though taking place elsewhere in the world, may nevertheless have an impact on countries in the region. The Internet is one simple example in the latter category.

An S&T policy must be sufficiently broad as to comprehend the crucial issues in all the areas outlined as falling within the ambit of S&T.

Policy is a framework for action. There is, however, a range of potential actions and alternative arrangements. The S&T policy must thus establish criteria for generating, identifying and choosing among the various alternatives and direct actions relating to the application of S&T to the development process.

Several studies have indicated that science, technology and innovation play a significant role in economic performance. In several European countries, there have been increases in several components that affect productivity. Such increases reflect increased efficiency in the use of labour and capital but there are also elements of improved managerial practices, organisational change and innovative ways for the production of goods and services.

In the regional context, the objectives of an S&T policy must therefore provide a framework for innovation and technological change. Appropriate action is urgently required at the national and regional levels to address:

(a) The growing role of innovation and technological change and the decreasing importance of labour inputs in industrial enterprises;
(b) An apparent inability of developing countries to respond to rapid changes in market demands and a reluctance to be pro-active and innovative in developing trade;
(c) The role of technology and innovation in the services sector;
(d) The pivotal role of human resources in knowledge-based networking activities in our region;
(e) Improving the interaction between science and industry;
(f) The granting of intellectual property rights and mobility of scientists between science and industry;

The ability of countries to respond to rapid technological change is a function of the availability of the right set of skills and well functioning product and capital markets. These two factors contribute to an environment conducive to innovation and also facilitate receptivity to new technologies.

In these circumstances, the S& T policies envisage that on an on-going basis at the national and regional levels, decisions will be made about specific areas in which sound knowledge and attendant skills must be developed. Within the areas identified, countries either individually or collectively will formulate innovative strategies and plans of action to achieve the desired outcomes.

1.3 Science and technology in society

The development and application of S& T in the Caribbean will depend largely on the creation of the required climate and infrastructure.

While policies must focus on improving the interaction between science and industry, the approach must be pragmatic in nature and this region's access to the global stock of knowledge is the key. The policies must also seek to improve public involvement in R&D and encourage science to be more responsive to business needs. Simultaneously, there is a need to improve the leverage of public research.

2. A vision of the Caribbean in the future

The Caribbean vision is one in which the region is transformed to one that sustains its competitive advantage through the application of S& T, innovation and entrepreneurship. There is the implied expectation that the regional governments put the right policies in place as well as implement appropriate strategies. Consequently, the region will become a net exporter of goods and services but only after a shift to innovation and more knowledge-intensive activities has been made. Such a shift will place the region firmly among the developed nations. Wealth creation capabilities would be enhanced and result in corresponding improvements in the quality of life, the ultimate goal of people-centred development.

The development of the human resources and the application of S&T in a regional context must target the realisation of such a vision. Faced with the effects of globalisation, this vision for the Caribbean region includes that of a single-market economy, where the rights of each country and its peoples will be enshrined in international law and social justice.

2.1 The position of science and technology in achieving this vision

To achieve this vision, a planned developmental path must be pursued both nationally and regionally. Such a path will be expected to maximise the utilisation of the region's resources, achieving competitiveness, improved quality of output, greater efficiency and productivity.

The use of Science & Technology provides a basis for the articulation and realisation of this plan. For this reason, co-ordination of S&T at all levels through the organisation and rationalisation of the mandates of national and regional institutions perhaps are among the most urgent tasks to be addressed. Appropriate mechanisms must be established within the national planning process to treat specially with the issue.

There is need for clear guidance for preparation of plans based on these policies, identification of resources for monitoring and evaluation to ensure effective implementation of a well-focused Science & Technology regional programme. Consultation will inform policy. It is imperative that there is a strong regional body that is authorised to perform the important role of a focal point to facilitate the process.

Education and training play a critical role in the application of S&T for development. The promotion of adequate literacy and numeracy skills at the primary level is required. At the secondary level, exposure of all students to a broad and balanced programme of science and technology will constitute a complementary element of the plan. Finally, at all levels including tertiary level training (Universities and Community Colleges), innovation and entrepreneurship programmes will be included as integral parts of their curricula.

These initiatives can only be effective in conditions where there is people involvement. Accordingly, it is imperative that targeted programmes be aimed at popularising S&T among all sectors of society. In this context the role of science parks, incentives to attract youth to scientific and technical careers and to institutions of higher leaning as well as to industry can be appreciated.

3. The objectives of and scope of a science and technology policy

A Regional S&T Policy for the Caribbean Region therefore must serve to promote the optimal advancement and application of science, technology and innovation to satisfy the aspirations of Caribbean peoples. This implies a quest for a quality of life that the globalisation process and the openness of the regional economies that are direct consequences of free trade in new products and processes. Increased competition in trade generally and in the new growth areas such as biotechnology and information communication technology place human resource development along the critical path for regional development. For sustainable development, the conservation and preservation of our environment must remain an overarching principle of our development effort.

In the context of the vision, scope and objectives a **Regional S&T Policy** must seek specifically to promote the following:

- development and mobilisation of human resources as the critical engine for ransformation and growth;
- fostering an environment conducive to development, exchange and application of technology;
- fostering innovation and technological change;
- introduction of greater competition and regulatory reforms;
- facilitating investment in new growth areas like information, communication technology (ICT) and biotechnology.

4. General policy areas

4.1 Planning and infrastructure

To ensure that S&T considerations are structured into the national development planning process. Member States will be encouraged to:

(a) incorporate in each sectoral plan the technological requirements to fulfil the goals, objectives, and targets as stated;

(b) establish the most appropriate mechanisms for review of policies, monitoring and evaluating the incorporation of S&T into the Planning Process,
(c) formulate and monitor a programme and plan of activities to support the S&T policies, and for advising on S&T implementation strategies generally either in dedicated S&T Units,
(d) determine through a process of consultation, the priorities for selective action related to S&T.

4.2 Research and development, innovation and competitiveness

It is widely recognised that technological and knowledge-based inputs have become the principal determinants of economic growth. Access to these inputs and the generation of appropriate forms of technology through research and development are thus critical to the realisation of the development goals of the region. Governments, private sector agencies and institutions of higher education must take the lead in fostering a culture of research in the region.

Co-operation and networking between business interests and research institutions must be fostered in an effort to develop synergies and innovation potential. It should be noted, however, that research and development can flourish only when securely anchored on polices that foster interaction between science and industry on a long-term and sustainable basis. Research that is overly dependent for its support on demand-pull is unlikely to yield the innovative breakthroughs that are necessary to trigger economic growth in new sectors. The challenge to Caribbean institutions is how to allocate adequate funding for the support of research and development from their own modest resources. Such allocation should be regarded however as investments in regional research competitiveness and regional development, since a strong level of research will draw development assistance and attract capital investment.

While individual Caribbean territories need to identify and prioritise their individual R & D agenda the following are among those that may attract priority considerations:

(a) Biotechnology in Agriculture and the Food Sector
(b) Natural Resources Management and the Environment
(c) Disaster Preparedness, Construction and Environmental Management
(d) Health
(e) Tourism
(f) Alternative Energy
(g) Innovation Change and Competition
(h) Standardisation and Competitiveness
(i) Water and Wastewater Management

Priority should be accorded to research and development in those areas which are most likely to produce benefits in the near to medium term, and should include:

(a) the development of applied research and technology adaptation capabilities in biotechnology with emphasis on agriculture
(b) expansion of current efforts in mariculture and aquaculture;

(c) the development of new systems of agriculture production including livestock;
(d) the linking of research and development with the productive sector, and the stimulation of new industries based on local raw materials, including agriculture residues;
(e) the management of natural resources and the environment, especially the coastal zone and watershed areas;
(f) promotion of alternative energy sources and information technology
(g) the development and strengthening of a network between national scientific and research institutions and industry in member states
(h) the fostering of research capability among the Caribbean youth through such programmes as school-industry links and competitiveness for young inventors and innovators.

4.3 Education and training

There is a need to optimise the benefits of education and training. The potential of S&T for the promotion of regional development goals can only be realised in the context of sound educational systems. The new technologies require skilled workers but skill is more readily accessed by literate and numerate populations. Additionally if the strategy for development is knowledge-based, it is evident that education and training become even greater in importance as building blocks for the future.

Among the major objectives in education are:

(a) the development of a cadre of highly skilled and committed scientists and technologists in the Region who are responsive to the needs and potential of the Region;
(b) development a cadre of skilled technicians;
(c) the creation of a level of scientific and technological literacy in Caribbean populations that would allow them to function with competence and confidence in a society that is increasingly being influenced by S&T and to provide informed support for Caribbean scientists and technologists;
(d) fostering entrepreneurial activity based on the application of technology and innovation;
(e) stimulation of a competitive spirit, creativity as required in knowledge-based activities.

5. Specific policy areas

Technical progress has accelerated in all of those areas in which innovation is rooted in science. Examples can be found in biotechnology as most recently in the mapping of the human genome, information technology as in the new materials such as the microchip that has transformed almost every scientific and engineering application. Indeed progress has been exponential.

5.1 Agriculture and the food sector

The sector comprising direct food production and related agro-industrial production is particularly poised to benefit from science, technology and innovation. The exponential growth in economic performance and social well-being of peoples around the world can be directly linked to the rapid application of recent scientific advances in new products and processes.

Within our region the agricultural sector has traditionally been the major employer of unskilled labour. Today primary commodity trading has largely declined and preferential markets have been displaced by free trade, no longer can direct production absorb all the unskilled labour. This represents a major shift in the economic paradigm and the region must respond to this change by identifying it as an opportunity. In this regard, based on new technologies and scientific advances, innovation and competition in agro-industry and services are the keys to new opportunities and can make a unique contribution to employment creation.

5.2 Environment and natural resources management

Caribbean States like so many other island States around the world are typical examples of vulnerable and fragile ecosystems. There are far reaching consequences for any development that ignores considerations of sustainability. It is therefore absolutely imperative that particular attention be paid to the maintenance of the integrity of the environment.

The value of living and non-living natural resources, the possibility of their irreversible loss, and the importance of incorporating ecological principles into development objectives need to taken into account in the policy brief. Management issues of areas of valuable bio-resources, wetlands, watersheds, hillside slopes, and coastal zones warrant very high priority in the Caribbean context.

Deforestation and water management issues are other major issues that will also have to be addressed.

The exploitation of mineral and forest resources contributes very significantly to the economies of many Caribbean countries. In the case of mineral resources, cognisance must be taken of the fact that these resources are non-renewable and, in many instances their extraction contributes much to environmental and human health problems. The incorporation of environmental issues within resource extraction and the promotion of the concept of natural resource management are very important for the sustained extraction of these resources in a manner that is internationally acceptable. Member States will therefore be encouraged to:

(a) Promote recycling or reuse of materials such as road metal, metal cans, glass, etc;
(b) Restore present mined out areas which have not been effectively closed;
(c) Use appropriate technology to enhance extraction and recovery rates;
(d) Use appropriate technology for mineral exploration so as to reduce cost for exploration and environmental damage;
(e) Promote and develop technologies to process these resources prior to exportation;

5.3 Disaster preparedness, construction and environmental management

The quality of environmental management of our islands in the region depends on understanding the characteristics and peculiarities of each landmass together with the associated coastal zone. In fact, it is often said that our destiny is intimately bound to our coasts. The challenge therefore is to manage our biodiversity (marine and terrestrial) while improving the quality of life of the mass of our peoples.

Sustainable development strategies must facilitate the input from S&T in addressing issues of construction methods and technology and solving problems associated with increased land pressure, degradation of materials and recycling, pollutants, waste disposal and natural disasters.

Rational management will take into account all social, cultural and economic activity since these impact either directly or indirectly on our capacity to advance.

5.4 Health and tourism

A main objective of the regional S&T policy has been identified previously as targeting the development of skilled human resources. Necessarily, the achievement of this can only be maximised in an environment that conditions a healthy population. It must also be seen as critically important in improving the quality of life.

In this regard, four main issues have been identified in the Caribbean region viz.

- Deficiencies in the individual national health research capability in terms of a research culture, a mismatch between existing health problems and capacity to provide solutions and neglect of community stakeholders;
- Gross inequity in the health status and also in the delivery of health care to our peoples;
- Absence of linkages between development issues and R&D, generally, and health, in particular;
- Inadequate interface between researchers and policy makers, planners etc., further exacerbated by the absence of users and health advocacy groups that can promote information/knowledge needs that can be met by S& T research.

The Caribbean policy brief for health must therefore include some considerations of:

1. Promotion and advocacy;
2. Capacity building and priority setting;
3. Networking;
4. Linking development policy to health issues;
5. Facilitating innovation in solving health problems;
6. Community involvement.

Reliable and efficient primary health care and services are generally considered as necessary pre-requisites to a robust tourism sector.

The more effective use of existing knowledge, technologies, investment in simple and affordable health interventions for meaningful partnerships will contribute to the goal of a robust tourism sector. These considerations must therefore be addressed as a part of the S&T policy.

5.5 Alternative energy

Energy features among the costliest items in the economies of the Caribbean countries. Despite the region's endorsement of natural sustainable and alternative energy sources such as solar, wind, hydropower, and the opportunities for energy generation through waste conversion (biogas), these energy resources remain largely underutilised. Instead, the region continues to rely heavily on the use of fossil fuels, despite its high costs, and the harmful effects on the environment.

There is an increasing body of knowledge from research that indicates that the use of some fossil fuels may be a more expensive option, when the costs associated with human health and the environment are considered. Against this background, individual governments are encouraged to re-examine the possibilities of harnessing other forms of energy (sun, wind, geothermal). This can reduce their dependency and expenditure on energy and permit increased investment in new areas. As well, such a policy of renewable energy promotion would assist in the reduction of environmental degradation.

5.6 Information communication technology, innovation and competition

Information is a key resource and prerequisite for national and regional development. In this context information in S&T is therefore a very important resource in the application of S&T to development. Developing this resource and making it accessible are essential elements of a policy on information technology. Each country needs to have ready access to information generated within its borders, regionally and internationally, that might impact on, or influence its activities or decisions at all levels. Scientific and technological information systems and services also constitute an important element of technological capacity to evaluate and select imported technology, as well as to generate local technology.

(a) S&T Information already existing in various forms should be made available in an easily accessible format that conforms to simple guidelines which meet national legislation. For this purpose, the internet may be a useful mechanism to facilitate information sharing;
(b) National and regional information databases and networks should be developed, fostered and rationalized;
(c) Recognising the limited electronic access to information that exists, regional knowledge networks should be fostered as an alternative to simple electronic networking;
(d) Emphasis needs to be placed on information systems related to trade and market.

Telecommunications technology lies along the critical pathway in many of the changes in the innovation process. During the last decade changes in both the hardware and software in

information and communication technology have been spectacular. These have radically influenced the way in which traditional interactive transactions are conducted. The result has been increased networking and faster diffusion of codified knowledge information.

Telecommunications in developing countries is therefore an essential prerequisite for economic, social and cultural development. Over the past few years, major changes have taken place internationally in the telecommunications sector. These changes have been principally in the areas of technology development, international regulations and standards as well as in the participation of private interest in the provision of telecommunication services.

The challenges arising from these changes are so enormous that developing countries now find it necessary to develop mechanisms for monitoring them. In light of these challenges it is important that individual governments re-examine their national policy instruments and attempt to co-ordinate a regional approach on this issue.

5.7 Standardisation and competitiveness

The need to improve efficiency, quality and productivity is readily recognisable by everyone in our region, however the need for improvements in standards, and conformity assessment procedures are not. The growth of complex economic activity across national frontiers impels a demand for systems that are designed to provide assurances to a large array of buyers in different markets concerning performance of either the products or the processes. This brings the issue of standardisation and, by extension, conformity assessment into sharp focus.

Most of the countries in our region are only now developing their conformity assessment capability. Conformity assessment procedures directly affect enterprise competitiveness. In the absence of or a deficiency in conformity assessment procedures, small and medium enterprises (SMEs) incur higher costs for testing. In many cases, large buyers in the export markets require testing for conformity to international standards. Where there is no local or regional capability either through a shortage of human resources, through low access to technical/scientific knowledge or appropriate infrastructure, these costs can be prohibitive and may seriously reduce competitiveness.

5.8 Water and wastewater management

In recent years water is becoming scarce in many countries, due to the increasing consumption by growing populations, agriculture, industry and tourism. Insufficient water occurs in:

- Quantitative terms as a result of decreasing water flows and water storage caused by earlier consumption and/or environmental degradation.

- Qualitative terms as a result of pollution by human population, agriculture and industry.

This tendency towards water scarcity and increased competition for water highlights the growing need to manage water resources in an integrated manner to promote sustainable socioeconomic development. Member States will therefore be encouraged to:

(a) Implement the concept of Integrated Water Resources Management;

(b) Establish frameworks for Integrated Water Resources Management to include policies, strategies, legislation, institutions and mechanisms for stakeholder involvement;

(c) Establish permanent water resources assessment programmes to determine the sources, extent, dependability and quality;

(d) Establish decision support systems (including databases, models, etc.) to maximise the value of the information for making decisions;

(e) Formulate plans to deal with water related emergencies;

(f) Formulate comprehensive water resources plans;

(g) Establish continuous, permanent monitoring of meteorological, hydrological parameters; including monitoring for climatic change and sea level rise;

(h) Implement best available and appropriate technology to treat wastewater to acceptable standards;

(i) Foster national and regional studies of hydro meteorological origin to create early warning systems and disseminate information on disasters;

(j) Design and carry out ongoing strategies for education and communication, and special public information programmes in all the mass media (radio, press - including posters and television) to make known, in simple language and with readily understood graphics, the current water situation, with emphasis on the *effects* of pollution, rational and sustained use, and the economic value and the real cost of water;

(k) Create and strengthen programmes aimed at training and specialisation of the staff who will be needed for the integrated management of water resources;

(l) Establish programmes for the research and assessment of potential and available water uses and resources (quantity and quality), including extreme events (floods and droughts); ensure the regular updating, publication and dissemination of results; and see that programme recommendations are implemented;

(m) Set standards from water and wastewater effluents.

OTHER ISSUES

The following is a synopsis of the issues plaguing the management of Science Councils, along with recommendations for the improvement of this system.

Management

The management of Science Councils has been fraught with numerous problems, many of which are readily solvable with the proper administration. Several of the S&T institutions that do exist are poorly coordinated, and either have no legal status or are generally marginalised and have unclear mandates. They are generally not involved in policy formulation, direction or planning at the level of the national economy. Furthermore, allocated resources are inadequate and, because councils are seldom involved in decision-making at the national level, they are not taken seriously by the bureaucracy or at the political level. Finally, evaluation and monitoring systems are often not structured in the councils themselves.

Establishment of national science & technology councils

A legal framework should be created for the establishment of Science Councils, and priorities carefully determined. This will alleviate several issues outlined above, and provide a structure by which future Council members can abide. Proper resources should also be allocated to allow for adequate support in terms of financial and human resources.

Human resource development

There is a need for greater thrust in science and technology at all levels in society. Public awareness and education is a first step towards the attainment of this goal. Several corrective measures can hence be taken with regards to Human Resource Development. These include the reduction of the curriculum load at the primary level, and the introduction of universal secondary education as recommended in CARICOM Education Policy and the OECS Education Reform Strategy. The assurance of early computer literacy in schools, together with the reintroduction of the apprenticeship system and the community colleges will serve as a framework upon which technological advancement can be made. The re-enforcement of science popularisation is critical to the successful integration of S&T into the lives of the populace. This encompasses the continuation of education and training in all relevant areas with particular emphasis on technology and the industrial technology extension service for small and medium enterprises. Lastly, one should consider the establishment of public engagement in S&T issues to safeguard systemic reform in human resource development.

Annex 2

LIST OF PERSONS CONSULTED

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Mr. Howard Chin
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Executive Director
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Mr. Peter Thompson
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Ms. Rosina Wiltshire
President Representative
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Caribbean Environmental Health Institute (CEHI).

Mr. Herold Gopaul
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Ms. Patricia Aquing
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Mr. Guy Mathurin
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Mr. Joshua Palteo
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Eng. Mel Sankès
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Eng. John Lewis
President
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Mr. Andrew Bishop
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Mr. Naseem Nasir
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TRINIDAD & TOBAGO

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\ Secretary, Caribbean Council for Science & Technology (CCST)

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Prof. Winston Mellowes
President
Caribbean Academy of Sciences (CAS)

Annex 3

LIST OF ACRONYMS

CARICOM	Caribbean Community (Secretariat)
CARDI	Caribbean Agricultural Research and Development Institute
CARIRI	Caribbean Industrial Research Institute
CAST	College of Art, Science and Technology
CCST	Caribbean Council for Science and Technology
CDB	Caribbean Development Bank
CDCC	Caribbean Development and Cooperation Committee
CEHI	Caribbean Environmental Health Institute
CERMES	Centre for Resource Management and Environmental Studies
CRFM	Caribbean Regional Fisheries Mechanism
CROSQ	Caricom Regional Organization for Standards and Quality
CSC	Commonwealth Science Council
EEZ	Exclusive Economic Zone
GIS	Geographic Information Systems
GPS	Global Positioning System
IAST	Institute for Applied Science and Technology
ICENS	International Centre for Environmental and Nuclear Sciences
ICT	Information and Communication Technology
ICTA	Imperial College of Tropical Agriculture

IICA	Inter-American Institute for Cooperation on Agriculture
IMA	Institute for Marine Affairs
MDG	Millennium Development Goals
NCST	National Council for Science and Technology
NIHERST	National Institute of Higher Education (Research, Science and Technology)
NSTC	National Science and Technology Council
ODA	Overseas Development Assistance
OECS	Organisation of Eastern Caribbean States
R&D	Research and Development
S&T	Science and Technology
SIDS	Small Island Developing States
SRC	Scientific Research Council
UB	University of Belize
UG	University of Guyana
UNCSTD	United Nations Conference on Science and Technology for Development
UNDP	United Nations Development Programme
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UTech	University of Technology
UTT	University of Trinidad & Tobago

UWl	University of the West Indies
UWIDEC	University of the West Indies Distance Education Centre
UWI/FSA	UWI Faculty of Science and Agriculture

Annex 4

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