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THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE CARIBBEAN: POSSIBILITIES AND PROBLEMS

A Paper Prepared for the
International Studies Association Meeting
Washington, DC
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The mobilizing of science and technology for development in the Caribbean is proving to be agonizingly slow. Although reliable information on research and development expenditures and research personnel is not available, the region and each of the member states remains overwhelmingly dependent on imported science and technology[1]. Efforts to foster indigenous capabilities are at very different stages from country to country but their impacts are still limited. While rapid progress has been made in a number of countries science and technology remain marginal and precariously institutionalized.

There is no accepted and uniform definition of the Caribbean nor need there be. We define the region as consisting of the islands of the Caribbean Archipelago and the culturally related countries of Belize, Guyana, Suriname and French Guyana with the majority of their populations living on the Caribbean Sea. This provides in 1984 a region consisting of 30 million people in 22 independent and non-independent countries speaking English, French, Spanish, and a variety of dialects and Creole languages. It is in this region that scientific and technological exchanges have existed for several decades and where a rudimentary regional S & T network is beginning to take shape. The five

Central American republics and Panama operate essentially in another S & T framework although the Caribbean has much to learn from the impressive experience of Costa Rica.[2]

Our emphasis is on the development of indigenous capabilities for research, development, demonstration, adaptation and diffusion of science and technology (R,D,D,A, and D). The research to development cycle is further disaggregated in this definition to indicate the entire process and the stages at which Caribbean countries may participate. Thus most basic research and much applied research will continue to be imported but the region has a role to play in demonstration, adaptation, and diffusion. Indigenous capabilities are broadly defined to include research by multinational corporations or other non-regional actors provided that it is carried out in the Caribbean and is of relevance to regional needs.[3] Our interest is in the human resource capabilities of the Caribbean peoples.

Science and technology are used to make weapons, medicine, food, knowledge and many other items. Tradeoffs and contradictions between equity and efficiency goals, ecological and economic growth objectives, are persistent in the region.[4] Currently indigenous S & T is so limited that it makes a minimal contribution to any of these objectives, even in Cuba which tries harder than anyone else in the region. There is almost no military research in the region but there is also not enough of any other research to contribute significantly to economic growth. The evolution of indigenous capabilities can be measured in several ways including publications and citations in internationally circulating journals, patents and copyrights, R&D expenditures, cost-benefit analysis of research projects, quality of life indices, and air and sea pollution counts. Economic analysis suggests that one fourth to one half of economic growth in countries such as Brazil and the United States can be attributed to science and technology. The work of economist Nathan Rosenberg and others underlines the importance of shop-floor innovation, learning by doing, in the process of economic growth.[5] The scanty evidence indicates that the Caribbean has little formal or informal shop-floor R&D.

History of Caribbean Science and Technology

There is a long uneven history of science and technology in the Caribbean which remains to be documented. Science for several centuries was the prerogative of learned amateurs; botanists, naturalists, physicians and others. Technology was mostly imported and lightly adapted. Rarely was either institutionalized. A major Spanish scientific expedition was based in Cuba from 1795-1798 but neither the University of Havana or any other 19th century Caribbean university or academic academy found a secure place for science.[6]

The first significant Caribbean adaptations of science and technology occurred in the late 19th and early 20th century with the introductions of the steam engine, railway and control of yellow fever and other mosquito-borne diseases. The striking decreases in mortality in Cuba, Puerto Rico and the West Indies after 1900 were based on applied research, demonstration and diffusion. These successes contributed to the establishment in the 1920's of modest agricultural, tropical medicine and public health research facilities.

In general the Caribbean colonial heritage in science and technology came late, was oriented towards production of export crops, and failed to provide career opportunities for local scientists. Secondary and university education retained its humanities and law bias and remained predominant numbers throughout the colonial period. Rigid race and class statified societies failed to diffuse popular knowledge of science and technology.

The drive towards indigenous science and technology capabilities has roots in Caribbean political nationalism. It is an expression of the desire to reduce political and economic dependency, to provide outlets for national creativity, and to generate economic growth which is subject to national direction. Caribbean Development Bank (CDB) President William Demas declared that "what Third World countries need is a vast increase in expenditure on Research and Development which would enable them to utilize their own domestic raw materials and ultimately to produce and

export products based on their own resources or their own designs styles. Even more important, technological innovation in Third World countries is required to develop efficient labour-intensive techniques of production."[8] The two themes of indigenous R & D for new exports and for appropriate technologies were linked to the desire to alter the terms of technology transfer.

Beginning in Cuba in the 1960's and reaching by the mid 1980's most of the region has been the concern for national science and technology policies, planning and institutions. The concept that science and technology required government force-feeding as well as regulation was promoted by several United Nations agencies, especially the Economic Commission for Latin America. This concept was fortified by the energy crisis of the 1970's and the felt need of governments to respond with coherent national energy policies. Conferences, seminars and workshops spread the message to politicians, civil servants and researchers. All independent Caribbean governments were asked to present national science and technology plans at the 1979 UN Conference on Science, Technology and Development. Most complied and for many it was their first attempt at a policy statement.

The new government awareness of possible roles for science and technology has not been accompanied by private sector or academic participation or much public support. Scientific communities within the Caribbean have vastly extended their formal and informal contacts over two decades but their principal ties are still outside the region. Lacking internal funding, adequate equipment, competitive salaries, technicians, and information services, most Caribbean national scientific communities are loosely structured and organized. At the regional level their ties are still embryonic. The pressure for mobilizing science and technology has come from the politicians rather than the scientists. It has come from the frustrations of energy imports, massive external debts, limited markets for traditional exports, and popular demands. It is often derived from a naive belief that science and technology once mobilized could provide responses to urgent short-term problems. At the 1983 first meeting of Caribbean ministers responsible for science and technology one politicians

remarked "I cannot go back to my Government and say that all we have produced is another report."[9]

The promise of a mobilized science and technology can only be realized if and when indigenous infrastructures come into being. This requires years of effort at improving and extending the teaching of science in the schools, popular science and technology education programs for adults, the establishment of critical masses of well-funded and supported researchers effectively networked within and outside the region, and agreement on research priorities. There are few shortcuts without an infrastructure and no shortcuts to its achievement although its size will vary. A quick review of national efforts to date conveys the state of existing infrastructures and research program.

National Efforts

Cuba has invested in the most impressive science and technology infrastructure in the Caribbean but it does not work well. Adopting since 1965 the highly centralized Soviet model of science and technology planning and even the Soviet system of pre and post-doctoral degrees, Cuba has a pool of researchers, institutes, science information and documentation systems, priorities and plans, publications and meetings but limited results.[10] The Cuban Academy of Science administers the dozen major institutes and universities are relegated to training and some applied research. Enterprises lack authority and funds to engage in shop-floor adaptation and innovation and learning by doing suffers.[11] The Central Institutes work to rigid plans and have poor links with producers and universities. The persistent problems of Soviet S & T appear magnified on a Caribbean island. The choice of priorities with R & D funding directed at sugar mechanization and use of byproducts is also questionable. Cuba is the only Caribbean country with a policy and an infrastructure but S & T are not contributing to economic growth or to reducing dependency. Ironically the major Cuban equity gains in extending education, health and other services have been through management and investment not R & D.

Puerto Rico has a science and technology infrastructure in search of a policy. Next to Cuba it has the largest number of researchers and research spending in the region. US federal government agencies support agriculture, forestry, fisheries, climatology and other basic and applied research in Puerto Rico. The University of Puerto Rico and several other newer Puerto Rican universities carry out applied and basic research. The Puerto Rican government has modest applied research programs in a number of fields. While the private sector relies basically on unrestricted technology transfer from the United States, there is evidence that some informal shop-floor adaptation goes on in Puerto Rico.[12]

However, Puerto Rico has no national science and technology planning, policy or institutions. The Center for Energy and Environment Research of the University of Puerto Rico initiated a study of the viability of a science and technology center. As a consequence of the study the Governor appointed a commission to further consider the proposal. The commission recommended that a center be established as well as enhancing the research capabilities of the University of Puerto Rico, and growing emphasis on the needs of the small entrepreneurs. As of this writing, the report has not been officially acknowledged, in part became of a change in Governors. The plan would involve the use of fiscal incentives to motivate multinational firms located in Puerto Rico to substantially increase their local R & D efforts. It would be the first attempt in the Caribbean to establish institutionalized university-private sector links for research, drawing on US experience.

The Dominican Republic has framented and highly uneven research in agriculture, alternative energy systems, fisheries and other areas.[13] Government ministers, parastatal corporations, non-profit foundations, and the universities compete for far too few researchers, technicians, and funds. Efforts at coordination through science and technology offices in the Presidency and presidential science advisors have faltered. Each R & D unit seeks to jealously guard its turf. The National Energy Policy

Commission was established in 1979 and has launched several research programs but with little coordination or coherence. If Cuba is overcentralized then the Dominican Republic has spread scarce resources too thinly and widely. It has particularly neglected investment in science education, science for adults, and science information systems. One result is that it is still basically dependent on overseas graduate study in the sciences and engineering in spite of huge increases in undergraduate student enrollment.

Haiti has for its 5 million population the weakest science infrastructure in the region. Three decades of brain-drain have resulted in more Haitian researchers abroad than within the country. A handful of foreign-funded projects in agriculture, alternative energy, and reforestation through fast-growing species go on but without an infrastructure. High turnover, low salaries, poor networking, no information systems, and other problems quickly frustrate researchers. National plans and policies are reduced to empty words in the absence of an infrastructure or serious efforts to create one. Since most Haitian receive less than 3 years of formal education, one must begin with elementary science concepts imparted by audio-visual, radio and other means in Creole rather than French which is not understood.

One of the few hopeful elements in the Haitian picture is the remarkable informal learning by doing of Haitian entrepreneurs in producing local components for assembly plants. Joseph Grunwald of the Brookings Institution recently conducted a study comparing backwards linkages in assembly plants in several countries. He found that Haiti's record was outstanding, taking advantage of low-cost labor, and tax and other incentives to replace imported with local components for baseballs and other products.[14]

The French Antilles and Guyana and the Netherlands Antilles still rely on metropolitan countries for most of their science, technology and institutions. This results in excellent marine biology, tropical forestry and other centers manned by European scientists. Applied research on

local problems has had though to wait the organization recently of local universities and research institutes.

The Caribbean independent mainland states of Belize, Suriname and Guyana share low population densities, large tracts of undeveloped territory, and the possibilities of unexploited natural resource. Their research efforts and policies are at similar stages of seeking the funds, personnel and organization to carry out comprehensive natural resource surveys. Government ministries, parastatal organizations, and universities and technical colleges are unequal to the task and donors operate on a project by project basis. Guyana with its predominant public sector has gone furthest in national science and technology policy and planning but has little ability to implement. Belize and Suriname are mostly groping to improve extremely weak infrastructures.

The smaller Leeward and Windward Islands lack policy, planning, institutions, researchers, and research. Scattered projects are externally funded and implemented, often on alternative energy, with minimal local participation. The exception are the appropriate technology centers promoted by the Caribbean Council of Churches but their record of adaptation and diffusion of results is spotty. There has been little consideration of what constitutes appropriate science and technology infrastructure for these islands and too much emphasis on policy and institutions which are appropriate.

Perhaps the emphasis in the smaller islands of the Eastern Caribbean should be on science education and popular science for adults. Long-distance teaching by radio and satellite, computer and audiovisual technologies can all be used to raise indigenous capabilities without costly formal instruction. Research should be undertaken at the request of and with the full participation of locals even if this means a slower research timetable.

There is an enormous contrast between the R & D capabilities of Trinidad and Tobago and those of the rest of the Eastern Caribbean. Housing a University of the West Indies campus, the Caribbean Industrial

Research Center serving the private sector, a branch of the Caribbean Agricultural Research Development Institute, and various government ministry efforts, Trinidad has a working if inadequate infrastructure. The government decision to invest oil revenues in joint venture industrial export projects in petrochemicals has also improved local information and documentation capabilities. Trinidad has and should continue to provide advice on technology and technology transfer to the Eastern Caribbean.

Like Puerto Rico, Trinidad has an infrastructure in search of a policy. This is reflected in the discussions over a strategy of joint ventures and technology transfers, industrial import substitution, and the proposed National Institute of Higher Education, Research, Science and Technology. Small-scale scattered applied research efforts in a number of areas including agriculture and marine biology have limited impact. Attention is needed to science education and information to improve and extend the infrastructure.

Barbados has relied on informal and formal networks to achieve coherent if modest performance. It benefits from the location in the country of the Caribbean Development Bank, the headquarters of the Caribbean Meteorological Institute and other regional organizations with technical capabilities, including the local campus of the University of the West Indies. It has achieved some success with commercial dissemination of work on biogas digesters, solar heaters, and agro-industry. It has also recently surveyed its research, researchers, and spending and has baseline data generally absent elsewhere. The role played by universal literacy, public awareness of S & T, and informal public-private sector linkages has given Barbados an edge. The question may be whether to continue with effective gradual efforts or to attempt more rigorous and concentrated priorities and performance?

Jamaica has had a topsy-turvy experience with science and technology in recent years including a stark exodus of professionals and technicians in the 1970's, and a drastic switch from emphasis on controlling the transfer of technology to encouraging uncontrolled transfers. There have also been numerous changes in personnel in institutions responsible for

science and technology. What has continued is a basic and applied research capability at the Jamaica campus of UWI; especially at the Medical School and the Caribbean Food and Nutrition Research Institute; a tradition of government research in agriculture as well as private efforts, and some scattered energy, fisheries, and other R & D. A key problem is too many small, uncoordinated research efforts underfunded and understaffed.

Jamaica has severe infrastructure and policy problems. It must provide competitive salaries and working environments which probably means regrouping researchers in groups of minimum efficient size. Cooperation between public and private sector is essential if research is to be adapted and diffused. Consideration of fiscal incentives for R & D is relevant in an economy crippled for lack of foreign exchange.

The College of Science and Technology has a useful role to play in working with the private sector to foster shop-floor innovation and training. A national policy and plan may be appropriate for Jamaica if the process is open and participatory including the increasingly organized scientific community.[15].

These thumbnail sketches of national efforts are partial, subject to change, and arbitrary. They do indicate the enormous range of science and technology experiences and approaches within the region, and the basic obstacles to regional cooperation. Such cooperation at present consists of the Caribbean Community (CARICOM) nations whose relations focus on politics and trade also includes, UWI, CMI, CDB, the Caribbean Examination Council, and a number of non-governmental professional associations. At the regional level the Association of Caribbean Universities and Research Centers (UNICA) founded in 1967 has continued a low-profile program of conferences, workshops and exchanges of information and has discussed possible joint research projects. Its membership includes universities throughout the Caribbean, as well as Colombia, Venezuela, Mexico, and the US, but Cuba has not joined.

The Commonwealth Caribbean has attempted several regional science and technology projects and proposed others. Using US funding, the Caribbean Development Bank and the CARICOM Secretariat have spent $7 million over five years on small-island alternative energy research. The CDB also operates a Technological Consultancy Service for the Eastern Caribbean. The Organization of American States has had several small-scale subregional projects. The CARICOM Secretariat lacks the authority and the technical competence to coordinate these efforts. CARICOM at the political level appears to be too beset with major problems and unwieldy to find attention for S & T initiatives.

Instead the focus since 1979 has been at the Caribbean-wide level with the initiative coming from ECLA and UNESCO and a few individuals such as Dr. Dennis Irvine, Vice-Chancellor of the University of Guyana. These efforts produced in 1981 the Intergovernmental Caribbean Council of Science and Technology (CCST). Its membership includes most of the CARICOM states plus Cuba, the Dominican Republic, Haiti, and even the Netherlands Antilles as a possible non-independent Associate Member. It is the widest Caribbean governmental grouping for science ever except for the World War II and postwar Caribbean Commission that was confined to the colonial powers. However, several CCST members have not paid their dues, lack of internal and external funding has continued reliance on ECLA for Secretariat services, and member participation and interest is markedly uneven. There is agreement on a specific "coordinating, advisory, and implementation role" for the CCST.[16] The initial work program calls for a regional science journal, assessment of national S & T capabilities, and other information and exchange activities. Like UNICA, the CCST with such a diverse membership, has settled for activities likely to afford benefits to all if at a lowest common denominator.

The state of regional and sub-regional activity is growing but still incipient. The extraordinary range of bilateral and multilateral donors certainly results in duplication, fragmentation, and too many donors chasing too few qualified researchers. Regional and subregional cooperation is easiest at the level of exchanges of information and yet to be realized at the level of joint research or support of research centers

except in the Commonwealth Caribbean. The dilemma is that without much more extensive regional cooperation many Caribbean countries will be shut out of science and technology.

Sector by Sector

The present state and prospects for S & T in the region need to also be examined by sectors. Table II provides available information on current national and research spending, a more reliable guide than policy statements. There is striking convergence and an apparent basis for further regional cooperation. Our discussion attempts to highlight the issues in each key research sector.

Alternative Energy Research

The Caribbean is 90 percent dependent on imported oil at present to fuel its energy needs (Trinidad and Tobago is the only oil and gas exporter, Barbados and St. Vincent produce some oil and gas). Yet the Caribbean and other sub-tropical islands have energy energy advantages not necessarily shared by other developing countries. The energy opportunities associated with coastal activities are of particular interest.[17]

It is widely recognized that the Caribbean possesses a wide array of energy resources which may be exploited to provide from a small to a large proportion of indigenous energy needs. Renewable energy presents the greatest opportunities. Recent oil and gas explorations in Cuba, Jamaica, Guyana, and Suriname have yet to produce significant finds. It is thought that Puerto Rico and the Dominican Republic may have offshore reserves, however prospects elsewhere are slim. By contrast there is extensive solar insolation, the winds tend to be strong and predictable, good ocean thermal potentials exist, several countries have geothermal and/or hydro resources, and the biomass resource base in large and varied.

There is disagreement over the appropriateness of research, development, demonstration, application and diffusion focusing on renewable energy. Some analysts favor a wide range of research programs.[18] Other come up with priorities and propose their development by external sources using economically and technically proven technologies and donor-imposed regional, subregional and national energy policies.[19]

The track record of energy research in the region is mixed to date. Table IV presents a lengthly list of donors, projects, and sectors which includes foreign governments, international organizations, private foundations, and others. Some governments have responded by organizing their own national policy offices as in the Dominican Republic, Puerto Rico and elsewhere.

In spite of this activity and interest, there has been relatively little actual energy research in the region. The Center for Energy and Environment Research in Puerto Rico has been the single most active research center, working on energy from sugar cane, solar air conditioning, industrial hot water, ocean thermal energy and other technologies. Because of changing US government priorities the Center has had to curtail much of its work. The CDB has funded a variety of research, including a passibe solar water heater program in Barbados. It too has run into funding constraints on future energy research. The Regional Energy Action Plan proposed by the Organisation of Eastern Caribbean States is problematical due to lack of external funding. The first round of energy research risks being lost or dissipated if the donors lose interest or change priorities.

The goal of reducing energy dependency has been widely accepted but not translated into action. Recognition that energy research requires long-term commitments to infrastructure in order to train, retain, and retrain qualified researchers has often been missing.

Discussions of international, regional and national planning, policy, and cooperation skip the specifics needed to sustain energy research. Project by project episodic funding makes it difficult to develop those very indigenous research capabilities that are needed.

Agriculture and Forestry

Export crops such as sugar and sea-island cotton have provided the historically most effective examples of Caribbean public and private sector research linkages. Discouraging markets and prices for traditional exports present new challenges to a post-colonial research structure.

There are advocates of new research programs on non-traditional export crops such as fruit trees for whose products new markets may exit.[20] The emphasis is placed on commercialization and marketing. Others maintain that research should focus on low-cost, labor-intensive technologies at the disposition of small farmers with little credit or formal education. Then there are those who argue for agro-industry research to adapt known dairy, poultry, sheep and pig, animal fodder and other conditions to Caribbean commercial agriculture and food processing. The emphasis here is on agricultural extension, mechanization, and technology transfer with the goal of reducing present extremely high food imports.

The debate over research approaches and goals divides governments, ministries of agriculture, researchers, university faculties of agriculture, external donors and others. It even occurs in Cuba where the small remaining private sector is denied research but still outyields the state farms.[21] It is a debate with a different balance in each country due to the different prevailing systems of land tenure, extent of rural migration, and other factors. For instance Puerto Rico has opted for agro-industry research in a society where few smallholders remain; Haiti is overwhelmingly rural and small farmer and concentrates on labor-intensive research. The debate is further complicated by the possible use of sugar for fuel and its economics.

The problem is that at the national level the resources are lacking to effectively pursue several agricultural research strategies at the same time. A World Bank study of developing country agricultural research has indicated the diseconomies of scale from too few and isolated researchers. Work on new crops and traditional crops such as sugar and bananas must be carried out at the subregional or regional level for the

smaller countries. Given a regional division of research labor it might be possible to follow several research lines simultaneously but this is a long-term goal.

Reluctantly it appears that research decisions need to be forced between smallholders and agro-industry. A similar although less painful decision lies between research on commercial forestry and fast-growing species for reforestation in peasant societies. Haiti and the Eastern Caribbean must choose agricultural and forestry for peasants while the rest of the Caribbean de facto opts for agro-industry. Ironically agro-industry research is less expensive because it involves adapting proven large-scale technologies through scaling down. Since the Green Revolution was for cereals and rice there is no on-the-shelf technological package for tropical small farmers and much costly and time-consuming basic research is needed.

Appropriate Technology

The concept of labor-intensive, small-scale technologies has received an enthusiastic reception in much of the Caribbean. Church groups, non-profit foreign donors, and other organizations have sponsored centers, fairs, meetings and demonstration. Results are uneven and mixed but an important increment to adult technology awareness and skills has occurred, especially in the smaller islands. The appropriate technology groups have also developed formal and informal networks and information-sharing; an important lesson for the scientific community. While its total economic contribution may be limited appropriate technology efforts in the region are a welcome sign of self-reliance. Where local interest merits they may be extended to crafts, construction technologies, materials recycling, and small industries.

Environmental Sciences

The Caribbean consists of densely populated highly fragile human and organic ecosystems subject to periodic hurricanes, earthquakes and man-made disasters such as oil spills. The environmental sciences are recent

arrivals in the region although there is a distinguished record of academic research in marine biology in Puerto Rico, Trinidad, Jamaica, Barbados, Curacao, and elsewhere. Recognition of environmental concepts has been stressed by UNEP, UNESCO with its Man and the Biosphere research program, and by the non-governmental Caribbean Conservation Association. Ecological problems have also received some attention from the Caribbean Tourism Center in Barbados established by the Caribbean Hotel and Tourism Associations.

The growth versus pollution debate of the 1960's and 1970's has a different context in the Caribbean. Poliution in a closed island ecosystem threatens survival in a way that it does not in Calcutta or Mexico City. There has been growing demand for applied research on short-term problems of harbor pollution, oil-spills, coastal zone management and beach and sand erosion and coastal and fish farming. There are political demands for research to improve fishing practices and yields, reduce imports and generate employment.

Unfortunately increased interest in ecological research has not been matched by a strengthening and revision of environmental science infrastructures. Technicians are desperately scarce making fisheries and marine extension programs unrealistic. Research centers lack critical masses of researchers and adequate information services with a consequent loss of staff. Important work has been done in Caribbean archaeology, marine biology and other fields but often through collaboration between local and better-equipped foreign researchers. The small islands have become particularly dependent on donors for assistance with their multiple ecoiogical problems. The possibility of regional cooperation immediately runs into the short-term needs of many countries versus the long-term commitment of building infrastructure.

Climatology and seismology are the two disciplines in which Caribbean applied research and international basic research interests have been bridged. The Caribbean Meteorological Institute collects weather data for the Eastern Caribbean and uses satellite data for forecasting and hurricane and storm warnings. Its cooperation and that of other Caribbean

national weather services with US agencies has markedly improved regional forecasting capabilities while adding to global data. Similarly international oceanographic and seismic work on the Caribbean has added to basic research knowledge of tectonic plates and planetary climatic history.[23] The lesson is that the Caribbean can participate in first-rate basic research by providing facilities and staff and matching applied to basic research interests. The principal advantage comes from the on-the-job training of Caribbean researchers.

Industrial Research

There is very little formal industrial R & D in the Caribbean and an unknown but presumably limited amount of informal shop-floor adaptation. Cuba is the sole exception with its need to adapt Soviet and East European capital goods and its efforts at industrial import-substitution including designing its own micro-computers. Elsewhere technology transfer is largely unregulated except for foreign exchange constraints. Industrial technology institutes in the Dominican Republic, Trinidad, Jamaica and elsewhere provide information services consulting, and some trouble-shooting for the private and public sectors.

The debate over industrial R & D in the Caribbean has several dimensions.[24] One element concerns the range of choices and terms of technology transfer and calls for regional or other advisory mechanisms. The problem is that the same scarce pool of manpower is available for research or for assessing technology to be transferred. Another element concerns the need for regional design and feasibility capabilities for new export industries such as petrochemicals.[25] Again the lack of available manpower suggests that the costs of establishing such capabilities would come at the expense of other R & D. There is also the element of fostering local adaptation in industrial import-substitution rather than simply scaling-down technologies. There is room here for experiment with fiscal incentives to encourage energy conservation and other forms of adaptation in plants producing for local or regional markets. Finally there is the need to promote backwards linkages in assembly plants in order to increase employment, taxes and use of local materials. This opportunity merits regional study and use of fiscal incentives.

Information and Social Sciences

There has been more than 50 years of solid scholarship in the social sciences in the Caribbean, much of it by local scholars. Topics such as race and class, kinship and gender, Africanisms in the New World, the plantation economy, emigration and others have been competently studied over several decades. The research findings have been widely diffused and constitute part of the basic world views of many Caribbean people. There are a number of social science research centers in the region, notably the Institute of Social and Economic Research of UWI, and a steady stream of publications.

While research must continue on the topics first delineated before World War II there are signs of new emphases. Management of enterprises-public, private, non-profit cooperative etc. urgently requires understanding in these societies. Urban planning, land use, coastal resource management, are intellectual imperatives for research in the face of rapid change. Researchers need to come to grips with tourism as a multidisciplinary phenomena requiring highly sophisticated research rather than superficial analysis. Longitudinal and cross-cultural research which treats the entire region as an entity has yet to be realized. As science and engineering research in the region increases the social sciences which have played a leading role need to expand their interests and empirical data bases.

Health Sciences

The Caribbean strength lies in applied research such as drug trials, demonstration and diffusion. Basic research on tropical medicine continues in Cuba, Jamaica and Puerto Rico but major advances are likely to be made elsewhere. Instead the challenge is to devise and implement para-medical health delivery systems in those countries where universal hospital and physician based medicine is not feasible. These are essentially public health and management challenges and there are important gains from regional sharing of information and comparative research.

Natural Resources R & D

Several Caribbean countries such as Guyana, Belize, Suriname and French Guyana have extensive unexplored areas of potentially economically valuable natural resources. Other countries such as Cuba and Jamaica have potential oil and gas deposits. Natural resources research also includes uses of local materials such as kaolin, minerals processing and marketing studies. This research tends to be expensive and highly risky. Investment in regional capabilities is not justified except perhaps to participate in joint ventures. Where this has occurred as with the state petroleum corporations of Jamaica and Cuba it is not clear that an increase in useful indigenous capabilities has taken place.

Service Sector

The most developed Caribbean economies have growing service sectors, even if their industrial bases are limited. There has been no systematic research on service sector productivity in the region although this may be an important factor in future economic growth. Issues of office automation, industrial relations in the service sector, banking productivity, retail and wholesale trade organization and others merit attention. The tourism sector has yet to be studied from a productivity perspective. Wages policies in the service sector need to be examined also in relation to motivating output. As the balance shifts from agriculture to assembly plants to tourism and services so do the relationships of individuals to technologies. There is no study of the comparative use of computers in the Caribbean.

Human Resources

The Caribbean for two decades has barely been able to replace its existing numbers of researchers and in several countries such as Haiti there are fewer researchers now than there were in 1960. Investment in science education and science teaching at all levels is the highest priority due to the long lead-times needed to train researchers. Augmentation of

science education with fairs, clubs, prizes, science museums, audiovisual materials, etc. is vital and lends itself to regional cooperation. Science education for adults is also important on the job, through clubs, unions, and other organizations. The goal should be augmented job-related knowledge and skills rather than a vague awareness of the importance of science. Audiovisual and computer on the job training should be attempted.

Numerous studies have shown that researchers emigrate due to frustation with local working conditions and salaries as well as foreign opportunities.[26] The Caribbean has the advantage of geographic proximity to major research centers and possible on-line communications. Keeping good researchers in the region requires providing them with frequent keep-up access to major centers, on-line data bases and overseas communications, and centers with "critical masses" sufficient to permit stimulating exchanges. Handfuls of isolated researchers scattered around the region are not productive. Adequate information systems and telecommunications are a sine qua non of effective Caribbean R & D; not luxuries. The alternative is to continue to see some of the best people emigrate.

Research Priorities

Several lists of possible Caribbean research priorities have been put together[27] Ours is derived from the long-term goal of building indigenous research capabilities. It argues for highest priority to in situ research on problems unique to the region where transferable technologies will not work or must be adapted. Renewable energy systems and agriculture and appropriate technology fit this criterion. So does research on Caribbean ecosystems. Investments in information science, improved telecommunication and science education are needed to make any R & D program possible, including our suggestions. The priorities we propose require infrastructure buildups and cannot promise economic results before the 1990's. We do not believe that there are short-cuts in the Caribbean. Science and Technology in the region must be nourished

before it can deliver. Short-term crash projects lead nowhere since local capabilities are not altered. Continued reliance on technology transfer cannot deal with sectors where in situ research has not substitute. It is possible to argue for other priorities but a minimum 10 year time-frame is essential. Otherwise researchers and centers will be asked to deliver what they cannot and disillusionment will be general.

Approaches

Donors to Caribbean science and technology have their individual agenda and constituencies. The World Bank has sought with some success to coordinate major government donors. An indication of broad funding levels for several years in advance would help. It is undesirable though for donors to dictate priorities or to coerce clients into regional or subregional cooperation. The donors can insist though that clients match stipulated priorities with their own resources. Currently a majority of Caribbean R & D is directly externally funded in every country except Cuba. Indigenous capabilities need to be increasingly funded from indigenous resources.

Most R & D in the Caribbean will continue to be carried out at the national level, whatever the sources of funding. Funding needs to be restructured to facilitate user-researcher linkages. Fiscal incentives can be tried to induce the tourist sector to fund solar energy; agro-industry to support university work, etc. The self-imposed segregation of researchers and possible users must be forcefully broken-down or no diffusion will occur. Where National councils of science and technology exist there should be broad participation of trade unionists, farmers groups, teachers, etc. The smallness of these societies should be an asset for research diffusion and not a liability. Public sector corporations like the electric utilities should have set aside R & D funds to be used for contracting with universities and the private sector. Linkages should explicity aim at strenghtening local and regional engineering and design capabilities. Non-profit organizations also have an important role to play

in R & D support. The donors can create supply but demand for research is a function of linkages established nationally.

The scope for regional and subregional cooperation is extensive; the prospects so-so. Even Cuba, Puerto Rico, Trinidad, and Jamaica will within a decade exhaust the R & D they can effectively perform at an island and national level. The smaller countries rules out projects of most interest to the most advanced. Bilateral cooperative as between Puerto Rico and the Dominican Republic or Cuba and Jamaica as in the 1970's may be more promising but can also be unbalanced.

Donor and internal support is needed to maintain the momentum in support of regional cooperation. There needs to be a step ahead from conferences and surveys to carefully designed shared research. It is the true that baseline data is unavailable on most countries and that science and technology policies are often lacking or non-existent. What does it mean though to ask a government which has no research or researchers to produce a policy? Better to step on the infrastructure and R & D acclerator. The convergence of current research agendas and spending patterns indicated the possible gains from launching regional projects.

Conclusion

How to get from nowhere to somewhere? The Caribbean at present does not have sufficient science and technology capabilities to affect its own future. Compare this to India which was able to demonstrate, adapt, and diffuse the Green Revolution to change from a net food importer to being food self-sufficient. Compare this to Singapore which has developed the ability to increasingly design and produce its own industrial exports. It is possible for the Caribbean within a decade to have the indigenous capability to alter its future in energy, agriculture, and ecology. This does not mean that these capabilities will be used or used wisely. Nor does it mean that all Caribbean societies will share in those capabilities, even if some are regional. Nor does it mean that dependency on imports will be necessarily reduced although the import mix could be

changed. Surely it is better to import computers rather than apples and dried fish?

The alternative is also visible. It is a perpetuation of the status quo. Most energy is imported depending on the vagaries of world markets, prices, and politics. More and more food is imported and more and more rural people leave for Kingston, Por-au-Prince, Miami or New York. Ecological pressures increase, more beaches erode, forests denude, and finite natural resources dwindle. The alternative is not apocalyptic but it is not pleasant. Science and technology do not have the answers to the outstanding problems of the Caribbean but they tell us how to look.

TABLE I

Caribbean Science and Technology
Principal Regional and International Organizations

Association of Island Marine Labs of the Caribbean (AIMLC)
Coordinates marine science information exchanges

Appropriate Technology International (ATI). US government funding agency

British Development Division (BDDM) of the Ministry of Overseas Development

Caribbean Development Corporation (CADEC). Barbados based promoter of appropriate technology centers (CATC) with support from Caribbean Council of Churches

Caribbean Association of Chambers of Commerce and Industry (CAIC)

Private sector promoting improved information systems

Caribbean Agricultural Research and Development Institute (CARDI). Trinidad base

Caribbean Food and Nutrition Institute (CFNI). Located in Jamaica and attached to the University of West Indies Medical School.

Caribbean Economic Community (CARICOM) Secretariat based in Guyana

Coordinates alternatives energy and related projects

Caribbean Industrial Research Institute (CARIRI). Trinidad government industrial technology research and consulting center

Conference of Caribbean and Latin American Ministers Reponsible for Science and Technology (CASTALAC). UNESCO group scheduled to meet in 1985

Caribbean Appropriate Technology Centre (CATC). Established in Barbados-1981.

Caribbean Conservation Association (CCA). Barbados based non-profit group concerned with ecology and historical restoration.

Caribbean Development Bank (CDB). Technology and Energy Unit based in Barbados; funds alternative energy and consulting.

Caribbean Council for Science and Technology (CCST) Intergovernmental organization established in 1981 under ECLA auspicies. Possible coordinating role for CARICOM and other states.

Table 1 - continuation

Commonwealth Development Corporation (CDC) British government aid-investments

Caribbean Development and Corporation Committee (CDCC) ECLA-UNESCO sponsored intergovernmental adivsory group which preceded CCST.

Commonwealth Fund for Technical Cooperation (CFTC). London based

Caribbean Group for Cooperation in Economic Development (CGCED)

World Bank sponsored club of donors active in energy and other projects

Canadian International Development (CIDA). Supports agriculture, fisheries and other research

Caribbean Meteorological Institute (CMI). Barbados based; serves CARICOM area for weather data collection, wind project. Works closely with U.S. oceanographic and weather agencies.

Commonwealth Science Council (CSC). London based. Funds surveys and conferences.

Caribbean Technology Policy Studies (CTPS). Joint research project of the University of the West Indies and the University of Guyana funded by IDRC in Canada to publish a series of papers on CARICOM states.

Export Development Corporation (EDC) Canad. Promotes technology exports

European Development Bank (EDF). Brussels based.

European Community (EC)

European Investment Bank (EIB)

Eximbank. U.S. government export credit finance.

Gulf and Caribbean Fisheries Institute (GCFI) Marine science information exchanges

International Bank for Reconstruction and Development (IBRD). Coordinates Caribbean donors group and lends for oil exploration, hydro, agricultural research and other projects.

International Development Association (IDA). Self-loan fund of the World Bank

Inter American Development Bank (IDB). Washington based like World Bank. Lends for agricultural research, alternative energy, fisheries, etc. Caribbean independent states have increasing role in IDB administration.

Table I - continuation

International Development Research Center (IDRC). Ottawa based and Canadian governmetn funded autonomous supporter of small-scale technology and other projects. Funds CTPS study.

Inter American Institute for Agricultural Cooperation (IICA). Based in Costa Rica and affiliated with the OAS. Holds Caribbean workshop on fruit trees

Intergovernmental Oceanographic Commission of the Caribbean (IOCARIBE). UNESCO affiliated advisory group for marine science research

Japanese Investment and Consulting Agency (JICA). Donor agency

Latin American Scholarship Program at American Universities (LASPAU) Graduate and post-graduate education of UWI, Dominican Republic and others Organization of American States. Science and Technology Division in Washington sponsors Caribbean science and technology policy seminars and funds small-scale research projects.

Organisation of Eastern Caribbean States (OECS). Secretariat in St. Lucia coordinates technical assistance for member states.

Latin American Organization for Energy Development (OLADE). Based in Ecuador; conducts workshops and surveys in the Caribbean

Pan American Health Organization/World Health Organization (PAHO/WHO). Coordinates health data, surveys and training

Rockefeller Brothers Fund (RBF). Based in New York funding Caribbean alternative energy projects

United Nations Centre for Science, Technology and Development (UNCSTD). New York based follow-up to the 1979 Vienna Conference. Conducts surveys.

United Nations Conference on Trade and Development (UNCTAD). Geneva based promoter of regional electronics and pharmaceuticals projects

United Nations Development Program (UNDP). New York based funder of small-scale energy, fisheries and other projects

United Nations Economic Commission for Latin America (ECLA). Caribbean region office in Trinidad is Secretariat for CCST. Promotes regional role.

United Nations Environmental Program (UNEP). Nairobi based with Caribbean plan of action emphasizing oil spills, coastal management.

Table I - continuation

United Nations Educational, Scientific, and Cultural Organization (UNESCO). Based in Paris with representative in Jamaica. Promotes science and technology policy and planning, marine science research and Caribbean participation in global Man and Biosphere (MAB) research

United Nations Industrial Development Organization (UNIDO). Based in Austria. Promotes Caribbean technology transfer studies, small industry

United Nations Interim Fund for Science and Technology (UNIFST). Based in New York as follow-up to 1979 UNCSTD conference. Limited funds for CCST secretariat, meetings.

U.S. Agency for International Development (USAID). Funds alternative energy, agriculture, fisheries and other research, national and regional.

University of the West Indies (UWI). Applied and basic research in agriculture, natural sciences, marine biology, Institute of Social and Economic Research and other fields. Campuses in Barbados, Jamaica, and Trinidad. Long-distance science teaching project and other extension activities for smaller islands.

Volunteers in Technical Assistance (VITA). Washington based non-profit clearing house for appropriate technology information

Association of Caribbean Universities (UNICA). Groups public and private universities and research institutes. Membership extends to Colombia, Venezuela, Mexico, and the U.S. Holds workshops on agricultural and energy research, curriculum, and other exchanges

World Intellectual Property Organization (WIPO). Paris based and promoting new patent, copyright and related organization in the region. Opposes UNIDO.

World Meteorological Organization. UN agency responsible for data collection

This list is not exhaustive and requires updating. It includes the principal non-national organizations involved in Caribbean science and technology.

TABLE II

Current Caribbean Research and Development Spending Priorities

Country	Priorities
Barbados	Alternative energy, sugar and byproducts, crops, food processing
Belize	Agriculture, fisheries
Cuba	Sugar & byproducts, industrial technology, pharmaceuticals, electronics construction
Dominican Republic	Alternative energy, hydro, sugar and byproducts, fisheries
French Antilles & French Guyana	Space, agro-industry, marine biology Alternative energy, agriculture, forestry, minerals
Haiti	Agriculture, alternative energy, forestry, assembly plants backwards linkages
Jamaica	Alternative energy, agro-industry, crops, construction
Netherlands Antilles	Alternative energy, marine biology
Puerto Rico	Alternative energy, agriculture and agro-industry
Suriname	Alternative energy, hydro, agriculture, fisheries
Trinidad and Tobago	Industrial technology, agro-industry, fisheries

Table II - continuation

Regional	
CDB/CARICOM	Funding alternative energy, technological consulting
CADEC	Appropriate technology centers
CARDI	Agriculture and forestry
CCST	Coordinating science and technology policy and publish science magazine
UNICA	Hold agriculture and energy university research workshops
UWI	Basic and applied research at Barbados, Jamaica, and Trinidad campuses
CMI	Collect meteorological data for Commonwealth Caribbean

Sources: Report of the First Meeting of Ministers Responsible for Science and Technology, Chairman Dr. R.A. Irvine, Kingston, 6-7 April, 1983 and Interciencia, 1979-1984, Inter-News

TABLE III

DEVELOPMENT AND POTENTIAL OF ENERGY RESOURCES IN THE CARIBBEAN

Island or Country	Oil and Gas	Coal	Hydro Power	Geothermal Energy	Biomass Energy	Solar Energy	Others (Wind, etc.)
Antigua	1A	1A	1A	2A	2A	5A	5A
Bahamas	2A	1A	1A	2A	2A	5A	5A
Barbados	3B	1A	1A	2A	4B	4A	5A
Colombia	4D	1C	5D	2A	5B	4A	5A
Cuba	3C	2A	3B	2A	5B	5A	5A
Dominica	1A	1A	4C	2A	2A	4A	5A
Dominican Republic	2A	2A	3B	2A	5A	4A	5A
Grenada	2A	1A	2A	2A	2A	4A	5A
Guyana	2A	1A	5B	1A	5B	5A	5A
Haiti	2A	1A	3B	2A	4A	5A	5A
Jamaica	2A	2B	3B	2A	5B	5A	5A
Martinique	1A	1A	1A	2A	4B	4A	5A
Mexico	5D	5C	5C	4C	5B	5A	5A
Monserrat	1A	1A	1A	2A	2A	4A	5A
Puerto Rico	1A	1A	3B	2A	5B	5C	5A
St. Kitts-Nevis	NA	NA	NA	NA	NA	NA	5A
St. Lucia	1A	1A	1A	3A	2A	4A	5A
St. Vincent	1A	1A	3C	2A	2A	4A	5A
Trinidad/Tobago	5A	1A	1A	2A	3B	4A	5A
Venezuela	5D	2B	5C	2A	4B	4A	5A

POTENTIAL

1. poor
2. not determined but possible
3. limited
4. medium
5. important

DEVELOPMENT

a. without development
b. limited development
c. medium development
d. good development

NA = Not Available

DATA FORM

Esquema de la energía y el ambiente en la zona del Caribe, 7 de agosto de 1979, Organización de las Naciones Unidas.

TABLE IV

SUMMARY OF ENERGY PROJECTS IN THE REGION

A number of international and regional organizations are active in the Caribbean. The following is a list of their main activities. The purpose is to serve as a project checklist, whcih may be updated with final data regarding the investment and status of the individual projects and with information regarding projects to come. The projects listed include those executed, under execution, under preparation, planned, or suggested.

Energy Subsector	Donor/Executing agency	Activity	Recipient country
Oil	Venezuela/ Mexico	Financing oil supply	Barbados, Jamaica, Dominican Republic
	Trinidad/ & Tobago	Financing oil supply	CARICOM countries
	UNDP/IBRD Canada	Caribbean regional exploration promotion	Bahamas, Barbados, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Suriname
	IBRD	Oil exploration promotion lending	Guyana, Jamaica
	IDB	Onshore oil exploration lending	Guyana, Jamaica
	IDB	Offshore seismic surveys lending	Regional
	UNDP/CDB/ IDB	Assistance for field operation and exploration	Barbados
	IDB	Seismic survey of fossil fuels	Barbados
	UNDP	Gas development	Barbados
	EDC Canada	LPG processing	Barbados
Solid mineral fuels	CDB	Peat survey	Belize
	OLADE, Germany	Lignite development investigation	Haiti
		Peat development	Jamaica
		Lignite development	Jamaica

Table IV - continuation

Electricity	U.K., Trinidad & Tobago	Restoration of existing power plant	Antigua
	CFTC	Technical assistance for electricity development	Antigua
	CDB	Distribution upgrading	Antigua
	IDB	First power project	Barbados
	CDB	Electricity rehabilitation	Dominica
	IBRD	Generation expansion	Dominican Republic
	Eximbank	Generation expansion	Dominican Republic
	CDB	Acquiring the electric utility	Dominican Republic
	CDB	Tariff study	Grenada
	IBRD	First power project; sector strenghening	Guyana
	IBRD/IDA, EEC, CIDA	Power development	Haiti
	IBRD, EEC OPEC	Power development	Jamaica
	IDB	Rural electrification	Jamaica
	CDB	Generation expansion	Monserrat
	CDB	Generation develop-; ment; transmission development	St. Kitts-Nevis
	CDB	Generation expansion	St. Lucia
	CDB, IEB	Improvement of electricity supply	St. Vincent
Hydro	CDB	Mini-hydro project	Belize

Table IV - continuation

	CDB	Hydroelectric study	Dominica
	CDB/TEU	Micro-hydro workshop (3/81)	Dominica
	IDB	Hydro and interconnection project	Dominican Republic
	IBRD	Rio Blanco hydroelectric project (suggested)	Dominican Republic
	IDB	López-Angostura hydroelectric project (suggested)	Dominican Republic
	Venezuela	Hydroelectric master plan	Dominican Republic
	Venezuela	Hydrological resource assessment	Grenada
	OLADE	Micro-hydro identification	Grenada
	IDB	La Chapelle hydro project feasibility study	Haiti
	Sweden	Hydro development	Jamaica
	IDB	Hydro development	Jamaica
	IDB	Mini-hydro development	Monserrat
	CDB, BDD	Hydro development	St. Vincent
	IDB, IBRD Netherlands	Kabalebo hydro project	Suriname
	Belgium	Micro-hydrp	Suriname
Geothermal	Belgium	Preliminary geothermal study	Dominica
	OLADE	Regional geothermal study	Regional

Table IV - continuation

	USAID	Geothermal development	Monserrat
	IEB	Geothermal assessment	St. Lucia
Renewable energy (general)		Alternative energy technologies	CARICOM, Dominican Republic, Guyana, Jamaica
	OAS	Regional research center (suggested)	Dominica
	UNDP/UNIDO	Industrial application of renewable energy technologies; alternative energy demonstration center	Jamaica
	IDB	Assessment of non-conventional energy	Jamaica
	IBRD	Recycling of lube oil	Jamaica
	EDF	Alternative energy demonstration units	Jamaica
	CDB	Demonstration facility	St. Lucia
Renewable energy (biomass)	CIDA, CDB	Bagasse burning studies	Barbados
	IDB	Pilot generator	Barbados
	CDB	Prefeasibility vegetable waste boiler	Dominica
	Brazil	Technical assistance, ethanol production	Guyana
	USAID	Utilization of rice husks	Guyana
	IBRD	Gasification of wood waste; oil-to-charcoal conversion of alumina kilns	Guyana

Table IV - continuation

	IDB	Utilization of wood waste	Guyana
	USAID, IDB IDA	Reforestation	Haiti
	USAID	Appropriate technology center (charcoal)	Haiti
	IDB	Charcoal project	Jamaica
	CDB	Biogas production from arrowroot	St. Vincent
Renewable energy (wind)	UN Interim fund	Wind generators	Antigua
	Rockefeller Fund	Wind generators	Antigua
	CDB	Wind power system	St. Lucia
	CDB	Wind power system	St. Vincent
Renewable energy (biogas)	CDB	Biogas digestors	Barbados
	OLADE	Biogas unit comparison	Grenada
	OAS	Biogas study Biogas demonstration unit (suggested)	Haiti Jamaica
	EDF	Biogas plant	St. Vincent
	OLADE	Biogas study	Suriname
Renewable energy (solar)	USAID/CDB	Solar component in the regional program Solar air conditioning	CARICOM, Dominican Republic, Guyana, Jamaica Barbados
	USAID/CDB	Solar collector manufacturing	Barbados

Table IV - continuation

	IDB	Research program for solar	Dominican Republic
	USAID/OLADE	Solar system manufacturing	Haiti
	OLADE	Solar drying and heating	Suriname
Institution building; organization	USAID/CDB	Regional project for renewable energy and institution building	CARICOM, Dominican Republic, Guyana, Jamaica
	IBRD	Energy conservation program	Barbados
	CDB	Energy development plan	Dominica
	CDB	Technical assistance in energy rationalization	Dominica Republic
	IDB	Planning and developing energy resources	Dominican Republic
	UNDP	Fromulating national energy policy	Grenada
	UK	Energy conservation program	Jamaica
	CARICOM	Energy assessemnt of the tourism sector	Monserrat
	CARICOM	Technical assistance for energy planning	St. Lucia

The Soviet Union is funding oil exploration and a feasibility study for a Commercial Nuclear Reactor in Cuba. France and Cuba have collaborated on a bagasse to paper factory.

United Nations Development Programme, June 1, 1982 - Coordination of Energy Policy in the Caribbea
J. Vardi:(UNDP Consultant)
Interciencia, InterNews Section, 1979-89, Caracas

Footnotes

The authors acknowledge the assistance and hospitality of the Center for Energy and Environment Research in the preparation of this paper. The views expressed are solely those of the authors.

1. Cuban R & D was estimated at 74 million pesos in 1977 with 94% Cuban. Jamaican R & D was estimated at J$52.6 million in 1980-81. Barbados R & D was estimated at $558,000 in 1980.

   There has been no regional survey of R & D and research manpower using a uniform methodology.

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3. The single largest research project currently in the region is the European Space Center in French Guyana. It is peripheral to the region.

4. Fuat Andic, "Efficiency vs. Equity, Economic Policy Options in the Caribbean," Caribbean Review, Vol. XIII, No. 1, Winter 1984, p.16-20.

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7. Sergio Díaz-Briquets, The Health Revolution in Cuba, University of Texas, Austin, 1983, p.35-53.

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9. Report of the First Meeting of Ministers Responsible for Science and Technology, Kingston, Jamaica, 6-7 April 1983.

10. Tirso W. Saenz y Emilio Garcia Capote, "Ernesto "Che" Guevara y el Progreso Científico-Técnico en Cuba", Interciencia, Vol. 8, No. 1, Jan-Feb. 1983, p.10-18.

    Latin American Newsletters, Science and Technology in Latin America, Longman, London, 1983, Cuba, p.102-109

11. Low-productivity in the Cuban economy is discussed by Carmelo Mesa-Lago, The Economy of Socialist Cuba, University of New Mexico, p.179-182, 1981.

12. The Center for Energy and Environment Research conducted in 1984 a survey of industrial R & D in Puerto Rico.

13. Impressions of the Dominican Republic and other countries cited are based on personal visits and interviews, the InterNews section of Interciencia, and the 1981 and 1982 reports to UNESCO on "Science and Technology for Development in the Caribbean Current Status and Possibilities for Regional Cooperation by Dr. D.H. Irvine. Latin American Newsletters, op.cit. has profiles of several of these countries.

14. Joseph Grunwald, Leslie Delatour, Karl Voltaire, "Offshore Assembly in Haiti," in The Internationalization of Industry, Brookings, Washington, forthcoming.

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16. Report of the First Meeting of Ministers Responsible for Science and Technology, op.cit.

17. Juan A. Bonnet, Jr., Wallace C. Koehler, Jr., "Status of Renewable Energy Programs in Caribbean Islands," Proceedings, Energex Conference, Regina, Sasketchewan, Canada, may 1984.

18. Ibid, Latin American Plan for Action for the UN Conference on New and Renewable Sources of Energy, A/Conf.100/7, March 28, 1981 and A. Conf.1008, April 1981, Draft Action Plan for the Caribbean. Environment Programme, UNEP/CEPAL-WE 48/3, September 16, 1980.

19. Energy Resources with Caribbean Development and Cooperation Committee Member Countries, E/CEPAL/CDCC/65, May 28, 1980; and J. Vardi, Coordination of Energy Policy in the Caribbean, UNDP, Revised Report, June 1, 1982.

20. Board on Science and Technology for International Development, Needs in Science and Technology for Development in Caribbean Island Nations, Report of a Workshop, August 30-31, 1982, Washington, D.C., National Academy Press, p.32-41.

21. Carmelo Mesa-Lago, op.cit.

22. World Bank, Agricultural Research, Sector Policy Paper, Washington, D.C., June 1981.

23. Jorge Enrique Corredor, "Identificación y Analisis de Ecosistemas del Caribe," Interciencia, Vol. 9, No. 3, June 1984, p.145-152

24. Social and Economic Studies, Special Number, Vol. 28, No. 1, March 1979 contains essays on science and technology policy in the Caribbean from the Caribbean Technology Policy Studies Project, UWI, Jamaica.

25. Ibid, Steve de Castro, "A Technology Policy for Petrochemicals in CARICOM," p.282-336.

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