CREER X-208 THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE CARIBBEAN: POSSIBILITIES AND PROBLEMS

A Paper Prepared for the International Studies Association Meeting, Washington, DC, March 1985

By Wallace C. Koehler, Jr. and Aaron Segal

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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By Dr. Wallace C. Koehler, Jr. Head of Technology and Policy Assessment, Center for Energy and Environment Research, University of Puerto Rico and Dr. Aaron Segal, Professor of Political Science, University of Texas at El Paso

The mobilization 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 its member states remain overwhelmingly dependent on imported science and technology. 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.

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. 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. Our people's interest in the human resource capabilities of the Caribbean is high. Science and technology are used to make weapons, medicine, food, knowledge, and many other items. Trade-offs and contradictions between equity and efficiency goals, ecological and economic growth objectives, are persistent in the region. 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 underscores the importance of shop-floor innovation and learning by doing in the process of economic growth. 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. For several centuries, science was the prerogative of learned amateurs; botanists, naturalists, physicians, and others. Technology was mostly imported and lightly adapted, rarely was it institutionalized. A major Spanish scientific expedition was based in Cuba from 1795-1798, but neither the University of Havana nor any other 19th-century Caribbean university or academic academy found a secure place for science.

The first significant Caribbean adaptations of science and technology occurred in the late 19th and early 20th century with the introduction 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 of modest agricultural, tropical medicine, and public health research facilities in the 1920s.

In general, the Caribbean colonial heritage in science and technology came late, was oriented towards the 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 throughout the colonial period. Rigid race and class stratified 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 and to provide opportunities for locals.

Outlets for national creativity and to generate economic growth, which is subject to national

direction. The Caribbean Development Bank (CDB) President, William Demis, 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 design styles."

Even more importantly, technological innovation in Third World countries is required to develop efficient labour-intensive techniques of production. 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 1960s and reaching by the mid-1960s, most of the region has been concerned with 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 1970s 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. However, 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, and competitive salaries, these communities face significant challenges in pursuing their research and development goals.

Technicians and information services are important yet most Caribbean national scientific communities are loosely structured and organized. At the regional level, their ties are still in their early stages. The pressure for mobilizing science and technology has come from politicians rather than scientists. It has been brought on by 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 politician remarked, "I cannot go back to my Government and say that all we have produced is another report." 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 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 programs. National efforts in Cuba have resulted in an 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 to limited results. The

Cuban Academy of Science and major institutes and universities are relegated to training and some research.

"Applied research enterprises lack authority and funds to engage in shop-floor adaptation and innovation, which hampers earnings. The Central Institutes work according to rigid plans and have poor links with universities. The persistent problems of Soviet S&T producers 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 sole Caribbean country with a policy and an infrastructure, but S&T are not contributing to economic growth or reducing dependency. Ironically, the significant 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 highest research spending in the region. 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 institutions carry out applied and basic research.

The Puerto Rican government has made modest contributions to applied research. The private sector relies primarily on unrestricted technology transfer from the United States, where there is the largest number of researchers and programs. There is evidence that some informal shop-floor adaptation occurs in Puerto Rico despite the absence of official planning, policy, or institutions for science and technology.

The Center for Energy and Environment conducted a study about the viability of a science and technology center. As a result, the Governor appointed a commission to further consider the proposal. The commission recommended that a center be established, which would also enhance the research capabilities of the University of Puerto Rico and place a growing emphasis on the needs of the state's entrepreneurs.

As of this writing, the report has not been officially acknowledged, in part due to a change in Governors. The plan would involve..."

The text seeks to address the use of fiscal incentives to motivate national firms based in Puerto Rico to substantially increase their local R & D efforts. This 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 implemented, albeit unevenly, research in agriculture, alternative energy systems, fisheries, and other areas. Government ministers, parastatal corporations, non-profit foundations, and universities compete for far too few researchers, technicians, and funds. Efforts at coordination through science and technology offices have faltered. Each organization jealously guards its territory. The National Energy Policy Commission, established in 1979, has launched several research programs but with little coordination or coherence.

If Cuba is overly centralized, then the Dominican Republic has spread scarce resources too thinly and widely. It has particularly neglected investment in science education, adult science, and

science information systems. The result is that it is still basically dependent on overseas graduate study in the sciences and engineering despite massive increases in undergraduate student enrollment. Haiti, with its 5 million population, has the weakest science infrastructure in the region. Three decades of brain drain have left more Haitian researchers abroad than within the country. A handful of foreign-funded projects in agriculture, alternative energy, and reforestation through fast-growing species are ongoing but without an infrastructure. High turnover, low salaries, poor networking, and the absence of information systems quickly frustrate researchers. National plans and policies are reduced to empty words in the absence of serious efforts to create infrastructure. Since most Haitians receive less than 3 years of formal education, efforts must begin with elementary science concepts imparted by audio-visual, radio, and other means.

Creole is more prevalent than French, which is not widely understood. One of the few hopeful elements in the Haitian landscape 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 backward linkages in assembly plants in several countries. He found that Haiti's record was outstanding. They took advantage of low-cost labor, tax, and other incentives to replace imported components with local ones for baseballs and other products.

The French Antilles, 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 to wait for the recent organization 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 resources. 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 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 it. Belize and Suriname are mostly trying 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 focusing on alternative energy, with minimal local participation. The exceptions are the appropriate technology centers promoted by the Caribbean Council.

The record of churches in terms of adaptation and diffusion of results is spotty. There has been little consideration of what constitutes appropriate science and technology infrastructure for these islands. There has been too much emphasis on policy and institutions which may not be 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, as well as computer and audiovisual technologies, can all be used to raise indigenous capabilities without the need for 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, albeit inadequate, infrastructure. The government's decision to invest oil revenues in joint venture industrial export projects in petrochemicals has also improved local information and documentation capabilities. Trinidad has been and should continue to provide advice on technology and technology transfer to the Eastern Caribbean.

Like Puerto Rico, Trinidad has infrastructure in search of a policy. This is reflected in the discussions over a strategy of joint ventures and technology. There is also a 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 had a 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.

The text 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. This includes the local campus of the University of the West Indies, which disseminates 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 1970s, 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 that are 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 the 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 plays a crucial role in collaborating with the private sector to foster shop-floor innovation and training. A national policy and plan may be suitable for Jamaica if the process is open and participatory, including the increasingly organized scientific community. 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 currently consists of the Caribbean Community (CARICOM) nations whose relations focus on politics and trade. It also includes UMI,

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 potential 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 Secretariat 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 energy research. The CDB also operates a Technological Consultancy Service for the Eastern Caribbean. The Organization of Eastern Caribbean States has had several small-scale subregional projects and the technical committees at the political level supervise these projects. CARICOM has not found a more comprehensive, Caribbean-wide strategy since 1973. Instead, the initiative is coming from individuals such as Dr. Dennis Irvine from the University of Guyana. These efforts have resulted in the Intergovernmental Caribbean Council of Science and Technology, which includes CARICOM states and Cuba.

"Dewinica Ru Nethertands Anritics" should be "Dominica and Netherland Antilles" and "wlvg, (CEST). oS memboreni" should be "Living (CEST). As members", the text should be:

"Dominica and Netherland Antilles Living, (CEST). As members, it includes most of the public, Maiti, and even the possible new Chinese Associate Member. It is the widest Caribbean governmental grouping for science ever, except for the World to the colonial powers. However, their dues, lack of funds for ECLA for Secretariat reviews. This was confined to the war and post-war Carribean Commerce. £034 members have not paid and concern. The issue has continued reliance on Commerce participation and interest is markedly uneven. There is agreement on any specific "coordinating, advisory, and implementers" so the ongoing initiative work Program calls for a regular update of national S&T capabilities, and shares information and exchanges with the CCST with such a diverse membership to afford benefits to all if at a common denominator for activities. Like UNICA, it's likely to be settled for activities. The state of regional and sub-regional activity is growing but still in an early range of bilateral and multilateral donors, incipient. The extreme certainly results in duplication, fragmentation and too many donors chasing too few qualified researchers. Regional and sub-regional cooperation is easiest at the level of exchange of information and yet 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 1 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 research sector issues in each key Alternative Energy Research. The Caribbean is 90 percent dependent on imported oil at present to fuel its energy needs (Trinidad and Tobago are the only oil and gas exporters, Barbados and St.

Vincer produces oil and gas. However, the energy advantages in the Caribbean and other sub-tropics are not necessarily shared by other developing countries. The energy opportunities associated with coastal activities of particular interest. It is widely recognized that the Caribbean

possesses a wide array of energy resources which may be exploited on a large scale, providing some of the greatest opportunities. Recent oil and gas explorations in Cuba, Jamaica, Guyana, and Surinam have led to significant finds. It is thought that Puerto Rico and the Dominican Republic may have offshore reserves, but prospects elsewhere are slim. By contrast, there is extensive solar insolation, strong and predictable winds, good ocean thermal potential, hydro resources, and a large and varied biomass resource base.

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. Others propose priority development by external sources using economically and technically proven technologies and donor-imposed regional, subregional, and national energy policies. The track record of energy research in the region is mixed to date. Table IV presents a lengthy list of donors, projects, and sectors which includes foreign government organizations, private foundations, and others. Some governments have responded by organizing their own national policy offices.

Despite 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 most active research center, working on industrial hot water, ocean energy from sugar cane, solar air conditioning, and wind energy.

Other technologies. Due to changing US government priorities, the Center has had to curtail much of its work. The CL has invested in a variety of research, including a passive solar water heater program in Barbados. It too has run into funding constraints in future energy research. The Regional Energy Action Plan proposed by the Organization of Eastern Caribbean States is problematic due to lack of funding. The first round of energy research risks being curtailed if donors lose interest or change priorities. The goal of reducing energy dependency has been widely accepted but not translated into action. Long-term commitments to infrastructure are needed in order to train, retain, and retrain qualified researchers. Recognition that energy research requires sustained funding 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 the indigenous research capabilities that are needed.

Agriculture and Forest 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 research structure. There are advocates of new emphasis on non-traditional export crops such as fruit trees for which new markets may exist. The emphasis is placed on commercialization and marketing. Others maintain that research should focus on new, labor-intensive technologies at the disposal 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 feed, 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 debates divide governments, ministries of agriculture, researchers, university faculties of agriculture, external donors, and others. This even occurs in Cuba, where the small private sector outperforms the state, each country due to the remaining private sector is seeing results from farms. It's a debate with many critics over the different private systems of land tenure, extent of rural migration, and other factors. For instance, Puerto Rico has opted for agro-industry, conducting research in a society where few competitors remain; Haiti is overwhelmingly rural and small farmer-oriented and concentrates on labor-intensive research. The debate is further complicated by the potential use of sugar for fuel and its economics. The problem is that at the national level, resources are lacking to effectively pursue several agricultural research strategies at the same time. A World Bank study of development has indicated that the diseconomies in developing country agricultural research come from too few and isolated researchers. Work on new crops and traditional crops such as sugar and bananas must be carried out at the sub-regional or regional level for the smaller countries. Given a regional division of research labor, it might be possible to follow several research initiatives simultaneously, but this is a long-term goal. Reluctantly, it appears that research decisions need to be made wisely. A smaller, although less painful, and fast-growing species for reforestation in peasant societies is needed. The decision between smallholders and large commercial forest industry research is crucial. The Caribbean must choose agricultural and forestry options. Ironically, agro-industry is less expensive and involves adapting proven large-scale technologies by scaling down. The Green Revolution was for cereals and rice, a technological package for tropical smallholders is needed. Time-consuming basic research is necessary. The concept of labor-intensive, small-scale technologies has received attention.

Enthusiastic reception in much of the Caribbean. Church groups, non-profit foreign donors, and other organizations have sponsored centers, fairs, meetings, etc. Demonstrations are uneven and mixed awareness and skill occurred, especially in the summation stands. The appropriate technology is an important increment to reach out to groups. They have also developed formal and informal networks and information-sharing, an important lesson for the scientific community. While its total economic contribution may be finite, appropriate technology efforts in the region are a welcome sign of self-reliance. They may be extended to crafts, cost recycling, and small industries where local interest merits technologies, materials, and industries.

Environmental Science: 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, Curacao, Jamaica, Barbados, and elsewhere. Recognition of environmental concepts has been stressed by UNEP, UNESCO with its Man and the Biosphere Research Program, and by the nation. Ecological problems have also received some attention from the Caribbean Tourism Center in Barbados established by the Caribbean Hotel and Tourism Associations and the non-governmental Caribbean Conservation Association.

The growth versus pollution debate of the 1960s and 1970s has a different context in the Caribbean. Pollution 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 management and planning. There are political problems of harbor pollution, oil spills, coastal zone management, and beach and sand erosion. There are also 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 an increase in funding or resources.

The text is matched by two areas: 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 and marine biology, often through collaboration between local and better-equipped foreign researchers.

The small islands have become particularly dependent on donors for assistance with their immediate needs. Regional cooperation immediately runs into issues of many countries' short-term needs versus the possible long-term commitment of building infrastructure. Multiple ecological problems exist.

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, along with other Caribbean national weather services, has significantly improved regional forecasting capabilities to date.

Similarly, international Caribbean agencies have needed to section rational oceanographic and seismic data as basic research knowledge. This serves basic research interest as well as aids in on-the-job training of Caribbean researchers.

The lesson is that the Caribbean can participate in generating applied knowledge about life and planetary climatic history. There is very little formal technology adaptation in the Caribbean and an unknown but presumably significant amount of informal adaptation. Cuba is the sole exception here, as it is seen to be working with Soviet and European capital towards import-substitution including design, where technology transfer is largely unregulated except for foreign exchange constraints.

Industrial technology in the Dominican Republic, Trinidad, Jamaica and elsewhere involves consulting and some information constraints.

The text seems to be quite scrambled and incoherent, but I'll try to fix it as much as possible:

"Troubles arising for the private web cubicle over the debate of industrial #6 643 continue to sever dimensions 578. One element concerns the curve of clues and forms of technology transfer and calls for regional or other supervisory mechanisms. The problem is that the same new cuts of cases are available for research or for assessing technique to be considered. Another element concerns the need for regional design policies for new export entities or new industries such as petrochemicals. Power suggests that this cost comes at the expense of other local adaptations and scaling-down technologies. There is a need for experimentation with fiscal measures, that would rather incentivize to encourage energy conservation in these forms of adaptation in plants producing for local or national consumption. Finally, there is a need to promote backward links to increase employment, taxes, and use regional study and use of plants for survival. This opportunity caters to information and social sciences.

There has been more than 50 years of substantial scholarship in the social sciences for the Caribbean, much of which has been contributed by scholars studying race and class, kinship and gender, the New World, the plantation economy, emigration and others. These have been competently studied and widely diffused among people. There are a number of social science research centers in the region, notably the Institute of Social Sciences at UWI, and a steady stream of research has flowed over several decades. The research findings have been delineated before World War II and constitute part of the basic world volume.

While research must continue on the topics laid out, there are signs of emerging trends. Management of enterprises, both public and private, and non-profit organizations needs understanding in these societies. It urgently requires research on housing, land use, coastal resource management, and intelligent tourism research in the face of rapid change. Researchers need to cope with tourism as a multidisciplinary subject rather than a superficial analysis. Longitudinal studies are needed."

The corrected text:

"Cole research, rather, cultural research, which treats the entire region as an entity, needs to be realized. As science and engineering research in the region increases, so do social sciences, which have played a trending role. They need to parse interests and empirical data bases in health sciences. The Caribbean's strength lies in opportunities in specialty areas such as drug trials, in continuing demonstrations and diffusion. Basic research in medical science, like in Cuba, Jamaica, and Puerto Rico, out-supports advances that are likely to be implemented elsewhere. Instead, the challenge is to paramedical health delivery in hospitals and other potential public health and management plans. Evidence-based medicine is still feasible. There are important gains from regional sharing of information and comparative research.

Natural Resources: Several Caribbean countries such as Guyana, Belize, Suriname, and French Guyana have extensive unexplored areas with valuable natural resources. Other mysterious areas have the potential for use and include use of local materials in the market. Investment in regional capacity is necessary to participate in joint ventures. This has occurred as with the state petroleum corporations of potentially economically viable regions like Cuba and Jamaica. Research also underscores the need for processing and extensive studies. This research is extensive and highly necessary. It's not clear that an increase in usefulness is guaranteed. The most developed Caribbean economies have a growing service sector. There has been no systematic research on service sector productivity in the region. This may be an important factor in future economic growth. Issues of office automation, industrial relations in the service sector, productivity, retail, and wholesale all deserve attention. The tourism sector has yet to be analyzed from a productivity perspective. Wage policies in the economy also need examination, especially in relation to motivating output. As the balance shifts from agriculture to assembly plants, urbanization, and others, these deserve to be examined for the relationships they form."

The text appears to be about the importance of science education and research in the Caribbean, but it contains many errors which make it hard to understand. Here's a corrected version, as best as I could make out:

"Individuals have 19 responsibilities. The use of computers in the Caribbean has been comparative

for two ages. Existing numbers of researchers and in several countries such as Haiti, there are fewer science education resources. In 196, science teaching was at its highest priority due to the long timelines needed to train researchers. Augmentation of science education with fairs, clubs, science museums, audio-visual 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 quality should be augmented job-related knowledge and skills rather than a vague awareness of the importance of science. Audio-visual and computer training should be attempted.

Numerous studies have shown that researchers emigrate due to frustration with local working conditions and salaries as well as foreign opportunities. The Caribbean has the advantage of geographic proximity to major research centers and possible online communications. Keeping good researchers in the region requires providing them with frequent access to major data bases and overseas communications, and centers with "critical masses" sufficient to permit stimulating exchanges. Handfuls of some researchers scattered around the region are not productive. 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 forth with the goal of building indigenous research capabilities. It accords the highest priority to onsite research on problems unique to the region, where transferable technologies will not work or must be adapted. Renewable energy systems, agriculture, and appropriate technology meet this criterion."

Research on Caribbean ecosystems. Investments in information science, improved telecommunication, and science education have been needed to make any R&D program possible. This includes our most required infrastructure build-ups and cannot promise economic results before the 1950s. We do not believe that there are shortcuts in questions that must be nourished in the Caribbean. Science and technology in the region need to be developed over time.

Before it can deliver short-term crash projects lead nowhere since local capabilities are not altered. One cannot deal with sectors where on-site research has no substitute. It is possible to argue for other priorities, but a minimum 1-year timeframe is essential. Otherwise, researchers and centers will be asked to deliver what they cannot, and disillusionment will be general. There needs to be less reliance on technology transfer.

Different donors to Caribbean science and technology have their individual agendas and constitute a difficulty in coordinating major government donors. An indication of broad funding levels for several years in advance would help. It is undesirable, however, for donors to dictate priorities or to coerce subregional cooperation. The donors can stipulate that Caribbean R&D is directly relevant to their needs. Indigenous capabilities need to be increasingly funded from indigenous resources. It is important that clients match stated priorities with their own resources. Currently, a majority of the funding comes from every country except Cuba.

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 interaction.

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, and other stakeholders.

Groups, teachers, etc., the smallness of those societies could 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 the construction sector. Linkages should aim at contracting with universities and the private sector explicitly to strengthen local and regional capabilities.

Non-profit organizations also have an important role in R&D support. The donors can create a supply but demand for research is a function of linkages. The scope for regional and subregional cooperation is extensive; the prospects, however, are mixed. Even Cuba, Puerto Rico, Trinidad, and Jamaica will within a decade exhaust the R&D resources they can effectively perform at an island and national level. The small countries often rule out projects of most interest to the most advanced.

Cooperation, as seen between Puerto Rico and the Dominican Republic or Cuba and Jamaica in the 1970s, may be more promising. However, the momentum in donor and international support is crucial. Support of regional cooperation needs to be a step ahead, from conferences and surveys to carefully designed shared research. It's true that baseline data is unavailable and that science and technology policies are inconsistent.

What does it mean, though, to ask a government with a weak research structure and R&D to produce a policy? Before we step on the accelerator, the convergence of research agendas and spending patterns indicates the possible gains from launching regional projects.

How to get from nowhere to somewhere? The Caribbean, at present, does not have sufficient influence and tools to affect its own future. Compare this to India, which managed to adapt and diffuse the Green Revolution, changing from a net food importer to being food self-sufficient.

Countries developed the ability to increasingly focus on exports. It is possible for the Caribbean within a decade to have the indigenous capability to understand its ecology. This does not mean that we should underestimate what has been developed.

The following text has been corrected for grammar, spelling, punctuation, and readability:

As for its own industrial sector, agriculture, and other industries, it will either be used wisely or shared. This does not mean that all of the Caribbean's capabilities, even for imports, will necessarily be reduced. Even though the import mix could be changed, this does not mean that dependency on certain regions will cease. Surely it's better to import computers rather than apples and dried fish?

The alternative is also clear: a perpetuation of the status quo. Most energy is imported depending on markets, prices, and politics. More rural people are leaving for cities like Kingston, Port-au-Prince, Miami, or New York. Ecological pressures are increasing, more beaches are eroding, forests are being denuded, and finite natural resources are dwindling. 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 show us how to approach them.

Caribbean Science and Technology Principal Regional and International Organizations:

1) Association of Island Marine Laboratories of the Caribbean (AIMLC): Coordinates marine science in the Caribbean and provides information exchanges.

2) Appropriate Technology International: A US government-funded agency.

3) British Development Division: An agency of Overseas Development.

4) Caribbean Development Corporation: Provides appropriate technology centers.

5) Council of Churches: A religious-based promoter with support from the Caribbean.

6) Caribbean Association of Industry and Commerce (CAIC): A private sector promoting improved forms.

7) Caribbean Agricultural Research and Development Institute (CARDI): Based in Trinidad.

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

9) Caribbean Economic Community (CARICOM): A secretariat based in Guyana. Coordinates alternative energy and related projects.

10) Caribbean Industrial Research Institute: Conducts industrial technology research and is sponsored by the Trinidad government.

11) Conference of Caribbean and Latin American Ministers Responsible for Science and Technology (CASTALA): Supported by UNESCO.

The group is scheduled to meet in 1985. The Caribbean Appropriate Technology Centre (CATC) was established in Barbados in 1981. The Caribbean Conservation Association (CCA) is a Barbados-based non-profit group concerned with ecology and restoration. The Caribbean Development Bank is based in Barbados and funds the Alternative Energy Unit. The Caribbean Council for Science and Technology (CCST) is an intergovernmental organization established in 1985. Page Break.

Table 1 - continuation

Commonwealth Development Corporation (CDC) invests in government aid. The Caribbean Development and Cooperation Committee (CDCC) is an ECLA-UNESCO sponsored intergovernmental advisory group which preceded CCST. The Commonwealth Fund for Technical Cooperation (CFTC) is based in London. The Caribbean Group for Cooperation in Economic

Development (CGCED) is a World Bank-sponsored club of donors active in energy and other projects.

The Canadian International Development Agency (CIDA) supports agriculture, fisheries, and other research. The Caribbean Meteorological Institute is based in Barbados and serves the CARICOM area for data projects. It works closely with the London-based Commonwealth Science Council (CSC), which funds surveys and conferences.

The Caribbean Technology Policy Studies (CTPS) is a joint research project of the University of the West Indies and the University of Guyana, funded by the International Development Research Centre (IDRC) in Canada. The Export Development Corporation (EDC) promotes technology exports in Canada. The European Development Bank (EDB) is based in Brussels. The European Community (EC) includes the European Investment Bank (EIB) and the U.S. government's Eximbank, which provides export credit finance.

The Gulf and Caribbean Fisheries Institute (GCFI) facilitates marine science information exchanges. The International Bank for Reconstruction and Development (IBRD) coordinates the Caribbean donors group and funds exploration, hydro, agricultural research, and other projects. The International Development Association (IDA) is the self-loan fund of the World Bank. The Inter-American Development Bank (IADB) is based in Washington, like the World Bank, and provides loans.

For agricultural research, alternative energy, fisheries, etc., Caribbean independent states have an increasing role in IDB administration.

Table | - Continuation

International Development Research Center (IDRC): Ottawa-based and Canadian government-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 (IOCC): 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: Supports 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, funds 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 pharmaceutical projects.

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

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

Nations Environmental Program (NEP). Based in Nairobi with a Caribbean plan of action emphasizing oil spills and coastal management.

Continuation table:

United Nations Educational, Scientific, and Cultural Organization (UNESCO). Based in Paris with a 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 and small industry.

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

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

University of the West Indies (UWI). Conducts applied and basic research in agriculture, natural sciences, marine biology, the Institute of Social and Economic Research, and other fields. Campuses are located in Barbados, Jamaica, and Trinidad. They offer long-distance science teaching projects and other extension activities for smaller islands.

Volunteers in Technical Assistance (VITA). A Washington-based non-profit organization that serves as a clearinghouse for appropriate technology information.

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

World Intellectual Property Organization (WIPO). Based in Paris. Promotes new patent, copyright, and related organizations in the region. It opposes UNIDO.

World Meteorological Organization. A 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.

Auspiciously, 'Aursnpuy-os6e * ABor0uy>93' also posits 'oumyna,s6e 'oupéy'.

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

TABLE IV - Continuation

Subsector	Donor/Executing agency	Activity	Recipient country
Electricity Hydro	UK, Trinidad & Tobago	FTC cos 108 coe	IBRD Eximbank coe coe
IBRD	IBRD/IDA, EEC, CIDA	IBRD, EEC ope De cos cop coe CoB, I68 coe	Restoration of existing power plant
Technical assistance for electricity development	Distribution upgrading	First power project
Electricity rehabilitation	Generation expansion	Generation expansion
Acquiring the electric utility	Tariff study	First power project: sector strengthening
Power development	Power development	Rural electrification
Generation expansion

Development; Transmission Development Generation Expansion Improvement of Electricity Supply
Hydro Project
- Antigua
- Antigua
- Antigua
- Barbados
- Dominica
- Dominican Republic
- Dominican Republic
- Dominican Republic
- Grenada
- Guyana
- Haiti
- Jamaica
- Jamaica
- Monserrat
- St. Kitts-Nevis
- St. Lucia
- St. Vincent
- Belize

Table IV - Continuation
- Hydroelectric Study, Dominica CDB/TEU
- Micro-Hydro Workshop (3/81), Dominica
- Hydro and Interconnection Project, Dominican Republic
- Rio Blanco Hydroelectric Project (Suggested), Dominican Republic
- Lopez-Angostura Hydroelectric Project (Suggested), Dominican Republic
- Hydroelectric Master Plan, Venezuela
- Hydrological Resource Assessment, Dominican Republic
- Micro-Hydro Identification, OLADE, Grenada
- La Chapelle Hydro Project Feasibility Study, Haiti
- Hydro Development, Sweden, Jamaica

- Hydro Development, Jamaica, IDB
- Mini-Hydro Development, Monserrat
- Hydro Development, COB, BDD, St.Vincent
- Kabalebo Hydro Project, Suriname, Netherlands, Belgium
- Micro-Hydro, Suriname, Belgium
- Preliminary Geothermal Study, Dominica
- Regional Geothermal Study, OLADE, Regional Zone

Table IV - Continuation
- Geothermal Development, USAID, Monserrat
- Geothermal Assessment, HEB, St. Lucia
- Alternative Energy Technologies (General), CARICOM, Dominican Republic, Guyana, Jamaica
- Regional Research Center (Suggested), OAS, Dominica
- Industrial Application of Renewable Energy Technologies: Alternative Energy Demonstration Center, UNDP/UNIDO, Jamaica
- Assessment of Non-conventional Energy, IDB, Jamaica
- Recycling of Tube Oil, IBRD, Jamaica
- Alternative Energy Demonstration Units, EDF, Jamaica
- Demonstration Facility, Renewable Energy, CIDA, COB, St. Lucia
- Bagasse Burning Energy Studies (Biomass), IB, Barbados
- Pitot Generator, Barbados
- Pre-feasibility Vegetable Waste Boiler, Domi
- Technical Assistance, Ethanol Production, Brazil, Guyana
- Utilization of Rice Husks, USAID, Guyana
- Gasification of Wood Waste; Oil-to-Charcoal Conversion, IBRD, Guyana

Alumina Kilns OE

Table IV ~ Continuation

SSS 1DB - Utilization of wood waste in Guyana, funded by USAID, IDB

Reforestation in Haiti, funded by IDA

Appropriate technology center (charcoal) in Haiti, funded by USAIN

1B Charcoal project in Jamaica, funded by COS

Biogas production from arrowroot in St. Vincent

Renewable energy fund (wind) by UN Interim in Antigua

Wind generators in Antigua, funded by Rockefeller Fund

Wind power system in St. Lucia, funded by COE

Wind power system in St. Vincent, funded by COS

Renewable energy (biogas) in Barbados, funded by COB

Biogas unit comparison in Grenada, funded by OLADE

Biogas study in Haiti

Biogas demonstration unit (suggested) in Jamaica

Biogas plant in St. Vincent, funded by EDF

Biogas study in Suriname, funded by OLADE

Table IV ~ Continuation

Solar component in the regional program by USAID/CDB in CARICOM, Dominican Republic, Guyana, Jamaica

Solar air conditioning in Barbados

Solar collector manufacturing in Barbados, funded by USAID/CDB

Research program for solar in Dominican Republic, funded by IDB

Solar system manufacturing in Haiti, funded by USAID/OLADE

Solar drying and heating in Suriname, funded by OLADE

Regional project for building renewable energy and organization institution in CARICOM, Dominican Republic, Guyana, Jamaica, funded by USAID/CDB

Energy conservation program in Barbados, funded by 18RD

Energy development plan in Dominica, funded by COE

Technical assistance in energy rationalization in Dominica Republic

Planning and developing energy resources in Dominican Republic, funded by UNP

Formulating national energy policy in Grenada, funded by UK

Energy conservation program in Jamaica, funded by CARICOM

Energy assessment of the tourism sector in Monserrat, funded by CARICOM

Technical assistance for energy planning in 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 Caribbean J. Vardi: (UNDP Consultant) Interciencia, InterNews Section, 1979-89, Caracas

Footnotes

The authors acknowledge the assistance

The hospitality of the Center for Energy and Environment Research contributed greatly to the preparation of this paper. The views expressed herein are solely those of the authors.

1. Cuban R&D was estimated at 74 million pesos in 1977, with 948 Cubans involved. Jamaican R&D was estimated at J$52.6 million in 1980-81. Barbados R&D was estimated at $558,000 in 1960. There has been no regional survey of R&D and research manpower using a uniform methodology.

2. According to Ibelis Velasco in Interciencia, Vol. 7, No. 8, Jul-Aug. 1982, p.236-240, "Some Facts and Many Impressions of Science and Technology in Costa Rica."

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

4. Fuat Andi wrote an article in Caribbean, 20 titled "Efficiency vs. Equity, Economic Policy Options in the Caribbean Review," Vol. XIII, No. 1, Winter 1984, p.16.

5. Nathan Rosenberg, in his book "Inside the Black Box: Technology and Economics," Cambridge University Press, New York, 1962.

6. Iris Engstrand, "Spanish Scientists in the New World," University of Washington, Seattle, 1981, p. 159-172.

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

8. William Demas, "How to be Independent," Caribbean Review, Vol. VI, No. #, p.12-13.

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

10. Tirso W. Saenz and Emilio Garcia Capote, "Ernesto 'Che' Guevara y el Progreso Cientifico-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.102-108.

11. Low-productivity in the Cuban economy is discussed by Carmelo Mesa-Lago in "The Economy of Socialist Cuba," University of New Mexico, p.177-182, 1981.

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

13. Impressions of the Dominican Republic and other countries cited are based on personal visits and

Interviews, the "InterNews" section of Interclencia, 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. 1% Joseph Grunwald, Leslie Delatour, Karl Voltaire, "Offshore Assembly in Haiti", in 'The Internationalization of Industry', Brookings, Washington, forthcoming.

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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, p132-ste.

Carmelo Mesa-Lago, op.cit. World Bank. Agricultural Research, Sector Policy Paper, Washington, D.C., June 1981.

Jorge Enrique Corredor, "Identificación y Análisis de Ecosistemas del Caribe," Interciencia, Vol. 9, No. 3, June 1984, p.185-157.

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," pp.282-336.

26. Ransford, W. Palmer, Problems of Development in Beautiful Countries, North-South, Lanham,

Maryland, 1968, pp.20-28 on Jamaican emigration.

27. Board of Science and Technology for International Development, op.cit. Science and Technology for Development in the Caribbean: Current Status and Possibilities for Regional Cooperation, O.H. Vine, op.cit.