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

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§ CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE CARIBBEAN:

POSSIBILITIES AND PROBLEMS.

By

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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

whelmingly 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

the region and each of the member states remains over

and technology remain marginal and

Previously institutionalized,

There is no accepted and uniform definition of the Caribbean nor

eed 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 « rudimentary regional S & T network is beginning to take shape. The five

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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 0). 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 multi-rational corporations or other non-regional actors provided that it is carried out in the Caribbean and is of relevance to regional needs.> Our peoples.

ties of the Caribe

interest is in the human resource capabi

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." Currently indigenous S\$ 6 T is so limited that

it makes a minim

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 publi

tions 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.¹⁰ The scanty evidence indicates that the Caribbean has little formal or informal shop-floor R&D.

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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.®

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 stratified societies failed to diffuse popular knowledge of science and technology,

The drive towards indigenous science and technology capabilities

has.

roots in Caribbean pol

ical 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 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

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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 The two themes of indigenous R & D for new exports and for appropriate technologies were linked to the desire to alter the terms

production.

of technology transfer:

Beginning in Cuba in the 1960's and reaching by the mid 1960'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

missions for Latin America. This concept was fortified by the energy

United Nations agencies, especially the Economic Com-

mission 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 vestly extended their format 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 politician:

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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 reat

ited 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 sup-

ported researchers effectively networked with

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

Notions of

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 to administer the dozen

limited results. The Cuban Academy of Science

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 earning by doing suffers."

The Central Institutes work to rigid plans and have poor links with:

ies. The persistent problems of Soviet S&T

producers and univer:

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 exten

ding education, health and other services have been through management

and investment not R & D.

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Puerto Rico has a science and technology infrastructure in search of

2 policy, Next to Cuba it

Research spending in the region. 15 federal government agencies sup-

Port agriculture, forestry, fisheries, climatology and other basic and applied research in Puerto Rico. The University of Puerto Rico and several other newer Puerto Rican; carry out applied and basic research. The Puerto Rican government's modest applied research sector relies basically on transfer from the United States, there is

the largest number of researchers and

Programs in a number of

the private,

for unrestricted technology

evidence that some informal shop-"uor saapiaten goes on in Puerto

Puerta Rice

slence anu technology plan=

ing, policy or insitutions, ?The Comer tor Energy and Environment

ed a study of the

Jy center. AS a consequence of the

Research of the nsernty of Puss

Viability of @ scienze and teci-nol

Study the Governor »pcointed a commission te further consider the pro=

posal. The commission reccmmonded that @ center be established as well

98 enhancing the research capabilities of the University of Puerto Rico,

and growing emphasis on the needs of the state entrepreneurs. As of

this writing, the report has not been officially acknowledged, in part
because of a change in Governors. The plan should involve the use of

fiscal incentives to motivate firms located in Puerto Rico to

at least

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 upon US exper

The Dominican Republic has tremendous but highly uneven research in agriculture, alternative energy systems, fisheries and other areas.)

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 Havana have faltered. Each RG

wishes to guard its turf, ?The National Energy Policy

the Presidency and private

D unit seeks. to jc

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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

Haitian researchers abroad than within the country. A handful of foreign

drain have resulted in more

funded projects in agriculture, alternative energy, and reforestation through fast-growing species go on but without an infrastructure.

High turnover, low se

and other problem

policies are reduced to empty words in the absence of an infrastructure

So, poor networking, no information systems,

Quickly frustrate researchers. National plans and

of serious efforts to create one. Since most Haitians 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 earning 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. !#

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

---Page Break---

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 donors operate on

2 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. Guyana and Suriname are mostly

ties and technical colleges are unequal to the t

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

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Research Center serving the private sector, » branch of the Caribbean Agricultural Research Development Institute, and various government ministry efforts, Trinidad has @ 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 at infrastructure in search of a policy. This is reflected in the discussions over a strategy of joint ventures and technology

Proposed National Institute of Higher Education, Research, Science and Technology. Small-scale scattered applied research efforts in 2 number of areas including agriculture and marine biology have limited impact.

infers, industrial import substitution, and the

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 also disseminated work on biogas digesters, solar heaters, and agro-industry. It has also

achieved some success with commercial

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

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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; @ 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

limited 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.

These thumbnail sketches of national efforts are partial, subject to change, and arbitrary. They do illustrate 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, UNIC, 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 (UNICAR) 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.

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The Commonwealth Caribbean has attempted several regional science and technology projects and proposed others. Using US funding, the Caribbean Development Bank and the CAPICOM Secretariat have spent \$7 million over five years on scientific activities.

million over five years on scientific activities.

CB also operates the Technological Consultancy Service for the Eastern

Caribbean. The Organisation

at the subregional level

and the technical committee

at the political level supports work

in order to find

shes had several small-

ICG Secretariat jacks the authority

nate these slots. CARICOM at

NS and un-

Instead the focus since 1973 has room of wwe Caribbean-wide level

With the initiative coming from ECLA»

such as OF. Dennis Irvine, vice? hence:

and a f

individuals

University of Guyana.

These efforts produced in the intergovernmental Caribbean Council
of Science and Technology

CARICOM states that Cuba, the Dominican Republic

Netherlands Antilles

Wing, (CEST). The membership includes most of the

Caribbean, Haiti, and even the

possibility of becoming an Associate Member, It

Is the widest Caribbean governmental grouping for science ever except
for the World

to the colonial powers, Nowhere,

their dues, tack o

fon ECLA for Secrevriat se-views. 2

that was confined

War 11 ano postwar Caribtean Comm

ere £034 members have net pal

ane wcernm ?Ussing has rontinues: reliance

Comemye: peeLcipaiion ond tterest

Is markedly uneven. There is suraement ony suacitic "coordinating
advisory, and impionentatrs sow the oohh rne inntiat work

Program calls for a req} wat of national S 6 T
capabilities, ana vines information yd exch
the CCST with such a diverse members

to afford benefits te atl if at «awe! cone Gonominator

we activities. Like UNICA,
likely

» os settled fer activi

The state of regional and sub-regional activity is growing but still

in a range of bilateral and multilateral forums,

incipient. The extreme

certainly results in duplication, fragmentation and many donors

chasing too few qualified researchers... Regional and sub

regional cooperation

be

tion is easiest at the level of execution

realized at the level of Joint research

gives us information and yet

support of research centers

---Page Break---

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 *y Secta-

?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 attests to highlight the

research sector

issues in each key

Alternative

nersy 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-tropics not necessarily shared by other

isions have energy energy advantages

developing countries. The energy op

© of particular interest. 17

portunities associated with coastal activ

It is widely recognized that the Caribbean possesses a wide array of

energy resources which may be exploited

large proportion

the greatest opportunities. Recent oil and gas explorations in Cuba,

provide from 2 small to a

fon of indigenous onerny needs. Renewable eneray presents

Jamaica, Cuyana, ane Suri

Yer te produce significant finds. it

Is thought that Puerto Rico and the Ouminicas Republic may Nave off

shore reserves, however prospects cisevtiere ure stim, By contrast there

is extensive solar insolation, the winds ten:

good ocean thermal poten q

andior hydro resources, and the hienass resource base in large and

veried.

© be strong and predictabl

Is exist, severei countries have geotherm

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There is disagreement over the appropriate

ment, demonstration, application and diffusion: focusing on renewable

16

feasibility of research, development

energy. Some analysts favor a wide range of research programs.

Others come up with priorities and propose their development by external

Sources Using economically and technically proven technologies and

donor-imposed regional, subregions? are rational: energy policies.?'

The track record of energy ve:

arch In the region is mixed to date.

Table IV presents 2 ?engthly ¥st ct donors, projects, and sectors which

includes foreign goveranent rations, private foun-

dations, and others. Sere guverneris have respended by organizing

their owes nutio

and elsewnere.

'at poley offices az in chs Pew iniean Republic, Puerto Rico

In spite of tnis vetivity and wierest, there has been relatively tittle

actual energy reseorch in the region. fhe Carter for Energy and Envir-

fonment Research in Puerto Ricu hes been the single most active research

center, working on «

Industrial hot water, ocean

energy from sugar cane. solar air conditioning.

thermal energy and other technologies.

Because of changing US government priorities the Center has had to curtail much of its work. The CL has these a variety of research,

including a passive solar water heater program in Harbades, It too has,

run into funding constraints on future energy research. The Regional

Energy Act

IN Plan proposed by the Organisation of Eastern Caribbean
States is problematical due to lack of state The first round
of energy research risks bel

Interest or change priorities.

the donors lose

The goal of reducing energy dependency has been widely accepted
but not translated into act
long-term commitments to infrastructure in order to train, retain, and

Recognition that energy research requires

retrain qualified researchers has also been missing.

Discussions of international:

regional_ and national planning, policy,

?and cooperation skip the specific needed to sustain energy research.

Project by project episodic funding makes it difficult to develop those

Very indigenous research capabilities that are needed.

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Agriculture and Forest

Export crops such as sugar and so

land cotton have provided the

historically most effective examples, of Caribbean public and private sector

research linkages. Discouraging markets and prices for traditional ex-

Ports present new challenges to 2 erst-conditions! research structure.

There are advocates!

So focus on non-traditional

export crops such as fruit trees for whose products new markets may
exist

The emphasis is placed on commercial

ization and marketing.

Others maintain that research should focus on low-cost, labor-intensive

technologies et the discosition of smull tarmers with litte credit or formal education. Then there are those whs a-gue or sgru-industry research to adapt known dairy, poultry, sheep und 915, animal fedder and other

conditions to Carivtieas comercias a crt

sre and joud processing. The emphasis here is on

ricultural excension, mechanization, and technology transfer with the goat of reducing present extremely high food imports.

The debate over research approaches and ysats divides governments,

ministries of agriculture, researchers, university faculties of egriculture,

external donors wi

others. It even occurs in Cuba where the small

4 outyields the state

each country due to

remaining private sector is being res

farms." It is a debate with 9 criteria

the different private

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 scientists remain; Haiti is overwhelmingly rural and dependent on labor-intensive research. The debate is further fueled 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 development has indicated the diseconomies

impeding country agricultural research

stemming from the 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

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smaller countries. Given a 2 regional division of research labor it might be

Possible to follow several research lines simultaneously but this is @

long-term goal.

Reluctantly appears that research

Feasibilities need to be forced

Advisory. A strategy although less painful

? and fast-growing

Species for reforestation in peasant societies. Halt and the Eastern

between smaitnatders and sare:

decision fies etween research os commercial forest

Caribbean must -heose agricultural and fers

of the Caribbs

industry research is

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Ge facte opts ?or

ncustry. Ironically agro-

ss expensive i

savolves adapting proven

large-scale iecnnotogies through seating down, Sue ?he Green Revolu-

tion wa: for cereals and rice

ne-shcl? technological

Package for tropical mali te

esily and. time-consuming

basic researeis ?= nesced.

Appropriats Technion

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 cen-

®,

ters, fairs, meetings and demonstrations

are uneven and mixed

awareness and skills

occurred, especially in the tourism stands. The appropriate techn

but an important increment to add to

Groups have also developed formal: end by now? services and information-

sharing: an important lesson for the scientific community. While its total
economic contribution may be limited, appropriate technological efforts in the
Region are & welcome signs of self-reliance
they may be extended * crafts, cost
recycling, and small ind

Where local interest merits

Technologies, initiatives

ries.

Environmental Science:

The Caribbean consists of densely populated highly fragile human and

Organic ecosystems subject to periodic hurricanes. Ecosystems and water

made disasters such as oil spills. The environmental sciences are recent

---Page Break---

arrivals in the region although there is a distinguished record of academic

work in Jamaica, Barbados,

environmental concepts has been

research in marine biology in Puerto Rico, Tr:

Curacao, and elsewhere. Recognition of en

vironmental issues stressed by UNEP. UNESCO with its Man and the Biosphere research

Program, and by the n«

tion. Ecological problems have also received some attention from the

Caribbean Tourism Center in Barbados established by the Caribbean Hotel

and Tourism Associations.

n-governmental Caribbean Conservation Associe~

The growth versus pollution debate of the 1960's and 1970's has a different context in the Caribbean. Pollution in « closed island ecosystem threatens survival in a way that it does not" Calcutta or Mexico City.

There has been growths

demand for applied research on short-term

agement and

nicg. There are political

Problems of harbor pollution, oil-spills, coastal zone me

beach and sand erosion af

demands for research to improve fishing practices and yields, reduce

imports ai

and generate employment.

Unfortunately increased interest in ecological research has not been matched by strengthening and revision of environmental science infrastructures. Technicians are desperately struggling making fisheries and marine extension programs unrealistic. Research centers lack critical masses of researchers and adequate information services with a consequence in Caribbean archaeology done through collaboration

quent loss of staff. Important work has been done in marine biology between local and better-equipped institutions

and other fields but

researchers, The small islands

have become particularly dependent on donors for assistance with their regional cooperation

immediately runs into the short-term needs of many countries versus the

Multiple ecological problems. Inevitably

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

and other Caribbean

for forecasting and hurri-

cane and storm warnings

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ational weather services with i agencies to markedly improved regio-

| date. Similarly inter=

caribbean nes waded to

nal forecasting capabilities whi sectin

rational oceanographic and seismic s

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basic research by nreviding

basic research interes! The prine

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The lesson is taal the Gartonesn cen pacticibate in fiesterate

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eo amnitnt af inten chop-tlocy adaptation,

Cuba is the sole exception AK is seer oo wiur) Soviet and

pean capita: go attoots at * \noort-substitution

including designing here technology

transfer is largely unvegulates exept for leraigs esctange constraints,

ne Dotwucun Renublie, Trinidad,

st Euro-

Industrial techeciowy in

mation cons ne cansuiting, and some

Jamaica and elsewhere view the

trouble-shooting for the private wie cubic ve

The debate over industrial! #6 643 Gis Coctbneue has severed dimen=

578 One element concerns the carve of clues and terms of tech=

nology transfer and calls for regional ne otmar advisory mechanisms, The

Problem is that the same few jobs of cans eer. available for research

of for assessing technology to be online other element concerns

the need for re

ional design oley Ganebtities or new export

ook of available man

industries such os petrachem«.

Power suggests tha: ths cost

at the expense of other @ ¢ 0)

locai adaptation is fidust

scaling-down technelgies. There is. res

lities would come

lere ic sip the element of fostering

simply

Share for experience with fiscal

experiences rather than

incentives to encourage energy conservation use these forms of adaptation

in plants producing for local or regional air

usually there is the

need to promote backwards. tie London 10 in

create employment, taxes and use

merits regional study end use of 1 meeting

"

in these sorry plants

survives, This opportunity

cat

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information and: Social Science

There has been more than 50 years of serious scholarship in the social

sciences in the Caribbean. Much of this research has focused on

race and class, kinship and gender, as well as the New World, the

Plantation economy, emigration and other issues that have been

widely studied

by Caribbean people.

There are a number of social science research centers in the region,

including UWI, and a

ies such as.

ans

over several decades. The research findings have
and constitute a

of the basic world view. +

notably the Institute of Social

steady stream of

While research must continue until we have a better understanding of the

World War +

public-private.

© The signs of the . Management of enter

ate, non-profit

understanding in these societies.

even urgently requires

ing, land use, coastal

resource management, re-integrated research in the face

of rapid change. Researchers need to cope with tourism as

multidisciplinary

than superficial analysis. Longitudinal

cole research rather

//vutural research which

treats the entire region as an entity be io be cealized, As science

and engineering research in the reciny icceseers re social scisnces which

have played a tending rele need ty pane Jejerests and eupirical
data bases

healtis Sciences

The Caribbean strength lies in opp sed ecaity such as drug trials,

ine conti-

demonstration and diffusion. Basi: researc: repica!_ medic

Cuba, Jamaic and Puerto Rico out suuor advances are

J implement

kely to

be made elsewhere. instead the chailange to

para-mecical health dewvery <ysu

hospital and oh

tially public health and managemen:

class based medicine is still feasible.

services and there are important

gains from regional sharing of infrastructure and comparative research,

---Page Break---

Natural Resources

Several Caribbean countries such as Guyana, Suriname and

French Guiana have extensive unexplored areas

valuable natural resources. Timber, minerals and

have potential of agricultural products:

includes uses of local materials such as

market

fishery. Investment in infrastructure

to participate in joint ventures. Similar trends occurred as with the

state petroleum corporations of

potentially economically

Trinidad and Jamaica

oil research and

unersis processing and

Wg studies. This researc ter © exsensive and highly

ness Hot osttied except perhaps

ene Cups it Ty not clear that an

Increase in usefe tasienuous eu

The most developed Caritteen eeones growing service sec~

There has been ne

though

tors, even if their industria! bases

systematic researsn on service sector pr scuic" vity (6 he region

this may be an important factor in future evuncmc growth, Issues of

Office automation, industria! retations in ihe ser

productivity, retail ard wholesale

attention. The tourism sector has yet to hy + shee! trum & productivity

perspective. Wages poiicies in the eo-v

also in relation 10 motivating output. As the balance shifts from agri=

ce sector, banking

2 urzar?aaation and others merit

1 to be examined

culture to assembly plants tet: Lovliss co dia the relationships

of individuals 19 rectislogies. fh Suse of the comparative use

of computers in the

The Caribbean for two aees

existing numbers of researchers anti in geverxt counteles such as Haith

there are fewer 1

science education as

(es nas barely oven able to replace its

mere Jn 196 Investment in

J science leaching at ait fo

1s is whe highest priority

due to the long leastines needed te train rescurehers, Augmentation of

---Page Break---

science education with fairs, clubs. orizes, s-tence museums, audiovisual

materials, etc. is vita: and lends steelf to regional cooperation. Science

education for adults is also important cn the jt, through clubs, unions,

and other organizations. The qual shuiis be auginented job-related Knowledge and skilis rather than a vague awereness of the importance of science, Audiovisual and computer 7 the jet training should be at~ tempted.

Numerous studies ave shown that researchers emigrate due to frus~ tation with local worsing conditions end saiuries a well as foreign opportunities.?° The Cariobean has tne acvertexe of geographic proxi mity to mejor research centers ard pessinie on-line communications. Keeping good researcivers ip he region requires providing them with frequent keep-up access to major cee

we data bases and over

seas communications, and centers with ?eric: masses" sufficient to Permit stimulating exchanges. Hanafuis of soma researchers scattered

around the region are not productive. Aides

formation systems and

telecommunications are > sine qua non of effective Caribbean R & D; not

luxuries. The alternative

emigrate.

ive is to continue to serve some of the best people

Research Priorities

Several lists of possible Caribbean research priorities have been put

SP goal of building indigenous

nous research capabilities. It advocates for highest priority to invest

research on problems unique to the

together?! Gurs is derived from the ton

for where transferable technologies

Will not work or must be adapted. Renewable energy systems and agriculture and appropriate technology are valid criteria. So does research for Caribbean ecosystems. Investments in information science, improved telecommunication and science education are needed to make any R&D

Program possible, including our studies
require infrastructure buildups and cannot promise economic results before the 1950's. We do not believe that there are short-cuts in the
1» must be nourished

questions. The priorities we propose

Caribbean. Science and Technology in the region

---Page Break---

before it can deliver. Short-term crash projects lead nowhere since local capabilities are not there. Countries cannot deal with sectors where in situ research has not substituted. It is

possible to argue for other priorities but # minimum 1 year time-frame is essential. Otherwise researchers and centers will be asked to deliver what they cannot and disillusionment will be general,

used re!

lance on technology transfer

Approach

Donors to Caribbean science and technology have their individual agenda and constituent access to coordinate major government donors. An indication of broad funding levels for several years in advance would help, it is undesirable

ies. The World Bank has sought with some suc~

though for donors to « state priorities or to coerce

subregional cooperation. The donors can

stipe!

Caribbean R & D is directly exterrvaity

Cuba. Indigenous capabilities need to be increasingly funded from ind

genous resources.

Hients into regional or

{ though that clients match

ted priorities with their own resources. Currently @ majority of

(eer) i every country except

Most R&D in the Caribbean will continue to be carried out at the

national level, whatever the sources of funding need to be

restructured to face

user-research! incentives can

be tried to induce the tourist sector to (un)soar energy: agro-industry

to support university work, etc. The self-imposed segregation of re-

searchers and possible users must be forcefully broken-down or no diffu-

sion will occur, Where National councils of science and technology &

there should be broad participation of trade associations, farmers groups, teachers, etc. The smallness of those 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 construction. Linkages should be made between engineering and design

to play

cooperating with universities and the private

sector. explicit aim at strengthening technical and regulatory

capabilities

6. Non-profit: organizations else have an important role

---Page Break---

in RGD support. The donors can create a policy that demand for re-

search is a function of linkages between them

The scope for regional and sub-regional cooperation is extensive; the
Prospects so-so. Even Cuba, Puerto Rico, Trinidad, and Jamaica will
within 9 decades exhaust the RoE if they collectively perform at an

Island and national level, The small councils rules out projects of

most interest to the most advanced cooperative as between
Puerto Rico and the Dominican Republic or Cuba and Jamaica as in the

1970's may be more germanising OLT van ales BE Unwancedt

1 te momentum in

Donor and internal support ?nes :

Support of regional cooperation e needs to be @ step ahead from
conferences and sti*voys to carefully design! shared research. {1 is the
true that datasetine data is unavanna! les and that science

and technology peticie: sre it wristent. What does it

mean though to ask @ Government wich fas o> resuarch oF researchers

ructure and R&D

to produce a policy? Berier we ste:

acclerator. The convergence of rch agendas and spending

patterns indicated the vossible gains from tauoching regional projects.

how to get from pewnere wo sowewhere? The Ceribbean st present

0 affect its

does not have sufficient influence and tools

own future, Compare this to India which demonstrated, adapt,
and diffuse the Green Revolution from a change in a net food importer to
being food self-sufficient. Concerns

opened the ability to increasingly open
exports. It is possible for the Caribbean within 4 decades to have the
Indigenous capabilities
ecology. This does not mean that to

unre which has devel

s own industrial

ay, agriculture, and

oo alter iis lature tn

will be used or used

will share in those

wisely. Nor does i nisin that al! Coriebese s

capabilities, even if

fon imports wit be nece sarily reduced ev hounh the Taiport mix could be

ere regions? Nor sues 5 wean that dependency

---Page Break---

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:

fuels, prices, and politics,

more rural people leave for Kingston, Port

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

?depending on the vagaries of world mar-

More and more food is imported and more and

-au-France, Miami or New York.

outstanding problems of the Caribbean but they tell us how to look.

---Page Break---

TADLEY

Caribbean Science and eersatogy

Principat Regionat ond vernatior 2) Organizations

Association of Isiland marine

Coordinates marine seen

105 ot the Ceriboeat, {AMMLC}

8 informatia ex: ances

Appropriate Techniosy tnternadions?

agency

US government funding

British Development Oivisors 8

cy of Overseas Develop-

Caribbeut Developnen? Corpor

appropriste technolog, crmters 65

Council of Churcies

?os based promoter of

his support from? Caribbean

Caribbean Associstion © Chambers Commurce an ingustey (CAIC}

Private sector promoting improved ferns

Caribbean Agricultural Research ond

Trinidad base

Government Institute (CARDI)

Caribbean Food and Nutrition Institute (CRN) Located in Jamaica and
attached to the University of West Indies Mona School,

Caribbean Economic Community (CARICOM, Secretariat based in Guyana

Coordinates alternative energy and related projects

Caribbean Industrial Research Institute:

Industry? technology research centre

Trinidad government

Conference of Caribbean and Latin American Ministers Responsible for
Science and Technology (CASTAL). UNESCO Group scheduled to meet
in 1985,

Caribbean Appropriate Technology Centre (CATC), Established in Barba-
dos-1981.

Caribbean Conservation Association (CCA) Barbados based non-profit

group concerned with ecology and reforestation,

Caribbean Development Bank
in Barbados; fund for development

Energy Unit based

Caribbean Council for Science and Technology (CCST) Intergovernmental organization established in 1982. Look suspicious. Possible coordinating role for CARICOM and other states.

---Page Break---

Table 1 ~ continuation

Commonwealth Development Corporation (CDC) British investments

Government aid-

Caribbean Development and Corporation Committee (COCC) ECLA-UNESCO sponsored intergovernmental advisor, 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 (CIA), Supports agriculture, fisheries and other research

Caribbean Meteorological Institute

CARICOM area fund

Grenada based; serves

project. Works closely

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

Caribbean Technology Policy Studies

the University of the West Indies

IDRC in Canada to pursue a series

(TPS), Joint research project of

the University of Guyana funded by

of papers on CARICOM states.

Export Development Corporation (EDC)

exports

Cenad. Promotes technology

European Development Bank (EDF). Rrusse's based.

European Comunity (EC)

European investment Bani (£16)

Eximbank. U.S. government export credit finance.

Gulf and Cerinbean Fisheries Institute {GCF5 Morine science information

exchanges

International Bank for Reconstruction anç Development (IBRD). Coordi-

nates Caribbean donors group arc! lunds for =i 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.

a5

---Page Break---

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 (GOCARIBE). 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 five 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

Economic Commission for Latin America (ECLA). Caribbean

region office in Trinidad is Secretariat for CCST. Promotes regional role.

United Nations Environmental Program (NEP). Nairobi based with Caribbean plan of action emphasizing skills, coastal management.

---Page Break---

Table | ~ 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 island:

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 collec~

ton

This list is not exhaustive and requires updating. It includes the prin«

pal non-national organizations involved in Caribbean science and technolo-

oy.

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TABLE IV

SUMMARY OF ENERGY PRUJECTS IN THE REGION

A number of international and regional organizations are active in the Caribbean. The following is @ list of their main activities. The purpose is to serve as 2 project checklist, whcih may be updated with final cata regarding the investment and staius 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/Exe- Recipient

Subsector _cuting agency Activity country

oi Venezucial

?

Inancing oil supply Barbados, Jamaica,

ico Domincar? Republic

Trinidad/ Financing cil supply CAR!COM countries

8 Tobago

UNDP/IERU, on regional Bahamas, Barbados,

Canada ion prorotion Dominica Republic,

Grenada, Guyana,

Haiti, Jamaica,

Surhiame

IBRD Oil exploration

promotion fencing

1B Onshore olf expio- ?? Cuyana, Jamaica

ration lending

IDB Offshore seismic Regional

Surveys lending

UNDP/CDB! Assistance ?or fiets ? arbados

lbe operation and expic

ration

1B Seismic survey of Barbados

fossil tucls

UNDP Gas development Borbadtos

EDC Canady LPG provessi Berbedos

Solid coe Peat survey Betize

mineral

fuels OLAve, Lignite development Haiti

Germany investigation

Peat development Jamaica

Lignite devetopment

1

---Page Break---

Table IV ~ continuation

Electricity

Hydro

UK,

Trinidad

© Tobago

FTC

cos

108

coe

IBRD

Eximbank

coe

coe

IBRD

IBRD/IDA,
EEC, CIDA

IBRD, EEC

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De

cos

cop

coe

CoB, 168

coe

Restoration of
existing power
plant

Technical assis
tance for electri-
city development

tribution up-
grading

First power project

Electricity rehabi-
litation

Generation expansion

Generation expansion

Acquiring the elec

tric utility

Tariff study

First power project:

sector strengthening

Power development

Power development

Rural electrifica~

tion

Generation expansion

Generation develop-:

ment; transmission

development

Generation expansion

Improvement of elec

tricity supply

hydro project

Antigua

Antigua

Antigua

Barbados

Dominica

Dominican Republic

Dominican Republic

Dominican Republic

Grenada

Guyana

Haiti

Jamaica

Jamaica

Montserrat

St. Kitts-Nevis

St. Lucia

St. Vincent

Belize

---Page Break---

?Table IV = continuation

???

coe Hydroelectric study Dominica

CDB/TEU ?Micro-hydro work- Dominica

shop (3/81)

iB Hydro and intercon- Dominican Republic

nection project

1BRO Rio Blanco hydro- Dominican Republic

electric project

(suggested)

1B, Lopez-Angostura Dominican Republic

hydroelectric pro-

ject (suggested)

Venezuela Hydroelectric master Dominican Republic

plan

Venezuela Hydrological resource Grenada

assessment

OLADE Micro-hydro identi- Grenada

fication

1B La Chapelie hydro Haiti

Project feasibility

study

Sweden Hydro development Jamaica

1B Hydro development Jamaica

IDB Mini-hydro develop- Monserrat

ment

COB, BDD Hydro development St.Vincent.

IDB, IBRD Kabalebo hydro Suriname

Netherlands project

Belgium Micro-hydrp. Suriname

Geothermal Belgium Preliminary geo- Dominica

thermal study

OLADE Regional geo- Regional

thermal study

one

---Page Break---

Table IV - continuation

USAID Geothermal develop- Monserrat

ment

HEB Geothermal assessment St. Lucia

Renewable Alternative energy CARICOM, Dominican.

energy technologies Republic, ?Guyana,

(general) Jamaica

OAS Regional research Dominica

center (suggested)

UNDP/UNIDO Industrial applica~ Jamaica

tion of renewable

energy technologies:

alternative energy

Gemonstration center

IDB Assessment of non- Jamaica

?conventional energy

1BRD Recycling of tube oil Jamaica

EDF Alternative energy Jamaica

demonstration units

cos Demonstration faci- St. Lucla

tity

Renewable CIDA, COB Bagasse burning Barbados

energy studies

(biomass)

1B Pitot generator Barbados

coe Prefeasibility vege- Domi

table waste boiler

Brazil Technical assistance, Guyana

ethanol production

usaiD Utilization of rice Guyana

husks

IBRD Gasification of wood Guyana

waste; oil-to-charcoal

conversion of alumina

kilns

oe

---Page Break---

Table IV ~ continuation

SSS

1DB Utilization of wood Guyana

waste

USAID, IDB Reforestation Haiti

IDA

usain Appropriate techno- Haiti

logy center (charcoal)

1B Charcoal project Jamaica

cos Biogas production St. Vincent

from arrowroot

Renewable UN Interim Wind generators Antigua

energy fund

(wind)

Rockefeller Wind generators Antigua

Fund

coe Wind power system St. Lucia

cos Wind power system St. Vincent

Renewable COB Biogas digestors Barbados

energy

(biogas)

OLADE Biogas unit com- Grenada

parison

?ons Biogas study Haiti

Biogas demonstration Jamaica

unit. (suggested)

EDF Biogas plant St. Vincent

OLADE Biogas study Suriname

Renewable USAID/CDB_ Solar component in CARICOM, Dominican

energy the regional program ? Republic, ?Guyana,

(solar) Jamaica

Solar air condi~ Barbados

toning

USAID/CDB Solar collector Barbados

manufacturing

---Page Break---

Table IV ~ continuation

IDB Research program for Dominican Republic

solar

USAID/OLADESolar system manufac~ Haiti

?turing

OLADE Solar drying and ?Suriname

heating

Institution USAID/CDB Regional project for CARICOM, Dominican,

buildis renewable energy and Republic, ?Guyana,

?organization institution building Jamaica,

18RD Energy conservation Barbados

Program

coe Energy development Dominica

plan

cos Technical assistance Dominica Republic

in energy rationalize-

tion |

we Planning and develop- Dominican Republic

ing energy resources

unP Fromulating national Grenada

energy policy

uk Energy conservation Jamaica

program

CARICOM ? Energy assessemnt Monserrat

of the tourism sector

CARICOM ? Technical assistance St. Lucia

for energy planning

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

United Nations Development Programme, June 1, 1982 - Coordination of Energy Policy in the Caribbea

J. Vardi: (UNDP Consultant)

Interiencia, InterNews Section, 1979-89, Caracas

-36-

---Page Break---

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 948 Cuban. 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, Ibelis Velasco, *Interciencia*, Vol. 7, No. &, Jul-Aug. 1982, p.236-0;
"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,? It is peripheral to the region.

4. Fuat Andi

Caribbean,

20.

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

5. Nathan Rosenberg, *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 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.102-108

11, Low-productivity in the Cuban economy is discussed by Carmelo Mes Lago, The Economy of Socialist Cuba, University of New Mexico, p.i7-182, 1981,

12, The Center for Energy and Environment Research conducted In 1984 3 survey of industrial R 6 D in Puerto Rico.

-37-

---Page Break---

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.

15, The Jamaican Society of Scientists and Technologists is the only

Caribbean member of the Inter American Association for the Advancement of Science,

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

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