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Inter-American Development Bank

WORKING PAPER 5

Capacities of **Anglophone Caribbean countries** for collecting and analysing indicators on science, technology and innovation

Author: J. A. D. Holbrook

Índice

›› Presentation

This document was elaborated in the framework of the project "Strengthening the Information System in the Inter-American Science, Technology and Innovation Network", which is a part of the Regional Policy Dialogue for science and technology that is being promoted by the Inter-American Development Bank (IADB). The document sheds light on the results obtained after a diagnosis of the capacities of the English-speaking Caribbean countries (Bahamas, Barbados, Belize, Guyana, Jamaica and Trinidad & Tobago) in subjects such as data collection, information processing and the production of science, technology and innovation indicators. This diagnosis was reached through the implementation of a survey directed to the mentioned countries' national institutions of science and technology, as well as to the organizations responsible for making the collection of baseline data used as inputs for developing indicators. The information thus collected was analyzed by experts working for the project. The coordination of this work was provided by the Center for Studies on Science, Development and Higher Education (REDES), an Argentine institution.

The survey helped to identify the strengths and weaknesses of the English-speaking Caribbean countries in the qualification and the training of personnel responsible for data collection, the implementation of surveys, the processing of different types of statistical sources, the quality of the questionnaires used and of the methods applied, among other issues. The diagnosis has confirmed the leadership held by the Caribbean Council on Science and Technology (CCST) in the production of science and technology indicators. By the end of the nineties, the CCST had already organized various workshops in this field of work. These meetings led to an agreement upon a basic list of science and technology indicators that were considered of interest to most of the English-speaking Caribbean countries.

There are national institutions of science and technology in Barbados, Jamaica and Trinidad and Tobago. In other countries, however, it is unlikely to find activities devoted to the gathering of this type of data. This issue is connected with one of the main characteristics of this group of countries: their small populations and economies, both elements that generally result in a low production of local knowledge and a concentration of the scarce resources in actions not directly linked to the processing of science and technology indicators.

However, the activities carried out by the CCST have resulted in some measuring projects, particularly in areas such as human resources devoted to science and technology. This information has come mainly from public institutions. That is why coordinating the efforts of the English-speaking Caribbean countries should be considered a reliable tool to improve the measurements in science and technology and to guarantee the future expansion of their list of indicators.

Finally, it should be noted that the material presented here reflects the vast experience in the field of science and technology indicators that has been gained by the Ibero-American and Inter-American Network of Science and Technology Indicators (RICYT) in more than a decade. This document represents RICYT's contribution to the regional dialogue promoted by the IADB.

Mario Albornoz

01. Introduction

S&T and innovation (STI) policy makers in developing nations have many challenges in planning and implementing STI policies and programs. In both developed and developing nations, the objectives of national innovation policies are:

- To identify who are the innovators and what are the innovations
- To differentiate between inventors, innovators, and implementers
- To establish public sector infrastructure to support innovation

In general, the intent is to identify the knowledge required by the nation, the individuals and institutions in the nation who can generate that knowledge, and increasingly, the individuals and channels by which knowledge can be imported into the nation for economic and social benefit.

While money is always a challenge, in many cases the absence of appropriate academic or governmental institutions is also a problem, as can be the "brain drain" to wealthier countries. Thus STI policy makers need to know more about what skills exist in the country, and what skills could be attracted back to the country, if only on a temporary or part-time basis. Understanding the diaspora of a country's nationals may well assist in the development of sound STI policy at home. Similarly there are cases (for example minerals processing in Mozambique or textile industries in Sri Lanka) where government intervention can have a beneficial effect by forcing foreign investors to invest in local human capital, and in doing so develop innovation skills in local post-secondary institutions. Another source of economic and social advantages to these nations may also be the "value-added" that comes from the work of their nationals in foreign-controlled multinationals, rather than development of indigenous enterprises.

This is particularly true in resource-based economies. Resource-based economies are not unique to the developing world: there are several OECD nations with regional economies that mirror the problems in less developed economies (for example British Columbia in Canada - it is not that its per capita income is low, but that its economy is tied closely to the world markets of the commodities it exports). Thus even in some highly developed economies, the role of knowledge flows into the economy may be as important as the development of new knowledge within the economy.

The purpose of this paper is to provide a discussion paper on possible science, technology and innovation measurement frameworks for some of the economies in the Caribbean region. In this case we will focus on six English-speaking nations, four of which are islands, and two, although they are part of continental land masses are, for cultural, economic and social reasons effectively islands, and are members of the English-speaking community of the Caribbean. Table 1 provides a brief summary of available data on STI-related areas, taken mainly from the 2008 UNDP Human Development Report. These data include base data, educational data (as it relates to tertiary education), trade data and technology utilization data.

>> Table 1 Larger anglophone communities in the Caribbean

	Bahamas	Barbados	Belize	Guyana	Jamaica	Trinidad & Tobago
BASIC DATA						
Population (thousands, UNESCO data)	327	293	282	739	2699	1328
GDP ($US billion, PPP)	5.3	3.1	2.1	2.4	11.4	19.1
GDP growth, per annum, %	2.3	1.5	2.3	3.2	0.7	4.3
GDP/capita ($US, PPP)	18390	11465	7109	4508	4291	14603
Human Development Index (HDI)	.845	.892	.778	.75	.736	.814
HDI ranking	49	31	80	97	101	59
EDUCATIONAL DATA						
% in tertiary education	-	33	-	12	19	8
% of budget for tertiary education	-	33	1	4	20	11
Tertiary students in tech subjects	-	-	9	14	-	36
TRADE DATA						
Imports as % of GDP	-	69	63	124	61	46
Exports as % of GDP	-	58	55	88	41	58
Primary products as a % of GDP	5	56	86	78	34	74
Mfg. as % of GDP	42	43	13	20	66	26
High Tech. output as % of GDP	4.9	14.5	2.8	1.1	0.4	1.3
FDI as a % of GDP	3.5	2.0	11.4	9.8	7.1	7.7
TECHNOLOGY USE DATA						
Telephones per 1000 pop.	438	500	114	147	129	248
Cell phones per 1000 pop.	584	765	319	375	375	613
Internet per 1000 pop.	319	594	130	213	213	123
Researchers per 1M pop.	-	-	-	-	-	976
Royalties per capita ($US)	-	5.8	-	47.9	4.7	2.2
Energy – Electricity use (kWh) / capita / per annum	6964	3304	686	1090	2697	4921

Note: unless otherwise noted the data are from the 2008 UNDP Human Development Report, unless otherwise noted. The data refer to 2004 – 2006;

For small developing nations, collection of S&T data is infrequent, and often subject to imperfect interpretation. However both Jamaica and Trinidad and Tobago have had relatively recent surveys of R&D expenditures, and Trinidad and Tobago has surveyed its R&D personnel. Based on UNESCO data compilations:

>> Table 2

R&D Expenditures

	Jamaica (2002)	Trinidad and Tobago (2005)
GERD (local currency)	286 MILLION	115 MILLION
GERD in PPP, US$	11, 502 THOUSAND	24,660 THOUSAND
GERD per capita, PPP US$	4.4	18.6
GERD/GDP	.07%	,12%
% business expenditure	-	24.2
% business expenditure	-	54.9
% business expenditure	-	20.9

R&D Human Resources, Trinidad and Tobago (2005)

	Number of people	% female	Per million inhabitants
Total R&D workers	1103	39.2	631
Researchers	603	33.7	456
Researchers in business	16	N/A	N/A
Researchers in government	202	N/A	N/A
Researchers in higher education	385	N/A	N/A
Technicians	500	45.8	378

02. S&T Indicators

The formulation of STI policy and the development of S&T plans and programmes for the promotion of sustainable development and innovation require up-to-date, reliable and comprehensive data on a country's scientific and technological potential as well as its resource base.

The original purpose of collecting R&D data was to produce an indicator of technology-based innovation activity in member nations of the Organization for Economic Cooperation and development (OECD). Over the forty years since this concept was first developed, the measurement of R&D expenditures (and the human resources allocated to R&D) has been codified and refined. The formal Frascati Manual measurement of R&D focuses on surveys and censuses of activities where the individuals are (generally) treated as units. Thus relationships among the researchers are not explored, even though it is these relationships that help shape the national system of innovation (NSI).

But what is R&D and how do nations identify R&D workers? Definitions vary even within the OECD. For example, in Canada, the tax authorities allow a far more proactive definition of R&D and R&D workers, based on the results of their activities, than does Statistics Canada which follows the OECD standards.

In developing nations, the first requirement is to place R&D in the NSI in the context of development. Unlike developed nations, formal R&D may well play a very small role in innovation in that country, with the real innovations coming from skilled innovators who see the possibilities inherent in importing specific technologies and adapting them to local needs (see, for example, Holbrook and Hughes, 2001, and Salazar and Holbrook, 2004). Similarly the practice of R&D is closely

tied to the number and skills of technical human resources in the country. Thus the level of "informal" R&D, its influence on innovation activities, and its role in the NSI, may be far more important in such situations, than the level of formal R&D as defined by the OECD Frascati Manual.

For example, in developing nations the existence of teams of highly qualified personnel (HQP) may be far more important that the numbers of individuals may imply. The existence of informal collective S&T activities has implications for the concepts and definitions commonly used in the collection of STI statistics.

Over the past few years there has been a growing need in Caribbean countries for a consistent information system and database on S&T statistics. Policy makers, particularly those concerned about planning, implementation and management of technology issues, had felt the need for comprehensive information, not only on the use of input resources which comprise mainly the financial and human resources deployed and infrastructure available for S&T, but also the outputs of such activities measured in terms of increased productivity and increased economic growth and the use of new technologies and their impact on society. Such information is considered useful for undertaking cost benefit analysis and other economic studies as well as for efficient programming, planning and budgeting. It also helps in comparing national S&T efforts with other developing/developed countries.

According to Jan van Steen (1995) S&T indicators fulfil several functions:

- signalling or monitoring: giving insight and calling attention to developments and trends in the S&T system and its environment;
- accountability, evaluation and allocation: setting and justifying S&T budgets and giving insight into the performance of the S&T system against the goals established by policy-makers and planners;
- legitimisation; support for existing policies; and,
- awareness: providing information to set aside prejudices and incorrect perceptions of the performance of the S&T system

In the public sector, statistics on S&T inputs and outputs, and the consequent S&T budget, should support the following activities:

- formulation of S&T policy, in support of economic and social objectives including analysis of the national system of innovation;
- provision of advice to ministers and other senior officials;
- support for and justification of S&T program expenditures; and,
- information on scientific activities for elected officials, journalists and other stakeholders.

Most nations have one or more governmental or not-for-profit agencies charged with collecting and analysing S&T data. These are sometimes referred to as S&T observatories. Hernan Jaramillo (1996), in writing about S&T observatories has noted that an observatory, as an agency for collecting and processing S&T indicators:

"helps society to understand S&T development and the integration of S&T variables with other measures of economic and social development. The resulting information becomes a public good and a necessary input for the development of society."

The mandate of S&T ministers, ministries and institutions everywhere is to harness S&T to support social and economic

development of the nation. In practice this means that the over-riding question to be addressed by quantitative studies of S&T activities is "What is the state of S&T in the nation, and how do we compare to our economic competitors?" In the case of Caribbean nations this becomes a two-fold question - "What is the state of S&T in the nation?" and "What is the state of S&T in the Caribbean?".

In practice this means looking at changes in the levels of human and financial resources devoted to S&T (as inputs) and changes in the level of national development (as the desired output). Human resources for S&T are the common denominator among all nations - S&T programs are, by definition, carried out by skilled S&T professionals. In the Caribbean context, the allocation of human resources is more indicative of the distribution of S&T assets than actual expenditures. Thus it is possible to define what is, and is not, an S&T program by asking whether or not S&T professionals are a component of the program.

There are two universes which intersect: that of all people trained in S&T fields of study, and that of all people who are working as S&T professionals, regardless of their formal training. The sum of both universes is the area that is of interest to policy makers, although the policies may differ for the two. Indeed, it is important to know the relative magnitudes of the two universes and the degree of overlap between them. Understanding the role of post-secondary institutions in an economy and the employment outcomes of the graduates of these institutions is key to understanding the level of STI development in the nation.

>> Table 3 **Possible combinations of training and employment**

Case 1: No S&T training No subsequent S&T employment	**Case 3:** S&T training No subsequent S&T employment
Case 2: No S&T training Subsequent S&T employment	**Case 4:** S&T training Subsequent S&T employment

03. National Systems of Innovation

According to Metcalfe (2000), technology involves much more than science, and innovation involves much more than technology.

"A system of innovation is that set of distinct institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which government form and implement policies to influence the innovation process. As such is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies" (Metcalfe, 1995).

Not always does innovation involve the application of technology. Technology by itself is of no significance unless it is

translated into innovations. Innovation and diffusion are primarily economic and social processes which involve many other actors and behaviours besides those directly involved in the creation of technology itself. Dodgson and Bessant noted that:

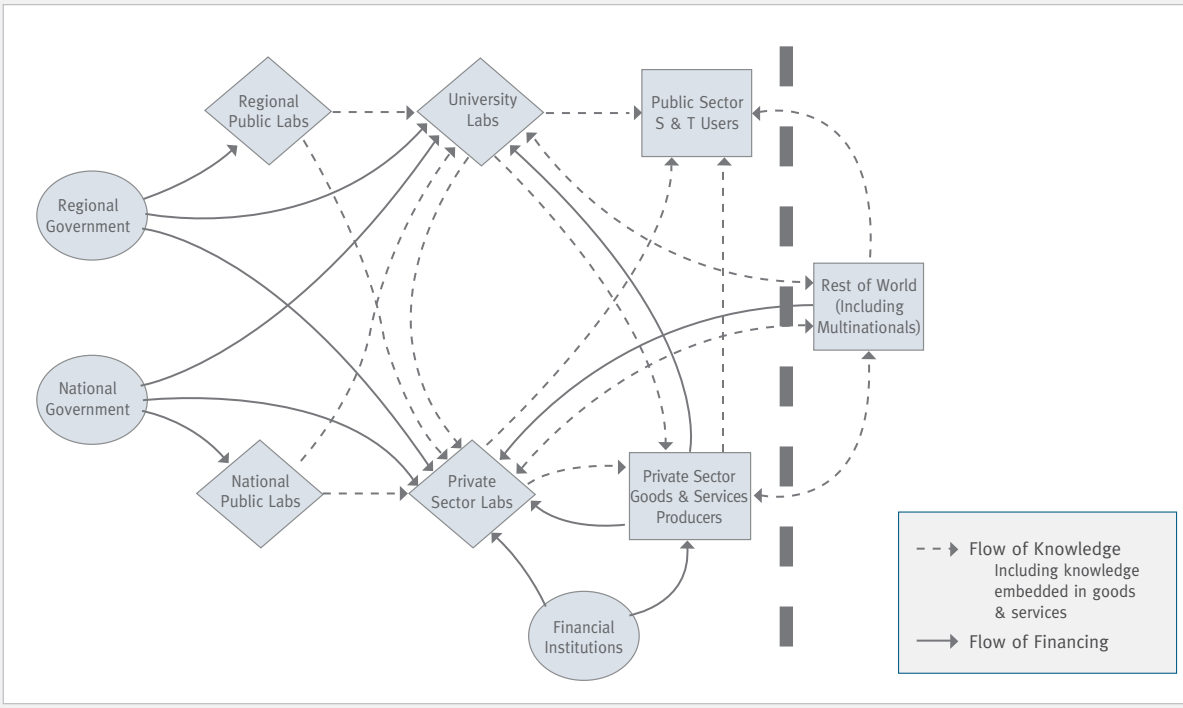
"It is inadequate to think of innovation in 'technological' terms alone. The process of innovation involves consideration of finance, marketing, organization, training, relationships with customers and suppliers, competitive positioning, as well as relationships between products and processes" (Dodgson & Bessant, 1996).

There are two views of innovation - a economic view and a social view. The conventional view of innovation is economic, - that first proposed by Josef Schumpeter in his book "The Theory of Economic Development". In it he argued that there are five forms of innovation: new products, new processes, new markets, new resources, and new organizations. Innovations, according to Schumpeter are disruptive of the existing economy; they provide an impetus to move to higher levels of development.

The social view takes a more gradual view of the effects of innovation. Innovations are incremental to existing practices and change society over a measureable period of time. The adoption and adaptation of innovations follows an "S" curve where there are early adopters and late adopters. This approach has been discussed by Everett M. Rogers in his landmark book "*Diffusion of Innovation*".

The OECD has noted that the study of NSIs offers new rationales for government technology policies. Previously government S&T policies focussed on market failures. Studies of innovation systems can identify systemic failures. An NSI describes the relationships among institutions, both public and private. These relationships are usually traced and measured through financial flows or movements of people.(please see figure 1 below, based on the Canadian NSI)

>> Figure 1 **A National System of Innovation**



Source: Dodgson and Bessant (1996)

The flows of knowledge can be measured in a number of ways - as actual financial transfers, the flow of human capital, and the flow of intellectual property, whether abstract, as with licences and patents, or embedded in goods and services. In order to obtain a clear picture of these flows, it would be desirable to have data on all such transfers. A key component of all NSIs is the inflow of knowledge from abroad. All nations import knowledge: for most their imports of knowledge exceed their exports. Knowledge can enter in a variety of ways - including formal tacit knowledge or intellectual property, and human capital.

Figure 1 was originally developed from studies in Canada. It shows regional institutions as well as national ones: Canada is a federal country. In federal states the NSI is the sum of several regional systems. In general, an NSI in a federal nation is much more than the sum of its regional (provincial or state) systems of innovation. This is as true for a developing nation as for a developed nation. Indeed (as with Canada) some regions can accurately be described as industrialized, while others are resource-based. In the Caribbean the regions and the nations are reversed: the regional innovation system is the result of the collective activities of the national innovation systems.

Flows of resources and human capital within Caribbean nations and among Caribbean nations contribute to the Caribbean regional system of innovation, as well as resources imported into the region. The Caribbean regional innovation system should be greater than the simple sum of the NSIs of the member nations. However there are many variations. In some nations there may be few national laboratories (or none at all). Universities and industries may not have formal research programmes. And most important, the role of sources of innovation external to the region is key to the development of innovations within the region.

Innovation is a complex process, and as such is difficult to measure directly. There are, however, many partial indicators of innovative performance: they include trade data, technology use, energy use, etc. These categories are significant indicators of the innovative capacity and technological growth of nations.

The role of human capital in the NSI

Knowledge as a commodity affects the very conditions of production; it is, in part, a determinant of the relation between inputs and outputs. These conditions are fundamentally social, made up of relationships between various actors. The development, attraction and retention of human capital are factors that affect the quantity and distribution of this (knowledge) commodity. As noted in Figure 1, the movement of knowledge around the NSI is key. This is principally carried out through the movement of people, who carry knowledge with them (goods and services also have knowledge embedded in them, but only human capital has the ability to apply knowledge to new situations.

Human capital is the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being (OECD definition). The OECD's *Canberra Manual* defines human resources in science and technology (HRST), as simply an input to research. Recognizing human capital as the basis of knowledge flows in the NSI economy alters the understanding of intellectual property and its movement. It is not information or facts that move and produce value but the first-rate talent that can appropriate knowledge in ways that lead to competitive advantages. Thus HRST is essential to any national economy as a whole, and its success depends on whether it attracts and retains the right people rather than the right technologies. Arguably stocks and flows of HRST are the most important pieces of data that policy makers need, particularly in nations where the capital stock of actual intellectual property is low.

04. A Caribbean Approach to S&T and Innovation Indicators

National S&T Performance Data

National S&T performance data is keyed to the identification of S&T activities, as defined by S&T-related occupations, and the activities, whether S&T or not, of individuals trained in S&T-related fields of study. The Caribbean Council on Science and Technology (CCST) has sponsored workshops on S&T indicators. At CCST workshops in Port of Spain, Trinidad and Tobago, and Santo Domingo, Dominican Republic in 1999, participants agreed on some basic indicators of S&T performance. These indicators were felt to be consistent with S&T policy interests that most CCST members would have in common. The CCST recommended that the S&T data collection process work at two levels:

- data collected and reduced from a specific, common, questionnaire outlined below.
- national economic and social data

The proposed common Caribbean S&T questionnaire that was discussed at these workshops (Appendix "A") was based on the collection of data from all projects, institutions, establishments, etc. which employ HRST. If a program has S&T professionals working in it (as defined in the OECD Canberra Manual, see Appendix "B") then it was to be included in the survey.

HRST, as defined by the Canberra Manual, includes individuals trained in both the natural and social sciences, and individuals working in occupations that are contained within the definitions of natural and social sciences. The test as which should be included and which should be excluded is whether the particular field of study or occupation falls within the mandate of a nation's S&T policy or programmes. If there is any doubt, then the test is whether the field of study or occupation would contribute to the development of a new product or process within the establishment in question.

Economic and Social Data Relevant to S&T activities

1. Population
2. Labour force
3. % of population with post-secondary education
4. GDP (US$, purchasing power parity (PPP))
5. GDP/capita (US$, PPP)
6. Exports as % of GDP
7. Imports as % of GDP
8. Foreign Direct Investment (% of GDP)
9. Electricity consumption (KwH/capita)
10. Telephone lines per 1000 population
11. Internet hosts/ 1000 population
12. Computers/ 1000 population

Note: These data are currently collected by most Caribbean nations

Specific CCST S&T indicators

13. Public sector personnel performing S&T (including R&D) as a percent of total public sector employment - *Public sector as defined in the Frascati Manual; use either full-time equivalents or total employed for both HRST and all employees.*

14. Public sector S&T expenditures (including R&D) as a percent of government budgetary allocations - *Government S&T budgetary allocations are the forecast current and capital expenditures, including funds from international development agencies, but excluding debt repayments.*

15. HRST workers as a percent of employed labour force - *Employed labour force is all individuals active in the formal economy.*

16. HRST-trained workers as a percent of total labour force - *Total labour force is the employed labour force plus all individuals 15 years and older available for work*

17. Percent of total labour force with post-secondary education.

18. Distribution of HRST by sector:

>> Table 4 Prop sed data collection grid for HRST

Sector	HRST (number)	% females	%< 35 yrs.old	HRST %employed labour force	Expatriate HRST % of total	Expatriate HRST % other Caribbean
Non-renewable resources, plus associated primary mfg.						
Renewable resources plus associated primary mfg.						
Secondary manufacturing						
Private sector services (except tourism)						
Tourism						
Public sector services (except tourism – related)						

Notes:

1. HRST is defined as all individuals who have tertiary level post-secondary education in at least one of the fields of study as defined in the Canberra Manual, Annex 3, Table 6, sections 1, 2, 3, 4, 5.1, 5.2, 5.3, and 6.1, or are employed in an HRST occupation as defined in Annex 4 of the Canberra Manual.

2. An expatriate is an individual who is working in the nation who is normally resident elsewhere regardless of citizenship or place of birth.

3. Primary manufacturing is any sector of industry where the major inputs are raw natural resources, whether renewable or non-renewable.

4. Tourism activities are those as defined by the local tourist board.

5. Public sector services include publicly funded health care. Privately funded health care should be included under private sector services.

19. Distribution of S&T Spending by Sector (National Currency)

>> Table 5 **Proposed data collection grid for S&T Expenditures**

Sector	S&T Expend.	R&D Expend.	S&T % Extramural	S&T % Capital	S&T % Salaries
Non-renewable resources, plus associated primary mfg.					
Renewable resources plus associated primary mfg.					
Secondary mfg.					
Private sector services (except tourism)					
Tourism					
Public sector services					

Note: S&T expenditures are those expenditures resulting from the activities of all individuals in HRST occupations. Measurement of R&D expenditures is desirable, but given the problems of identifying specific R&D activities, may be difficult.

05. Analysis and Summary of Caribbean activities

The results of the CCST workshops represent an ideal world. As noted, it can be difficult to identify precisely what is R&D and what is not. Indeed, splitting out R&D, while interesting, is done because of the OECD data collection procedures, which themselves are based on the perceived correlation between R&D activities and overall innovation activities. Similarly measurement of S&T expenditures can be difficult to isolate. Are capital expenditures on hospital equipment S&T expenditures? Where do "S&T expenditures" stop, and simple capital and operating expenditures begin?

In most nations, salaries for S&T personnel make up the bulk of S&T operating expenditures. From a data collection point of view the HRST-trained person is a much easier unit to identify, measure and allocate to specific elements of the economy. These people can be identified easily as part of labour force surveys (which are carried in any case[1]). Thus having an up to date list of post-secondary institutions that train HRST is key. This list should include technical training institutions, as technicians and technologists are important members of the HRST cadre in any nation.

A key question for discussion is whether identification of R&D activities is worthwhile in the Caribbean context. On the surface, it would appear not. Most Caribbean nations do not have the capacity to develop new knowledge; rather they innovate best by importing knowledge from other nations. But R&D does have other benefits: for example, Salter and Martin (2001) have argued that there are six principal types of impact of publicly funded research which can be summarised as:

- increasing the stock of useful knowledge;
- training skilled graduates;

[1] It should be noted that in nations using English Common Law as the basis of their legal systems, data collection by government authorities is often heavily circumscribed. Thus use of standard economic and social surveys as vehicles for collecting data is preferable to special purpose surveys.

- creating new scientific instrumentation and methodologies;
- forming networks and stimulating social interaction;
- increasing the capacity for scientific and technological problem-solving; and
- creating new firms.

The inclusion of research networks in the list of benefits lends weight to Caribbean initiatives to develop research and S&T networks.

However some realities must be recognized: most Caribbean nations are small (both economically and in population), relatively poor (even if they have highly developed educational systems) and relatively unsophisticated in technology management. To expect these economies to produce creditable S&T statistics may be unreasonable: what they are seeking are data they can use for their own governance and policy purposes. Thus, with the exception of Jamaica and Trinidad and Tobago (see Appendix "D"), some generalities about S&T in the Caribbean may be drawn, using the categories from the RICYT survey:

› S&T Information sources

Information on S&T activities and personnel will come only from public sector organizations. Most businesses have neither the resources nor time to carry out extensive surveys and likely have little understanding of the definitions and concepts of S&T statistical definitions.

› Indicators of financial resources

Most data, even in developed nations, come from public sector budget material, in that this material is usually in the public domain. Seeking budget material from organizations that do not normally reveal their budgets is difficult.

› Human resource indicators

As with budgets, getting information on individuals in the private sector is difficult. In the public sector it is usually a matter of public record. Thus seeking information by type and level of S&T training may be much easier, since this can be tied to Census surveys, which are sent to individuals, and for which responses are usually mandatory. The role of multinationals and expatriate HRST is very important: multinational firms (who employ many of the expatriates) do have S&T activities which may not be picked up currently by Caribbean statistics agencies. This includes the expatriate educational institutions - of which there are many (see Appendix "C").

› Organization of the statistical unit

Unless there is an organization specifically devoted to S&T activities (which does exist in Barbados, Jamaica and Trinidad and Tobago), there is little likelihood of finding a local champion to seek authorization from the central statistical authorities to collect S&T data, or to permit the collection of S&T data. Again the small size of Caribbean nations mitigates against this - there simply are not enough resources for policy and administrative activities to go around. All of the Caribbean nations are small economies, even compared to the smaller Central American nations. Any nation of, say, 5 million or more, which includes most Spanish speaking nations in Latin America, have sufficiently large statistical infrastructures (statistical agencies) such that they can afford to devote a very small portion of those resources to S&T data collection. When a nation's population is 300,000, this is not really an option: hence the focus on HRST and the

use of labour force data.

06. Conclusions and Future Studies

Traditionally, the value of S&T (and R&D) is measured by the potential and actual 'outputs' and 'impacts' of the S&T itself. Typically these are measured in terms of the economic impact of specific patents or licences, or performance measures such as numbers of high-impact academic papers. But in economies where there is little formal research and development activity (in its widest sense, not the OECD Frascati definition), many of these indicators are virtually meaningless.

HRST, whether developed within the nation, or imported from elsewhere is the driving force for innovation in an economy. The HRST salaries and other operating costs are the inputs to the NSI, and in measuring these, policy makers can asses the vitality of their NSI. Major benefits to a nation can accrue from the simple presence of HRST, not only from their economic outputs. Unmeasurable benefits include their contributions to society and the manner in which they contribute to the social capital of a society. For example, retired scientists, having spent their careers in developed countries could contribute to their birth nations simply by bringing their expertise home, and acting as volunteers in the public sector, whether in the educational system or elsewhere (some examples: hospital boards, resources for secondary school programs, utility boards of management).

The Caribbean region is a supra-national system of innovation: the NSIs of each nation are smaller than that of the region. Given this, it would be useful to have a Caribbean-wide S&T statistical program. The major conclusion of this paper is that Caribbean nations should seek to coordinate their labour force surveys and other human resource data collection so that they can extract information about the nature of the innovators in their society. The work originally started under the auspices of the CCST needs to be picked up and carried forward. In spite of major economic and social upheavals, conditions have not changed much in the intervening years. Thus the focus on HRST should remain, and nations should work to understand the magnitude and direction of their stocks and flows of human capital. The tables in points 18 and 19 that were first proposed at the CCST workshops (Table 4 and 5) should be the focus of future work.

Standard economic and social indicators (items 1 to 12 of the CCST list) are currently being collected and reported. However, as a result of focusing on HRST S&T data collection initiatives in the Caribbean should focus on the harmonization and increase in frequency of collection of HRST information rather than concentrating on R&D related expenditures.

Workshops on HRST topics could be hosted in one or more locations in the Caribbean, just as the CCST workshops were. Specific studies could include the potential for repatriating Caribbean HRST from other nations, whether into HRST employment or as retirees and the magnitude and sources of remittances to Caribbean nations from Caribbean nationals with HRST training or who are in HRST occupations resident in other countries. Perhaps RICYT, working with a regional funding agency, such as the IDB, could work with one or more of the nations to host workshops that will move forward from the previous series of CCST workshops.

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Appendix A. CCST Draft Questionnaire »

Survey frame (establishment level):

- All government S&T agencies
- All government-supported institutions (hospitals, libraries, etc.), excluding education
- All post-secondary educational institutions (UWI faculties will fill out separate questionnaires)
- All S&T NGOs and private-non-profit institutions
- All S&T professional associations - doctors, engineers, etc. (private practice members only)
- All business enterprises with any S&T employees as defined as HRST in Annex 4 of the Canberra Manual
- CCST will send questionnaires to international S&T organisations operating in the Caribbean

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1. HRST	# Males	# Females	% Expats	% Expats from other Caribbean	%<35 yrs. old
STA professionals (level 6&7)					
STA technicians (level 5)					
STA support staff					
R&D professionals (level 6&7)					
R&D technicians (level 5)					
R&D support staff					
Other employees with level 6&7					
Other employees with level 5					
Total all employees, all levels of education					

2. Expenditures (National Currency)	Salaries	Operating	Capital	Total
STA expenditures				
R&D expenditures				
Total				
	Internal	**External Public sector**	**External Private. sector**	**Total**
STA expenditures				
R&D expenditures				
Total				

Appendix B. Concepts and Definitions for Caribbean Regional Surveys ››

1. Scientific and Technological Activities (STA)

These are systematic activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of science and technology These include such activities as R&D, scientific and technical education and training (STET), and the scientific and technological services (STS)

2. Research and Experimental Development (R&D)

Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge of man, culture and society and the use of this stock of knowledge to devise new applications.

3. Scientific and Technological Services (STS)

STS are defined as activities concerned with R&D and its contributing to the generation, dissemination and application of scientific and technical knowledge;

(i) S&T services provided by libraries, archives, information and documentation centres, reference departments, data banks and information-processing departments.

(ii) S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections.

(iii) Systematic works on the translation and editing of S&T books and periodicals

(iv) Topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations; surveying of soils and of plants, fish and wildlife resources; routine soil, atmosphere and water testing; the routine checking and monitoring of radioactivity levels.

(v) Prospecting and related activities designed to locate and identify oil and mineral resources

(vi) The gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, e.g. population census; production, distribution and consumption statistics, social and cultural statistics.

(vii) Testing, standardization, metrology and quality control; regular routine work on analysis, checking and testing, by recognized methods, of materials, products, devices and processes, together with the setting up and maintenance of standards of measurement

(viii) Regular routine work on the training of clients and other sections of an organization of independent users which is designed to help them to make use of scientific, technological and management information

(ix) Activities relating to patents and licenses; systematic work of a scientific, legal and administrative nature on patents and licenses carried out by public bodies.

4. Human Resources in S&T (HRST) Basic Definition

In order to obtain a complete picture of both supply and demand for HRST, the definition is based on two dimensions, qualification and occupation. The qualification aspect tells about the supply of HRST i.e. the number of people who are currently or potentially available to work at a certain level. The demand of HRST i.e. the number of people who are actually required in S&T activities at a certain level, is related to the occupation dimension. Because demand does not always match

supply and because skills can be obtained outside the formal education system, the following combined definition is proposed.

HRST are people who fulfil one or other of the following conditions:

a) *successfully completed education at the third level in an S &T field of study*

b) *not formally qualified as above, but employed in a S &T occupation where the above qualifications are normally required.*

5. Education

Education at the "tertiary level" comprises successfully completed studies which result in a first or higher university degree and other post-secondary level studies which lead to awards or certificates not fully equivalent to a first degree. Successfully completed education at a given level leads to a formal qualification. The tertiary level corresponds to ISCED levels 5, 6 and 7, as defined by UNESCO.

Professionals are individuals engaged in the conception or creation of new knowledge, products, processes, methods, and systems, and in the management of the projects concerned. They are typically trained to ISCED levels 6 or 7

Technicians are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, lie and physical sciences, or the social sciences and humanities. They participate in S&T projects by performing scientific and technical tasks involving the application of concepts and operational methods , normally under the supervision of professionals

Supporting staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in S&T projects or directly associated with such projects.

6. Expenditures

a) Salaries: This comprises salaries and all associated costs or fringe benefits such as bonus payments, holiday pay, contributions to pension funds, NIS and health surcharge contributions, payroll taxes, etc.

b) Operating Costs: These comprise non-capital purchases of material supplies to support STA performed by the statistical unit in a given year. All expenditures on indirect services should be included here, whether carried out within the organization concerned or hired or purchased from external suppliers.

c) Capital: These are gross expenditures on fixed assets used in STA or R&D programmes. They are composed of expenditures on major and minor instruments and equipment.

Appendix C. Educational Institutions in the six Caribbean Nations ››

Bahamas

1. College of the Bahamas: http://www.cob.edu.bs/
2. Galilee College: http://galilee.ocatch.com/gc/gc.htm

Barbados

University of the West Indies, Cave Hill Campus: http://www.cavehill.uwi.edu/

Belize

1. American University of the Caribbean, School of Medicine: http://www.aucmed.edu/
2. Central America Health Sciences University (Belize Medical College): http://www.cahsu.edu/
3. Galen University: http://www.galen.edu.bz/
4. Medical University of the America's - Belize Campus: http://www.muabelize.com/
5. St. John's Junior College: http://www.sjcjc.edu.bz/index.html
6. St. Matthews University: http://www.stmatthews.edu/
7. University of Belize: http://www.ub.edu.bz/

Guyana

University of Guyana: http://www.uog.edu.gy/

Jamaica

1. Edna Manley College of the Visual and Performing Arts: http://www.ednamanleycollege.edu.jm
2. Northern Caribbean University: http://www.ncu.edu.jm/
3. The College of Agriculture, Science and Education: http://www.case.edu.jm/
4. The Management Institute for National Development: http://www.mind.edu.jm/
5. University of Technology Jamaica: http://www.utech.edu.jm/
6. University of the West Indies Centre: http://www.uwi.edu/
7. University of the West Indies, Mona Campus: http://www.mona.uwi.edu/

Trinidad and Tobago

University of the West Indies, St. Augustine: http://sta.uwi.edu/

University of Trinidad and Tobago

The University of the Southern Caribbean

Appendix D. Summary of responses by Caribbean S&T data collection authorities to the RICYT questionnaire on capacities for collecting and analyzing S&T indicators ››

- *National answers are italics*

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BAHAMAS

Agency: Department of Statistics of the Government of the Bahamas

Contact:
Ms. Kelsie Dorsett
Acting Director of Statistics,
Department of Statistics of the Government of the Bahamas,
Clarence A. Bain Building,
Thompson Boulevard,
P. O. Box N-3904
Nassau, Bahamas,
Tel: (242) 302-2400, (242) 302-2467
Fax: (242) 325-5149
Email: Kkelsiedorsett@bahamas.gov.bs

1.S&T Information Sources

- Periodicity: -
- Degree of coverage: -
- Techniques used: -
- Science fields covered: -
- Main operational problems encountered in carrying out surveys: -
- Comment on your impressions of the capacities in the institutions responding to surveys: -
- Are there differences in the survey tools in different sectors? -

2. Indicators for financial Resources

- Which are the sources of financial resources? -
- Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -
- Are estimates made to complement the use of these sources? -

3. Human resources indicators

- What sources used for the construction of human resources indicators? - Are estimates made to complement the use of these sources? -

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -

What human resources are there and what specialization level do they have? -

- To what degree are they dedicated to this area? -
- Are permanent technicians employed in the ONCYT or are they contracted temporarily for data collection? -
- Is the unit affected by frequent staff rotation? - .

5. Main issues and initiatives in S&T Statistics

There is no recent evidence of S&T surveys in this nation

Barbados

Agency: National Council for Science and Technology

Contact:
Mr. Lennox Chandler
Senior Director,
National Council for Science and Technology,
Reef Road
Fontabelle
St. Michael
Barbados
Telephone: (246) 427-1820/427-5270/427-5276
Fax: (246) 228-5765
E-mail: ncst@commerce.gov.bb

1. S&T Information Sources

- Periodicity: -
- Degree of coverage: -
- Techniques used: -
- Science fields covered: -
- Main operational problems encountered in carrying out surveys: -
- Comment on your impressions of the capacities in the institutions responding to surveys: -
- Are there differences in the survey tools in different sectors? -

2. Indicators for financial Resources

- Which are the sources of financial resources? -
- Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are

defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -

- Are estimates made to complement the use of these sources? -

3. Human resources indicators

- What sources used for the construction of human resources indicators? - Are estimates made to complement the use of these sources? -

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -

What human resources are there and what specialization level do they have? -

- To what degree are they dedicated to this area? -
- Are permanent technicians employed in the ONCYT or are they contracted temporarily for data collection? -
- Is the unit affected by frequent staff rotation? -

5. Main issues and initiatives in S&T Statistics

Although there is an organization devoted to S&T, there is no recent external evidence of S&T surveys in this nation. The NCST website is: www.commerce.gov.bb/Agency/NCST. Barbados participated in the CCST program of workshops

Belize

Agency: Statistical Institute of Belize

Contact:
Ms Phillipa Rowley,
Assistant Statistician,
Statistical Institute of Belize
Telephone: +(501)822-2207
Fax: +(501)822-2352
E-mail: prowley@statisticsbelize.org.bz

1.S&T Information Sources

- Periodicity: -
- Degree of coverage: -
- Techniques used: -
- Science fields covered: -
- Main operational problems encountered in carrying out surveys: -
- Comment on your impressions of the capacities in the institutions responding to surveys: -

- Are there differences in the survey tools in different sectors? -

2. Indicators for financial Resources

- Which are the sources of financial resources? -
- Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -
- Are estimates made to complement the use of these sources? -

3. Human resources indicators

- What sources used for the construction of human resources indicators? - Are estimates made to complement the use of these sources? -

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -

What human resources are there and what specialization level do they have? -

- To what degree are they dedicated to this area? -
- Are permanent technicians employed in the ONCYT or are they contracted temporarily for data collection? -
- Is the unit affected by frequent staff rotation? -

5.Main issues and initiatives in S&T Statistics

Although there is no organization devoted to S&T, the Statistical Agency has responded to our draft briefing, but no data has been given in response to the RICYT questionnaire. The Statistical Agency does carry out labour force surveys.

Guayana

Agency: Bureau of Statistics of Guyana

Contact:

Bureau of Statistics of Guyana
57 High Street, Kingston
P.O. Box 1070
Georgetown
Tel: 592-227-1155/592-226 -0982/592-227-0834
Fax: 592-226-2036
E-mail: info@statisticsguyana.gov.gy

1. S&T Information Sources

- Periodicity: -
- Degree of coverage: -
- Techniques used: -
- Science fields covered: -
- Main operational problems encountered in carrying out surveys: -
- Comment on your impressions of the capacities in the institutions responding to surveys: -
- Are there differences in the survey tools in different sectors? -

2. Indicators for financial Resources

- Which are the sources of financial resources? -
- Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -
- Are estimates made to complement the use of these sources? -

3. Human resources indicators

- What sources used for the construction of human resources indicators? - Are estimates made to complement the use of these sources? -

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) -

What human resources are there and what specialization level do they have? -

- To what degree are they dedicated to this area? -
- Are permanent technicians employed in the ONCYT or are they contracted temporarily for data collection? -
- Is the unit affected by frequent staff rotation? -

5. Main issues and initiatives in S&T Statistics

There is no recent evidence of S&T surveys in this nation. Guyana was an active participant in the CCST workshops.

Jamaica

Agency: National Commission on Science and Technology
Contact:
Ms. Merline Bardowell,
National Commission on Science and Technology (NCST),
1 Devon Road.
Kingston.10,

Jamaica
Tel: (876) 929-8880-5/ (876) 927-9941-3
E-mail: mbardowell@opm.gov.jm
Corporate e-mail: ncst-sec@opm.gov.jm

1. S&T Information Sources

- Periodicity: *Annually*
- Degree of coverage: *All S&T institutions in the public sector*
- Techniques used: *Survey questions mailed or e-mailed to institutions; follow-up calls done to retrieve information.*
- Science fields covered: *Basic and applied sciences, including engineering*
- Main operational problems encountered in carrying out surveys: *Lack of responsiveness.*
- Comment on your impressions of the capacities in the institutions responding to surveys: *No specific point person is assigned to retrieve information; individual assigned to respond often faces challenges in retrieving data from relevant sections of their institutions; survey results are not necessarily seen as important and may not be used. Data not always disaggregated*
- Are there differences in the survey tools in different sectors? *No. The same questionnaire is applied for government and higher education sectors.*
- Secondary sources

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Source	Organization Responsible	Periodicity	General Characteristics
Source 1	Ministry of Finance	Annually	National budget
Source 2	Statistical Institute	Annually	Statistics
Source 3	University of the West Indies	Annually	Statistics publication and Department Reports
Source 4	S&T Institutions	Annually	Annual Reports

2. Indicators for financial Resources

- Which are the sources of financial resources? *Budget information.*
- Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) *Budget information for institutions are taken from national budget publication or requested directly from institutions. Allocations for R&D is specified in budget breakout or is calculated by institutions and forwarded*
- Are estimates made to complement the use of these sources? *No.*

3. Human resources indicators

- What sources used for the construction of human resources indicators? *Data for human resources indicators are requested from institutions, or retrieved from reports or statistics publication. The total number of researchers are either specified or counted separately- from data provided on number or research-types provided.*

- Are estimates made to complement the use of these sources? *No.*

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D) *Budget information for institutions are taken from national budget publication or requested directly from institutions. Allocations for R&D is specified in budget breakout or is calculated by institutions and forwarded*

What human resources are there and what specialization level do they have?

1 individual is assigned with the responsibility; PhD in the Life Sciences

- To what degree are they dedicated to this area? *This is done as a part of normal duties.*
- Are permanent technicians employed in the ONCYT or are they contracted temporarily for data collection? *No technician employed.*
- Is the unit affected by frequent staff rotation? *No.*

5. Main issues and initiatives in S&T Statistics

- *R&D budget needs to be disaggregated in overall budgets. Dedicated funding and staffing for indicators collection will also be done.*
- *Workshop to apprise stakeholders as to the importance of indicators in order to improve cooperation in the provision of information.*
- *Level of coverage will be expanded for both input and output indicators.*
- Jamaica has hosted and participated in the CCST program of workshops. Jamaica issued an S&T report with statistics in 2005.

Trinidad and Tobago

Agency: National Institute of Higher education, Research, Science and Technology

Contact:

Ms. Sharon Parmanan ,
Science and Technology Statistical Unit
National Institute of Higher Education, Research, Science and Technology (NIHERST)
#43-45 Woodford Street
Port of Spain
Trinidad and Tobago
Tel (868) 628 1154
Fax (868) 622 8343
E-mail sparmanan@niherst.gov.tt

1. S&T Information Sources

- Periodicity: *Annually*

- Degree of coverage: *government, research institutions, public enterprises and higher education. In the first three sectors the population is surveyed and for higher education one university is surveyed. However, coverage will be expanded to include two more institutions.*
- Techniques used: *Questionnaires are delivered and completion monitored by field staff. The response rate interms of manpower is above seventy-five percent for research institutions and public enterprises but below fifty percent in the higher education institution. In terms of expenditure, there is a 100% response rate for higher education but a less than seventy percent for research institutions and public enterprises. In higher education response rates differ because the manpower data is obtained from the faculties while the bursary provides the data on expenditure.*
- Science fields covered: *natural sciences, engineering, agricultural sciences, medical sciences, social sciences and humanities.*
- Main operational problems encountered in carrying out surveys:
  - A lack of co-operation from respondents particularly the private sector, as a consequence of the confidential nature of the data requested, despite the undertaking of confidentiality.
  - Accounting systems do not generate expenditure on scientific and technological activities separately which in most cases are performed with the same resources used on routine assignments.
  - Respondents lack the necessary training and information to complete the questionnaires.

- Comment on your impressions of the capacities in the institutions responding to surveys: *Human resources are not dedicated or trained to respond to the questionnaires and low priority is given to data requests No specific point person is assigned to retrieve information; individual assigned to respond often faces challenges in retrieving data from relevant sections of their institutions; survey results are not necessarily seen as important and may not be used. Data not always disaggregated*
- Are there differences in the survey tools in different sectors? *No.*
- Secondary sources :

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Source	Organization Responsible	Periodicity	General Characteristics
Population Census	Central Statistical Office of Trinidad and Tobago (CSO)	Every 10 years	Data on human resources in science and technology are monitored by the CSO decennially.
Continuous Sample Survey of the Population	CSO	Quarterly	Data on the characteristics of the labour force including age, gender, industrial group, occupational group, type of worker and educational attainment.
UWI Official Statistics	The University of the West Indies (UWI)	Annually	This report contains information on the graduates of the university. It includes students' registration, new admission and graduates by programmes and field of study.

2. Indicators for financial Resources

- Which are the sources of financial resources? *Survey of Science and Technology Indicators - methodology as defined in the Frascati manual.*
- Are estimates made to complement the use of these sources? *Yes. Data are repeated or estimated after consultation with the non-responding agency.*

3. Human resources indicators

- What sources used for the construction of human resources indicators? *Survey of Science and Technology Indicators - methodology as defined in the Frascati manual.*
- *Aggregates are compiled annually by sector and population data are published decennially from Source 1 (1.2). counted separately- from data provided on number or research-types provided.* Are estimates made to complement the use of these sources? . *Yes. Data are repeated or estimated after consultation with the non-responding agency*

4. Organization of the Statistical Unit

Describe briefly how these sources are processed to construct the aggregated indicators. Describe how variables are defined (eg. What methods are used to determine what part of an institution's budget corresponds to R&D *Science and technology indicators are monitored by The National Institute of Higher Education, Research, Science and Technology (NIHERST) of Trinidad and Tobago. The Statistical Unit comprises of three members of staff: one senior statistician on contract, one permanent research officer and one technician. As required data collection and other support staff may be employed on a temporary basis. Staff are dedicated to the compilation of S&T indicators and the unit is not affected by staff rotation. The institution has identified a number of primary sources engaged in the production of science and technology indicators which have been collated and published.*

What human resources are there and what specialization level do they have? Several individuals work in this area. NIHERST has worked with and received assistance from RICYT and other multilateral sources. It also hosted some of the CCST workshops on S&T indicators

- To what degree are they dedicated to this area? This is done as part of normal duties.

5. Main issues and initiatives in S&T Statistics

Some common problems encountered in compiling the indicators are:

- *a lack of co-operation from respondents particularly the private sector, as a consequence of the confidential nature of the data requested, despite the undertaking of confidentiality,*
- *accounting systems do not generate expenditure on scientific and technological activities separately which in most cases are performed with the same resources used on routine assignments, and*

Some suggestions for improvement:

- *Trinidad and Tobago has committed resources towards indicator production but regional dialogue and co-operation are required in the area of survey methodology. Other agencies, mainly the private sector, need to recognize the importance of providing data on science and technology activities.*