National Commission on Science and Technology

Report on

Science &Technology Input and Output Indicators For Jamaica

Volume 1, December 2005

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Introduction

Science and Technology (S&T) Indicators are statistical data that are used to measure progress in S&T, thus providing a mechanism for the proper assessment and management of S&T. These may be **input** or **output** indicators and include data on expenditure on S&T, expenditure on research and development (R&D), information on human resources involved in S&T activities, publications, patents, combined data on high technology investments and trade, cooperative agreements on transfer of “know how” and imports and exports of components and services with a high technology content.

These indicators are useful for:

(a) *Signalling and monitoring*: giving insight and calling attention to developments and trends in the science and technology system and its environment;

(b) *Accountability, evaluation and allocation*: setting and justifying science and technology budgets and giving insight into the performance of the science and technology system against the goals established by policy makers and planners;

(c*) Legitimization*: support for existing policies and,

(d*) Awareness*: providing information to set aside prejudices and incorrect perceptions of the performance of the science and technology system.

In the public sector, statistics on S&T inputs and outputs should support formulation of S&T policy, provide advice to ministers and other senior officials, provide support for, and justification of S&T programme expenditures, and provide information on scientific activities for relevant stakeholders. The data should also provide important information for the assessment of innovative capabilities and identification of technology gaps.

In keeping with the strategic objective of collection and use of vital national S&T information outlined in Science and Technology Policy (2005) currently before Cabinet, the National Commission on Science and Technology has placed great emphasis on the development of a set of S&T Indicators for Jamaica, to begin the process of assessment of national S&T competence, identifying markers of progress and making necessary recommendations to set the stage for improved efficiency.

This first volume of the ***"Report on Science &Technology Input and Output Indicators For Jamaica"*** is a precursory attempt at fulfilling the objective outlined above. It provides information on public sector expenditure on S&T and Research and Development (R&D), a critical input indicator, which, when matched with corresponding output indicators, should provide the basis for national budgeting by performance of S&T. The first steps in the analysis of output indicators have begun with preliminary data on patents granted by Jamaica, and the status of publication rates by researchers in our local academic institutions. In subsequent reports, focus should undoubtedly be placed on the status of rates of publication in our public sector organizations.

In keeping with the policy objective of development of Jamaica's human resource capacity in S&T, the report also provides useful data on qualifications in S&T, based on the number of degrees awarded by our local universities and colleges.

The report, then, should provide useful information to policy makers and researchers engaged in policy reform and development.

Methodology/Scope

Formal requests for actual expenditure on R&D and S&T were made of the approximately 44-membered Jamaican S&T/R&D infrastructure (Annex) and exhaustive follow-up was done to obtain and clarify the data. Data was received from all organizations surveyed.

Data on patents was obtained from the patents register at the Jamaica Intellectual Property Office, an agency of the Ministry of Commerce, Science and Technology.

The University of the West Indies (Mona) (UWI), University of Technology, Jamaica (UTECH), Northern Caribbean University (NCU), and the College of Agriculture, Science and Education (CASE) provided information on publications and number of S&T degrees awarded.

SECTION I. PUBLIC SECTOR EXPENDITURE ON R&D AND S&T

Expenditure on S&T and R&D Relative to Total GOJ Expenditure

Table 1 outlines data on public sector expenditure on S&T and R&D during 2001 and 2004. The data reflect a 58% increase in public sector expenditure on S&T and 75% increase in the expenditure on R&D from 2001 to 2004.

Total expenditure on S&T-related activities represented 3.3% of the total GOJ budget in 2004, an increase of just over 22% from that expended in 2001. On the other hand, government's expenditure on R&D in the public sector increased by 57% from 2001 to 2004 and from 0.3% in 2001 to just under 0.5% of the total budgetary expenditure.

Table 1: Total public sector expenditure on S&T and expenditure on R&D relative to total Government of Jamaica (GOJ) budget of expenditure and GDP during 2001-2004.

$'000	2001	2002	2003	2004
R&D	270,984	400,752	644,947	642,402
%R&D/Total GOJ Budget	**0.30**	**0.31**	**0.57**	**0.47**
%R&D/GDP	**0.10**	**0.20**	**0.30**	**0.30**
Total S&T	2,854,856	3,265,362	4,015,761	4,497,519
%S&T/Total GOJ Budget	**2.70**	**2.50**	**3.57**	**3.30**
%S&T/GDP	**1.0**	**1.4**	**2.0**	**2.0**

Expenditure on S&T and R&D in the Public Sector Relative to GDP

Public sector expenditure on S&T showed a 2-fold increase from 1% of GDP in 2001 to 2% of GDP by 2004. On the other hand, public sector expenditure on R&D was 0.1% of GDP in 2001 and reflected a 3-fold increase up to 0.3% of GDP by the 2004/05 fiscal year.

Figures on gross domestic expenditure on R&D (GERD) relative to GDP for 20 countries are given below (UNESCO:UIS 2004):

Country	Year	%R&D/GDP
CARIBBEAN		
Bermuda	1997	0.08
Cuba	2002	0.62
Jamaica	***2004***	***0.30***
St. Vincent	2002	0.15
Trinidad and Tobago	1999	0.14
LATIN AMERICA		
Argentina	2002	0.42
Brazil	2000	1.04
Chile	2001	0.54
Costa Rica	2000	0.39
Mexico	2002	0.43
Venezuela	2001	0.44
OECD		
Canada	2002	2.00
China	2002	1.23
Finland	2002	3.46
France	2002	2.27
Japan	2002	3.11
The Netherlands	2000	1.95

Sweden	2000	4.61
Switzerland	2000	2.64
United Kingdom	2001	1.90
United States	2001	2.80

The GERD figures above for other countries also include industrial investment in R&D, but provides a reasonable benchmark for comparisons.

It is widely accepted that highly prosperous, industrialized nations of the world generally invest heavily in R&D and S&T. Even smaller developed States such as Sweden, Finland and Switzerland make heavy investments in R&D. This is reflected in R&D/GDP percentages of 4.6%, 3.5% and 2.6%, respectively, for the latter countries, as compared with figures for the USA (2.8%), UK (1.9%) and Japan (3.1%), for example.

Jamaica compares well with several Caribbean and Latin American territories (Cuba (0.62%), Trinidad and Tobago (0.14%), Costa Rica (0.39%), Mexico (0.43%) and Venezuela (0.44%), for example) based on their investments in R&D, however, the country should seek to increase investments in R&D up to 1 or 2% of GDP in the short term to increase its innovative capacity, as a tool for economic growth and development.

Sectoral Expenditure

As shown in Table 2, and as is expected, the highest government investment in R&D activities resided with research institutions, reaching a high of just over 49% of total expenditure of these institutions in 2004. However, based on the raw data, it was apparent that, in most instances, the bulk of expenditure of these organizations was concentrated on salaries, being over 50% in many instances. It is clear that there is need for rationalization and correction of this situation, if based on output, the role in production and technology transfer of these institutions is to be actualised.

Table 2: Sectoral public sector S&T expenditure and expenditure on R&D during 2001-2004

$'000	**2001**	**2002**	**2003**	**2004**
Public Sector				
R&D	80,628	132,732	253,850	245,406
Total	1,750,535	1,914,818	1,950,962	2,194,289
%R&D/Tot.	4.6	6.9	13.0	11.2
Research Institutions				
R&D	146,031	140,701	239,348	255,423
Total	461,011	455,730	499,496	517,036
%R&D/Tot.	31.7	30.9	47.9	49.4
Higher Education				
R&D	59,554	90,719	99,876	75,413
Total	678,726	774,283	1,142,903	1,298,194
%R&D/Tot.	8.7	11.7	8.7	5.8

It is also clear from the data presented on public sector organizations that R&D investment and hence, activities, should be increased, as R&D expenditure was only 5 – 13% of total expenditure in these S&T public sector organizations.

Government investment in R&D in Higher Education institutions is woefully inadequate ranging between 6 and 12% of total expenditure in these institutions during 2001 – 2004. Most of the research activities of these institutions are supported by overseas or local funding agencies, and government's contribution, except in the case of the UWI, is largely negligible.

Local competence cannot be reasonably or sufficiently built based largely on external bodies, which have their own development agenda.

SECTION II. TECHNOLOGICAL ACTIVITY MEASURED BY THE NUMBER OF PATENTS GRANTED

According to the principle of published patents indicator, technological activity may be characterized by the number of patents published by patent offices. Patents relate to, and are published by each national patent office and the decision to patent an invention forms part of a strategy for the exportation and protection of industrial property. The world's two biggest patent systems are the US and European patent systems.

In Jamaica, the patent system was first legislated in 1857. With the formation of the Jamaica Intellectual Property Office (JIPO) in 2001, the Patent Act has since been revised.

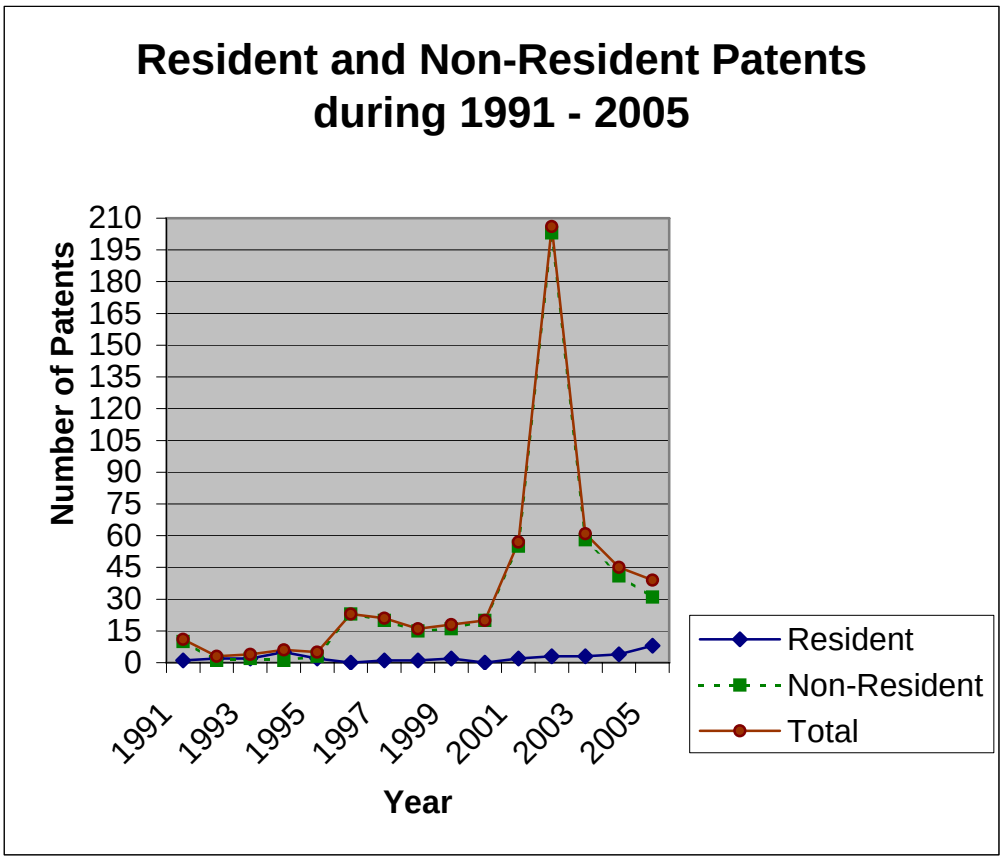
Figure 1 provides data on the number of patents granted in Jamaica to residents and non-residents during 1991-2005. As depicted in the figure, the number of patents granted to non-residents far outweighed those granted to residents in most instances, except during 1992 to 1994, when the number of grants was relatively low, and those to residents in two of three instances surpassed or equalled grants to non-residents.

The highest number of patents granted was recorded between 2001 and 2005, with an exceptionally high number of grants to 203 non-residents and 3 residents in 2002. Total number of grants ranged between 16 and 23 patents during 1996 – 2000.

The most notable patents awarded to residents during the period included a bedding system to a member of the private sector in 1994, a teaching aid in 1995 and two patents to individuals of the University of the West Indies (Mona) (UWI) for xanthum gum from molasses and nematicidal medicaments from plants in 1998 and 2002, respectively. Other examples include a patent granted to the Rural Agricultural Development Authority (RADA) in 2003 for the RADA cassava pancake mix.

Non-resident grants were made to individuals and companies based in Trinidad and Tobago, USA, Canada, UK, Japan, Hungary, Germany, Switzerland, Saudi Arabia, among others. Applications granted included those ranging from mouthwashes, fabric softeners, anti-fire agents, pharmaceuticals to pesticides.

Figure 1. Number of Patents granted by Jamaica during 1991 – 2005



	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05*
Residents	1	2	2	5	2	0	1	1	2	0	2	3	3	4	8
Non-Residents	10	1	2	1	3	23	20	15	16	20	55	203	58	41	31
Total	**11**	3	4	6	5	23	21	16	18	20	57	206	61	45	39

* - To Sept. 2005

SECTION III. SCIENTIFIC ACTIVITY MEASURED BY THE NUMBER OF REFEREED PUBLICATIONS (FROM UNIVERSITIES)

Scientific activity is traditionally measured by the production of scientific publications, that is, the number of articles published in scientific journals (science bibliometry). However, scientific publications are, indeed, but one of the basic products of scientific work. Other products generated by science also include higher education and technical expertise.

Data on science bibliometry is most popularly based on the Science Citation Index (SCI) and Compumath databases established in the 1980's by the Institute of Scientific Information (ISI) in the USA. The SCI provides coverage of articles of the 2,500 most cited scientific journals, but is limited by the fact that it covers primarily English-language journals based in Anglo-Saxon countries.

According to the SCI and Compumath databases, 38.4% of the world's scientific activity is concentrated in North America, 35.8% in Western Europe and 10.1% in Japan and the Newly Industrialized Countries (NICs).

In terms of strengths of disciplinary specialization, North America is reportedly very strong in the areas of fundamental biology and the earth and space sciences, while Western Europe's strong point is medical research. Japan, the NICs, China and the central Asian countries hold strong positions in physics, Chemistry, the engineering sciences and technology, but are reportedly weaker in the life sciences in general (except for Japan).

Table 3 provides data collected on the number of refereed S&T publications during the 2000/2001 to 2004/2005 academic years from Jamaica's three major universities. The UWI (Mona) is the single largest producer of refereed publications among Jamaica's tertiary institutions involved in S&T research activity. The number of refereed publications from the Faculty of Pure and Applied Sciences – (for disciplines including Chemistry, Life Sciences, Physics, Computer Sciences and Mathematics and Geography and Geology), and the Department of Basic Medical Sciences (including Biochemistry, Pharmacology and Physiology), registered a 2.1-fold increase from 58 in the 2000/2001 academic year to 120 by 2002/2004. Thereafter, there was a marginal increase in publications in the following academic year, followed by a 10% decrease by the 2004/2005 academic year.

With the upgrade to university status of the University of Technology in 1995 and the Northern Caribbean University in 1999, a shift in research orientation of these institutions have begun to evolve. The institutions are now increasing infrastructural and human resource capacities to strengthen scientific activities and the publishing of research work is beginning to emerge, with the number of refereed S&T publications for UTECH and NCU totalling 12 and 8, respectively, up to the 2004/2005 academic year.

SECTION IV. NUMBER OF S&T DEGREES GRANTED BY MAJOR JAMAICAN UNIVERSITIES AND COLLEGES

Table 4 outlines the quantities of certificates, diplomas and undergraduate and postgraduate degrees in S&T awarded during academic years 1999/2000 to 2004/2005 by the major Universities and Colleges, UWI (Mona), UTECH, NCU and CASE, while Figure 2 depicts the trends in the number of awards of degrees over the period. The data represent the number of awards from the Faculty of Pure and Applied Sciences and Department of Basic Medical Sciences within the

Table 3. Number of refereed publications in S&T from major Universities in Jamaica during 2000 – 2004

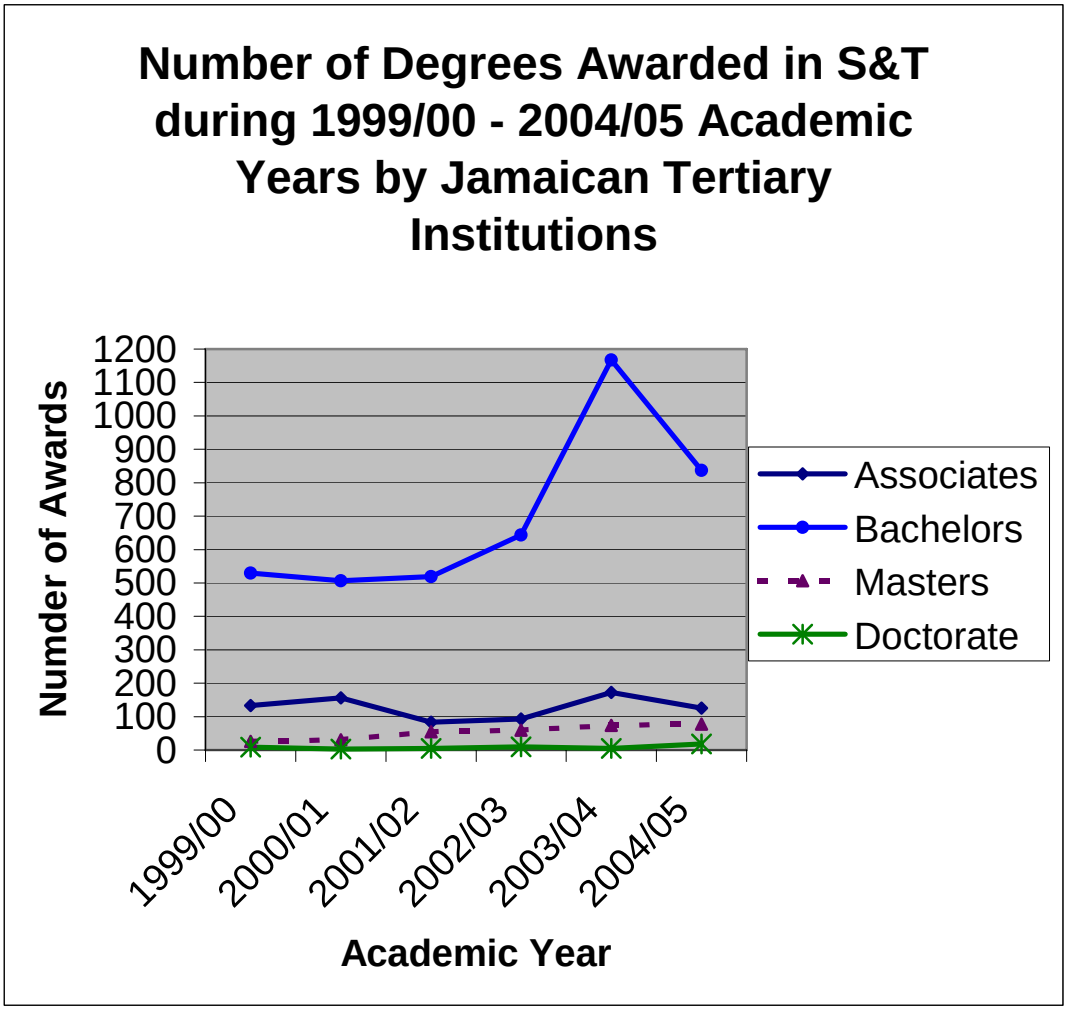
YR/ INST.	**2000/01**	**2001/02**	**2002/03**	**2003/04**	**2004/05**
UWI	58	84	111	120	87
UTech	**-**	-	-	-	12
NCU	**-**	**-**	1	4	3
Total	**58**	**84**	**112**	**124**	**102**

Table 4. Number of certificates, diplomas, undergraduate and postgraduate degrees awarded by Jamaican Universities and Colleges in S&T during academic years 1999/00 – 2004/05.

Year/ Certification	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
Certificate						
Total=UTECH	**254**	**177**	**179**	**157**	**72**	**102**
Diploma						
Total=UTECH	**323**	**300**	**161**	**178**	**169**	**138**
A.Sc.						
NCU	10	23	12	23	43	30
UTECH	0	35	23	6	33	44
CASE	123	98	48	64	96	51
Total	**133**	**156**	**83**	**93**	**172**	**125**
B.Sc.						
UWI	253	252	244	241	212	325
UTECH	240	196	217	252	844	373
NCU	37	59	58	51	93	104
CASE	0	0	0	0	18	35
Total	**530**	**507**	**519**	**644**	**1167**	**837**
M.Sc.						
UWI	24	21	42	44	51	47
NCU	0	0	0	2	1	2
Total	**24**	**21**	**42**	**44**	**52**	**49**
M.Phil.						
UWI	6	10	12	14	15	20
UTECH	0	0	1	1	1	2
NCU	0	0	0	0	6	8
Total	**6**	**10**	**13**	**15**	**22**	**30**
Ph.D.						
Total=UW1	**9**	**3**	**5**	**10**	**5**	**18**

NCU **–** Northern Caribbean University; UTECH – University of Technology; UWI – University of the West Indies (Mona)

Figure 2. Trend in Number of Degrees awarded in S&T by Jamaican Tertiary Institutions during 1999/00 to 2004/05 Academic Years.



Faculty of Medical Sciences of the UWI (Mona), the Faculty of Health and Applied Sciences and the School of Computing and Engineering of UTECH, the College of Natural and Applied Sciences of NCU and the faculties of Science and Agriculture of CASE.

Certificates and Diplomas awarded by UTECH have been in disciplines including Health Services, Child Care and Development, Arts and Science of Coaching and Computer Sciences. To facilitate upgrading of training of previously trained diplomas, Pharmacy, previously offered as a diploma course, has now been upgraded to a post-diploma programme and a degree programme. Most of the courses offered in the Faculty of Health and Applied Sciences of the University are now being upgraded to degree programmes. The University only currently offers Associate Degree programmes in Science Laboratory Technology and Computer Science.

The total number of bachelors' degrees in S&T disciplines by the four tertiary institutions ranged from a low of 507 to a high of 1,167 during the 6-years period. Over the period, the number of masters' level degrees granted in the pure and applied sciences by the UWI, NCU and UTECH, ranged from a low of 30 in 1999/00 to a high of 79 in 2004/05. In fact, the total number of graduates awarded Masters degrees in these fields, steadily increased annually and reflected an overall 62% increase by the end of the 2004/05 academic year.

Graduates awarded Ph.D. degrees in S&T disciplines were produced only by the UWI. The number of Ph.D. degrees awarded included those in the pure and applied sciences and basic medical sciences and ranged from a low of 3 in the 2000/2001 academic year to 18 by 2004/2005. A total of 50 Ph.D. graduates in the pure and applied and basic medical sciences disciplines were produced over this 6-years period.

Table 5 shows data on the award of certificates, diploma and degrees in engineering by UTECH. The number of certificates in engineering decreased from 116 in 1999/2000 to 8 in 2004/2005, in keeping with efforts at upgrading to higher levels of certification. Simultaneously during this period, the number of diplomas fluctuated from a high of 142 in 2000/2001 to a low of 13 in 2003/2004. The number of graduates with B.Sc. degrees in engineering averaged 42 graduates per year during 199/2000 to 2002/2003. This was followed by a dramatic peak to 399 in 2003/2004 and a subsequent decline to 87 in 2004/2005.

Table 5. Number of Certificates, Diplomas and Degrees in Engineering (from the University of Technology)*

Year/ Certification	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
Certificate	116	71	89	24	0	8
Diploma	121	142	77	108	13	82
B.Sc.	46	42	35	45	399	87
M.Phil.	-	-	-	-	-	1

* Data included in Table 4

RECOMMENDATIONS

The following recommendations are being made in the context of the experience in the collection and subsequent analysis of data:

- In light of the importance of this kind of work, supply of information should be mandatory and a policy requirement of government to allow for timely and accurate collection and analysis of data.
- Budget line items should be delineated to show specific allocations to R&D to facilitate monitoring & assessment.
- Budgetary allocations to R&D especially in “R&D Institutions” should be significantly increased and maintained above 50% of the total budgets of these institutions.
- Public sector institutions should be engaged in more R&D activities and appropriate funds provided to facilitate this endeavour.
- The R&D allocation to “Higher Education” institutions should be significantly increased and R&D activities in these institutions should be geared more directly towards government’s S&T policy objectives. Increased allocation for R&D activities is especially necessary for UTECH and CASE.
- ‘Input’ indicators such as budgets, should be compared with ‘output’ indicators including indicators of productivity and this information should guide future budgetary allocations to institutions by government.
- Numbers of local patents should be increased and specific strategies implemented to encourage individuals and organizations to protect their inventions.
- Requisite internal and external mechanisms should be implemented in tertiary institutions, especially UTECH, NCU and CASE, to support increased research activities and consequently publications output, in reputable journals. These universities and colleges in transition could increase collaborations with their overseas counterparts to enhance scientific output.

- Public sector organizations involved in *bona fide* research activities should be mandated to publish their research findings.
- The Planning Institute of Jamaica and Statistical Institute of Jamaica should be mandated to collect relevant S&T data as a part of their regular data collection activities.
- Work on conducting research on S&T indicators should be supported through funding allocated specifically to this activity.

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Annex 1: Classification and Listing of Institutions

The organizations surveyed were classified into four major categories according to the classification outlined in a previous publication of the NCST – "*Science and Technology in Jamaica: A Review of Public Sector Organizations (2nd Edition)*" :

Higher Education – Composed of universities and colleges of post secondary education.

Research Institutes – Composed of institutions having R&D as a significant part of their mandate. With the exception of the Scientific Research Council, they do not receive direct budgetary support from Government.

Public Sector (Government) – Composed of entities and departments that provide certain common services that cannot otherwise be economically and conveniently provided. These are funded from the Government's budget. They may or may not undertake R&D as part of their mandate.

List of Institutions Surveyed by Sector

Higher Education

University of the West Indies
Faculty of Pure and Applied Science
Faculty of Medical Science
Biotechnology Centre
Centre for Environment and Development
Centre for Marine Science
International Centre for Environmental and Nuclear Science
Tropical Medicine Research Institute
University of Technology
College of Agriculture Science and Education
Northern Caribbean University

Public Sector (Government)

Agricultural Development Corporation

Citrus Growers Association

Cocoa Industry Board

Coconut Industry Board

Coffee Industry Board

Food Storage and Prevention of Infestation Division, Ministry of Commerce, Science and Technology

Forensic Laboratories, Ministry of Security and Justice

Geology and Mines Division, Ministry of Agriculture?.

Government Chemist Laboratory

Institute of Jamaica

Bureau of Standards Jamaica, Min. of Commerce Science and Technology

Fisheries Division, Min. of Agriculture

Bodles Research Station, Ministry of Agriculture

Veterinary Services Division, Min. of Agriculture

Rural Physical Planning Division, Ministry of Agriculture

Environmental Control Division, Min. of Health

Vector Control Unit, Min. of Health

National Irrigation Authority

National Public Health Laboratories

National Water Commission

Natural Resources Conservation Authority

National Commission on Science and Technology

Pesticide Control Authority, Ministry of Health

Water Resources Authority

Research Institutes

Scientific Research Council, Min. of Commerce Science and Technology

Sugar Industry Research Institute

Jamaica Bauxite Institute

Banana Board

Natural Products Institute

Caribbean Agricultural Research and Development Institute

Earthquake Unit

Other

Petroleum Corporation of Jamaica

Caribbean Food and Nutrition Institute