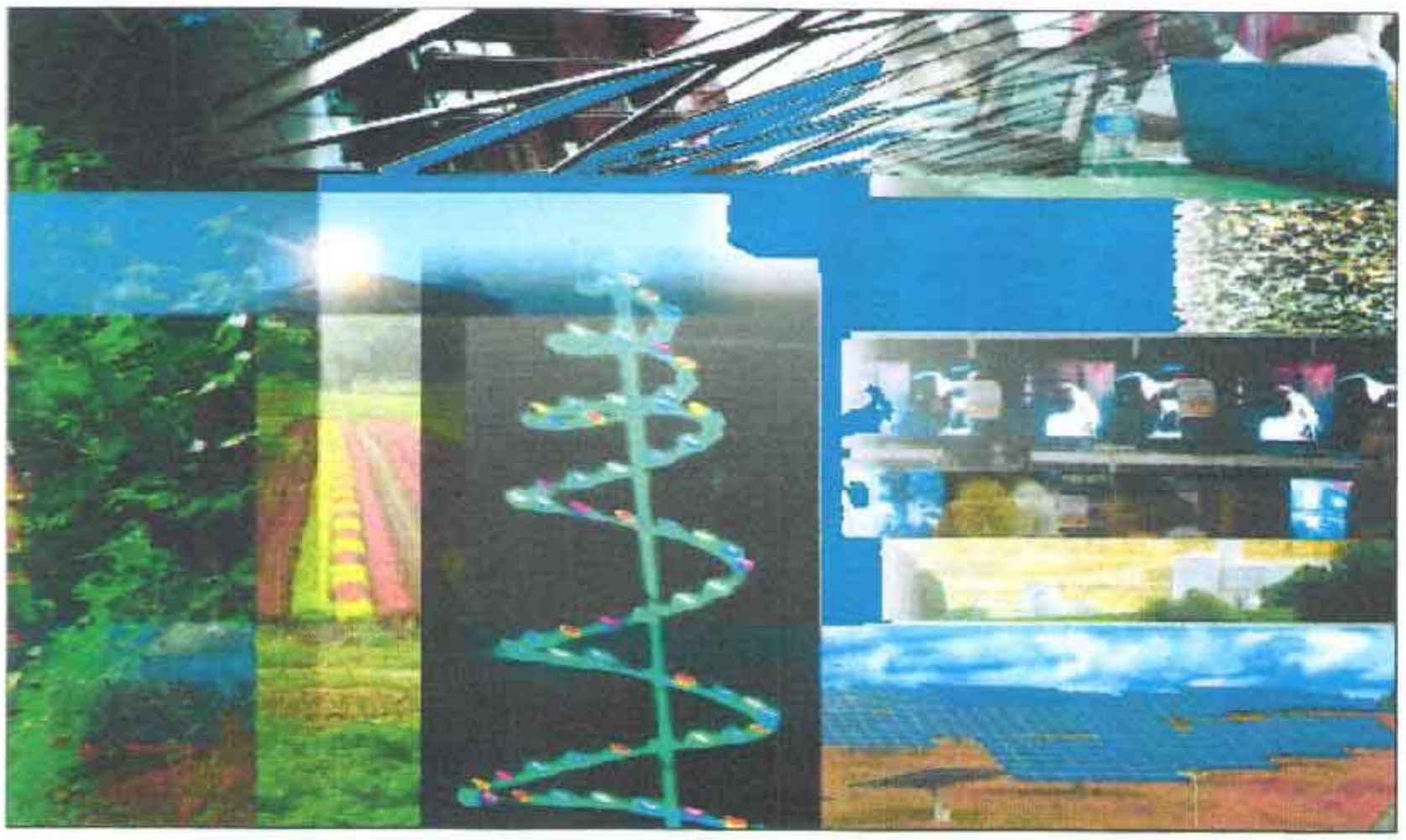

Jamaica Science Technology and Innovation Strategic Road Map

International STI Best Practice Delivery Models

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NEST

Final Draft 18/04/12

Contents

Introduction

The Principals of NEXT, Ian Ivey and Dr Nick Marsh, have had extensive experience in developing an understanding of how countries achieve economic and social progress by adopting an integrated approach towards national development. Many of the most successful examples can be found in small countries that face similar resource constraints to Jamaica. The difference between Jamaica and such small countries is essentially due to the fact that the latter have developed an integrated systems approach towards their entire economic and social development process. Such an approach is always implemented within a clearly defined long-term vision – one which defines the goals and end-objectives that the system is designed to support and achieve. Such goals and end objectives are revised on a regular basis to ensure that they remain relevant and take into account technological, sociological, political and economic trend shifts.

For this reason, this report focuses extensively on the structure of such integrated systems and the context that such a structure provides for thinking about the best way to derive value from national Science, Technology and Innovation (STI) initiatives and investments. It is not a sector that can perform effectively in isolation. It is just one small, but important, part of a much larger national system that either promotes or hinders economic and social progress. Such a system embraces many components and will only function if each of the components functions in a strategically aligned and mutually beneficial way. Some of the key components of such a system include:

- Educational Institutions at all levels – primary through to tertiary and life-long training/learning.
- Research and Development Organisations – public, private, and non-governmental organization operated.
- Business Development Organisations – public, private, and non-governmental organization operated.
- Regulatory and Trade Organisations – mainly public and non-governmental organization operated.
- Public Sector Agencies and Policy Development and Implementation Agencies.
- The Private Sector.
- Social Institutions – mainly public and non-governmental organization operated.
- Infrastructure Providers – public and private e.g. ICTs, ports, airports, transport systems, electricity, water, logistics services etc.

Unless all these groups work together towards a common long-term end-goal using a systems approach, it is challenging to achieve economic and social progress. The lack of economic progress in Caribbean region, compared to a number of other developing countries, is illustrated in Table 1. The forecast GDP/capita growth rate for Jamaica is one of the lowest in the region and internationally.

Table 1: Projected GDP/capita growth rates in 2012 for selected Caribbean and developing countries

Country - Caribbean	GDP/capita growth 2012	Country - Other	GDP/capita growth 2012
Antigua & Barbuda	2.0%	Columbia	4.4%
Bahamas	3.0%	Panama	5.1%
Barbados	0.5%	Peru	5.0%
Belize	3.0%	Chile	4.7%
Dominica	1.5%	Angola	10.8%
Grenada	2.5%	Côte d'Ivoire	8.3%
Guyana	4.0%	Ghana	7.5%
Jamaica	1.0%	Botswana	7.1%
St. Kitts & Nevis	4.5%	Rwanda	7.0%
St. Vincent & the Grenadines	3.0%	Zambia	6.7%
St. Lucia	3.5%	Kenya	6.0%
Suriname	4.5%	China	8.0%+
Trinidad & Tobago	1.0%	India	7.5%

In addition, Jamaica's Global Innovation Index (GII) ranking (a measure of the level of innovation within a nation) is low by international standards and has deteriorated in recent years – down from place 70 out of 132 countries in 2009/2010 to place 92 out of 125 countries in 2010/2011, as shown in Table 2.

Table 2: Global Innovation Index rankings for the top 10 nations and selected Caribbean countries ([1]

GII 2010/2011 (125 countries)		GII 2009/2010 (132 countries)		GII 2008/2009 (130 countries)	
Country	**Rank**	**Country**	**Rank**	**Country**	**Rank**
Switzerland *	1	Iceland *	1	USA	1
Sweden *	2	Sweden *	2	Germany	2
Singapore *	3	Hong Kong *	3	Sweden *	3
Hong Kong *	4	Switzerland *	4	UK	4
Finland *	5	Denmark *	5	Singapore *	5
Denmark *	6	Finland *	6	South Korea	6
USA	7	Singapore *	7	Switzerland *	7
Canada	8	Netherlands *	8	Denmark *	8
Netherlands *	9	New Zealand *	9	Japan	9
UK	10	Norway *	10	Netherlands *	10
Guyana	61	Barbados	50	Barbados	53
T&T	72	T&T	55	T&T	65
Jamaica	92	Jamaica	70	Jamaica	73
		Guyana	113	Guyana	103

[1] http://www.globalinnovationindex.org/gii/

All those countries marked with an asterisk in Table 2 have populations of less than 17 million persons. In 2009/2010, 70% of the top ten countries in terms of the GII were small countries. In 2010/2011 all the top 10 were small countries. These small countries are amongst the top performing countries in the world – both economically and socially.

According to a recent Global Entrepreneurship Monitor (GEM) report ([2]), Jamaica has a 'Factor Driven Economy', the least developed type of economy in the three categories used in the GEM evaluation process. 'Factor Driven Economies' are ranked lowest in terms of value creation. 'Efficiency Driven Economies' have achieved some level of value creation but mostly through economies of scale. 'Innovation Driven Economies' are those which generate the highest levels of GDP per capita internationally because the focus is not just on commodities and efficiency but how to generate the greatest value from a country's human capital and the resources that it has access to.

Jamaica is a small country and has a developed a national development plan, 'Vision 2030', the formulation of which has been supported by both the main political parties in the country. This is a positive situation because it provides a basis for continuous improvement and implementation no matter which political party is in power. The detail may change but the overall thrust is likely to remain.

No document of this type is perfect as it represents a great deal of consensus building and compromise. The value, however, is not in the detail. It is in the end goals, the targets for achievement that have been defined, and the allocations of responsibility that have been made. In 1996 Botswana, a poor nation, adopted a 20-year plan based upon a vision which aimed to increase GDP/capita 300% by 2016. By 2009 GDP per capita had increased by 700% and the country had achieved middle income status. The country's GDP continues to grow at annual rates of around 7%. This is just one of many examples, some of which will be described in greater detail in this report, that illustrate what can be achieved if a properly developed and detailed vision (similar to the Jamaican 'Vision 2030') is used to guide policy development and implementation programs in a country.

Of particular relevance to the STI Sector Strategic Roadmap project is an inferred end-goal included in the Jamaican 'Vision 2030' document which is essentially to lift the current GDP per capita level of approximately US$ 8,300 up to US$ 20,000+ by 2030 – a level commensurate with that prevailing in developed economies ([3]). This inferred end goal is used in this report in order to provide a context for the STI Sector Strategic Roadmap because one of the key platforms essential for achieving this end-goal is the contribution provided by the STI sector, a sector which should play a lead role in shifting an economy from being 'factor driven' towards becoming 'innovation driven'. To lift the GDP per capita levels in Jamaica by the magnitude envisaged in the 'Vision 2030' Plan will require a major shift towards a more innovative, modern and creative economy and society where value adding is at much higher levels than is the case today.

The STI sector in many countries around the world has tended to evolve in a fragmented and 'silo-based' fashion. As a result, the benefits delivered to the citizens of such countries by the STI sector have often

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2 http://www.gemconsortium.org/docs/640/gem-trinidad-tobago-2010-report

3 See pages 44 and 50 in the 'Vision 2030' document

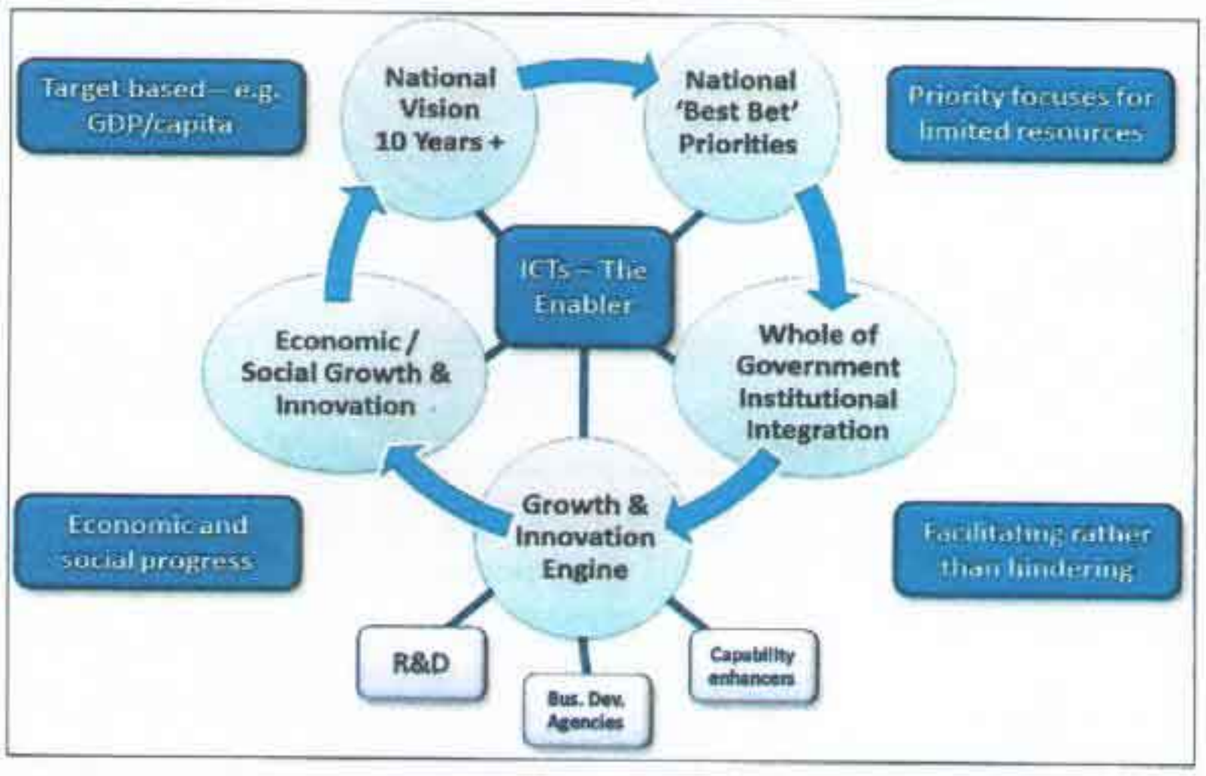
been less than satisfactory. A number of countries - including Singapore, Denmark, New Zealand, and South Korea (all relatively small countries) - recognized some years ago that to move forward, their STI sectors needed a new model to ensure that the greatest level of benefits could be delivered to citizens. In all cases these countries developed and have implemented (or are implementing) models that have transformed their STI sector into a mutually beneficial interconnected synergistic eco-system (a cluster type model) within an overarching National Innovation System and moved away from a traditional model that resulted in the evolution of numerous independent entities pursuing their own agendas, often in isolation and often not aligned towards a common national end-goal.

It is important to realize that a country's investment into STI is not for the benefit of individual institutions and individual persons. It is for the benefit of all citizens and the country as a whole. That is why it is important to review the current status of the STI sector in Jamaica and, through a comprehensive stakeholder engagement process, develop a consensus-based way forward that, if correctly implemented, will maximise the contribution from the sector towards achieving the ultimate inferred 'Vision 2030' end-goal – a GDP per capita of US$ 20,000+ by 2030. Other countries have been able to achieve such results. Now it is Jamaica's turn.

The Overall Context for National STI Sectors

To develop an STI Sector Strategic Roadmap for Jamaica, there needs to be a context within which the sector contributes towards national economic and social progress. A common characteristic of the small countries that feature in top 10 GII countries (shown previously in Table 2) is the approach they have adopted to advance their economies economically and socially. That approach can be best described as a National Innovation System (NIS) – a system that has a long-term goal and which engages and aligns resources and a broad range of relevant stakeholders within an integrated systems-based approach towards achieving that goal. A NIS is a dynamic system that evolves over time because the parameters associated with achieving the primary end-goal within a national vision alter over time and so how such change impacts upon the aims and form of the original vision needs to be monitored and reviewed on a regular basis. Changes to the vision will need to be made to reflect those changing impacts. In simple terms a NIS is a dynamic system and the context for STI within it can be simply described as shown in Figure 1.

Figure 1: The 'big picture' context illustrating how STI needs to be part of an integrated National Innovation System (NIS) in order to deliver effectively ([4])



The individual components of the NIS illustrated in Figure 1 are described in more detail in the following sections.

National Vision 10 Years +

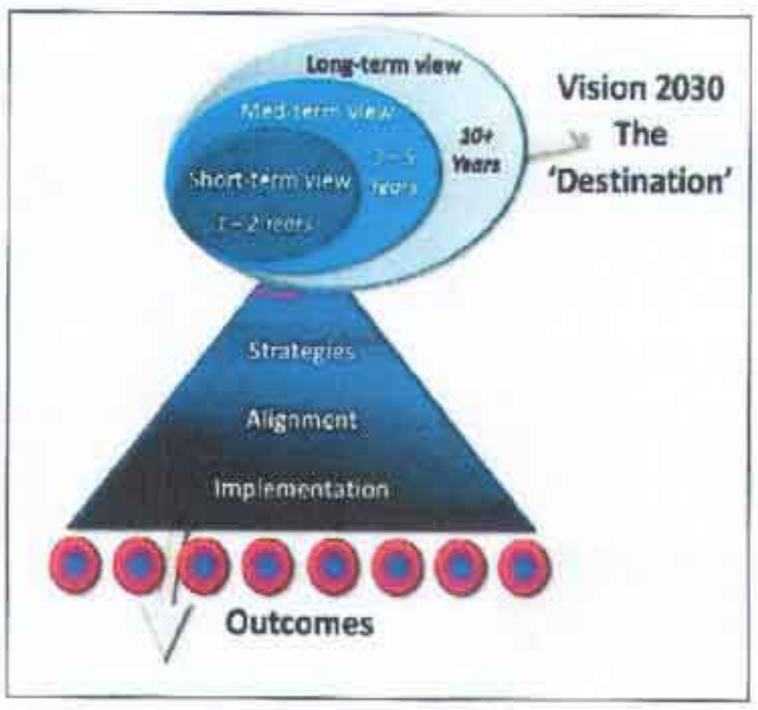
This is a vital component of any NIS as it provides a long-term end-goal towards which every person and every entity playing a role in economic and social development can aspire to. It is the preferred 'destination' towards which the entire nation is traveling. A useful analogy is a team of oarsmen/women in a large ocean-going canoe. If no-one knows what the ultimate destination is different persons tend to

[4] NEXT archives

paddle at different speeds and in different directions and the canoe spins around in circles. However, if the ultimate destination is clearly defined, everyone paddles in the same direction in a unified fashion to reach that destination.

A national vision is the destination which everyone aspires to reach – such as the 'Vision 2030's' inferred end-goal of achieving a GDP per capita level of US$ 20,000+ by 2030. By defining such a destination and end-goal, the process of developing medium-term policies and strategies, as well as annual business and operational plans to facilitate their implementation, becomes more meaningful and purposeful. It is also easier to set short-term targets that are aligned towards the long-term end-goal, to allocate responsibilities for achieving them, and to set key performance indicators (KPIs) that can be used to measure progress towards both intermediate targets and long-term end-goals. Figure 2 illustrates how the long-term end-goal shapes every aspect of the journey towards it and all the outcomes that are achieved this year, next year, and in ten years' time.

Figure 2: The preferred long-term 'Destination' (Vision) shapes the medium- and short-term policies, strategies, implementation processes, actions, and the outcomes achieved ([5])



If a nation does not have a clearly defined 'destination' towards which people and institutions can strive, the situation ends up being somewhat like the paddlers in the canoe. They make little progress because they are all paddling in different directions and end up going around in circles.

National Best Bet Priorities

This is another critical component for small countries. They simply do not have the skills sets and resources to do everything and achieve the best outcomes. Small countries that have achieved rapid economic and social progress have not tried to be good at everything. Rather, they have tended to focus on a few key strategic priority areas where they have good access to resources and the essential capabilities and enablers (infrastructure, skills-sets, natural resources, creative talents, uniqueness).

[5] NEXT archives

They then prioritise such capabilities, enablers and resources towards specific initiatives within those priority areas that have the potential to generate the greatest pay back and value to the citizens of a country.

In an analysis of ten small countries that have made substantial economic and social progress over recent years using an NIS approach completed by NEXT in 2008 ([6]), a common factor was their focus on a small number of high priority areas as shown in Table 3. **It should be stressed that the strategic focus of the most successful countries internationally has been on priority areas rather than priority sectors.**

Table 3: The number of key priority focus areas for each of 10 small countries/citistates

Country/Citistate	Priority Areas	Country/Citistate	Priority Areas
Qatar	3	New Zealand	3
Singapore	4	Norway	4
Botswana	4	Iceland	3
Denmark	4	Dubai	4
Dalian (China)	4	Laos	4

The pattern is consistent. Every small country that has made, or is making, successful economic and social progress has adopted a well-defined priority area approach which enables precious limited resources to be directed towards a small number of areas that offer the greatest potential for progressing a country towards its long-term end-goal(s).

Whole of Government Institutional Integration

This is perhaps the most challenging component of any NIS. Government ministries and agencies have tended to develop in a rather haphazard way over time. Each receives its own resourcing and each tends to pursue its own agenda, often in isolation. In other words, each tends to operate within its own 'vertical silo' resulting in limited collaboration and few opportunities to develop synergies. This applies to the STI sector as well as many other branches of the public sector. The development of most, if not all, Caribbean nations is being seriously hindered because of the fragmented organizational structure of the public sector and a lack of collaboration and synergies.

Successful small countries such as Singapore, South Korea, New Zealand and Denmark have focused strongly on rationalizing their public sectors to ensure that customer service, collaboration and synergy generation become essential components of their mandate.

Singapore has probably achieved the greatest success in this area compared to any other country in the world. That is one reason why it is now ranked number 5 in the latest global GDP per capita rankings. Their public sector is highly customer and service-oriented and is tasked with providing top-class service at all times. Every ministry and every state agency is required to contribute towards national economic and social development through policy and strategic plan development and implementation, defined target setting, accountability allocation, and progress monitoring and evaluation.

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[6] 'National Growth and Innovation Strategies and Frameworks', Ian Ivey and Nick Marsh, 02/2008. NEXT/NIHERST

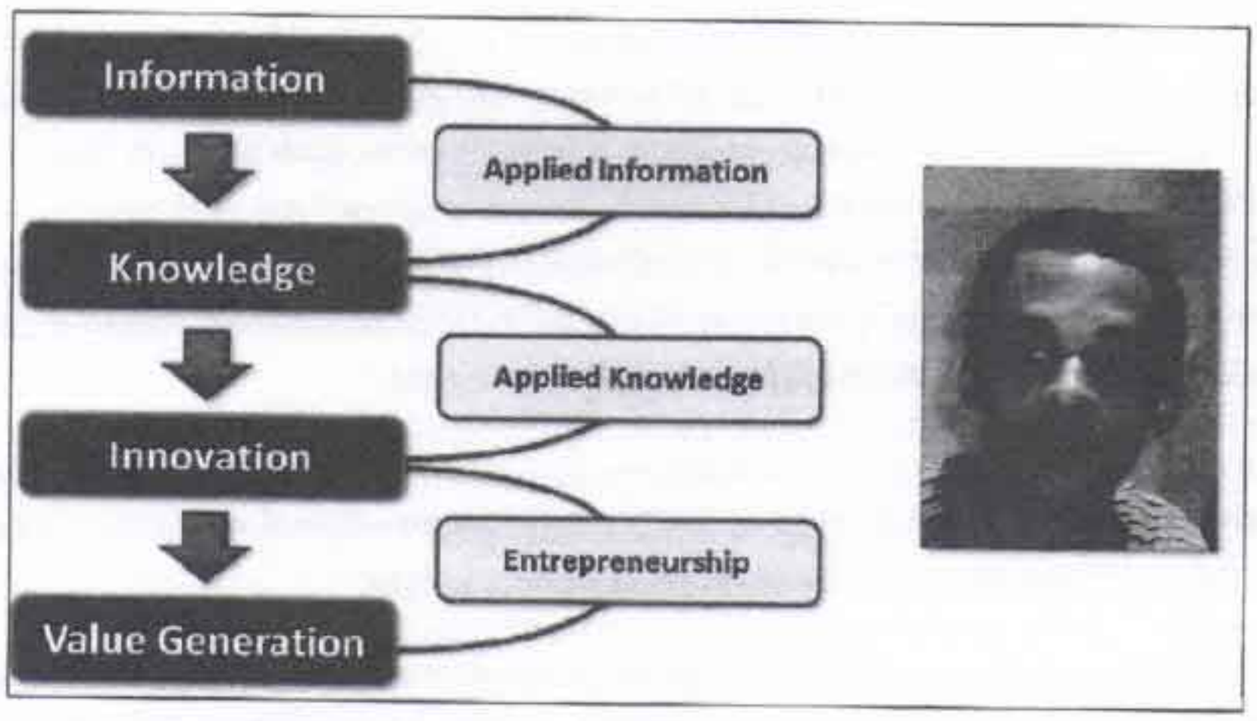
If government ministries and agencies are all 'paddling in different directions', then the canoe spins around in circles and little economic and social progress can be made. That is typical of what is happening throughout much of the Caribbean.

Growth & Innovation Engine

This is the most important part of a NIS. It embraces a wide range of institutions and entities which provide the capability and enablers necessary for innovative solutions to be formulated, delivered and to generate value. It is important to recognize that the 'Engine' does not just embrace R&D institutions. It also embraces business development agencies and organisations (public and private); capability and enabler enhancers (public and private) such as educational and training institutions; infrastructure providers; standards and regulatory agencies; funding and resourcing agencies; social program developers; trade development agencies; and any other public or private agency or institution that plays a role in supporting the advancement of a country economically and socially.

In an integrated NIS, the STI and R&D sector must collaborate with other 'Growth and Innovation Engine' stakeholders in order for a successful outcome is to be achieved. The Danish and Singapore models focus strongly on encouraging such collaboration and the generation of mutually beneficial synergies and their funding strategies and policies reflect this. In essence, the 'Growth and Innovation Engine' facilitates the process described in Figure 5.

Figure 5: The key outcome of collaborative efforts between the institutions, agencies and organisations within a national Growth and Innovation Engine



In other words, it is a system within the overall NIS that converts information into knowledge which is then applied to develop innovative solutions that entrepreneurs then utilise to generate the greatest possible value through commercial ventures. It is a continuum and the STI and R&D sector is just one part of that continuum. For this reason, it needs to be closely connected with all the other 'Growth and Innovation Engine' stakeholders and their associated agencies and entities.

Economic/Social Growth & Innovation

This is the output area for the entire NIS system. That output is measured in terms of new business developments that generate greater value from a range of resources (physical and human), expansion of existing businesses into additional higher value creating areas, and social programs that deliver far greater value for the state funds invested than was previously the case.

In the latter case an excellent example is shown in Figure 6. In this case if a preventative intervention could have been developed and implemented in the first three years of Jack's life, substantial societal costs later in his life may not have been incurred. The return on investment for a successful intervention in the first 3 years is estimated to be $9.70 for each $1.00 invested and drop to $1.50 for each $1.00 invested by age 14 – 18.

Figure 6: The cost of 'cure' increases over time [7]

Jack's Troubled Career: The Rising Intervention Costs

Life Stage	Age (Years)	Jack's Sequence	Risk Treatments	Treatment Costs USD
1	0-3	Problem parents	Social welfare	$6,900
2	3-5	Behavioural problems	Welfare/Care Psychiatry	$48,900
3	6-10	Foster care	Welfare/Care Health/Psych	$69,000
4	11-14	Crime / anti-social behaviour	Care /Education Police /Pysch	$198,150
5	15-17	Crime / anti-social behaviour	Care /Education Police /Pysch	$188,550
Jack's total Intervention Costs 0 – 17 years				$511,500
6	18+	Probable Outcomes: Unemployed; Prison; Suicide; Ill-health; Abusive father; Drug/alcohol dependent		

To reach Jamaica's 'Vision 2030' end goal (the inferred GDP per capita level of USD 20,000+ by 2030), much of the country's STI investment must be focused towards projects and interventions that lead to outcomes that provide the highest returns on investment i.e. more towards the $9.70 in value delivered per $1.00 of public funds invested than at the $1.50 of value delivered per $1.00 of public funds invested – whether in the commercial or social sectors. This is the greatest challenge for any STI sector initiative in small countries – to develop a way of delivering the maximum benefits to a country, socially and economically, within the many resource constraints that apply.

[7] Jack's Troubled Career, H Philip Hepworth. http://umanitoba.ca/resolve/newsletter/Volume%206/vol6%5B4%5D.04.pdf

Best Practice Models

In this section the objective is to provide a brief overview of STI sector strategic and operational models which are being employed in various countries and states to maximize the benefits from public investments and initiatives. In some cases such models have already delivered considerable benefits. In other cases, the plans are still 'works in progress'. However, several such examples have been included in this report because they embrace areas that are worthy of consideration as Jamaica develops its STI Sector Strategic Roadmap.

Singapore

Overview

Singapore has made an amazing economic and social transition since it gained independence in 1965. At that time it was a country plagued by poverty, ethnic unrest, high levels of unemployment, squatting, and a lack of direction. Lee Kuan Yew had a vision for Singapore – to become one of the world's top ranking countries in terms of GDP per capita. In 2011 the IMF ranked Singapore as number 11 internationally in terms of nominal GDP per capita. In terms of GDP per capita based on purchasing power parity, Singapore ranked in place 4 in 2011 ([8]). Aside from the fact that Singapore has tended to have an autocratic political system (which a number of people in the Caribbean in particular use as a reason to quickly dismiss Singapore as an example of what can be achieved in other countries), of greater importance and relevance is the strong emphasis that the government placed upon developing areas of economic strength within a country which had essentially no natural resources and which had serious space constraints.

In the early years the main focus was on developing Singapore as a petrochemical and refining hub as well as a regional logistical centre through the development of its port and airport facilities – which are today amongst the best in the world. As time progressed, specialist manufacturing (in particular in the electronics sector), tourism, and financial services all became priority focus areas. In recent years the focus has changed once more and the main priority areas for the country are in five specific science-based areas. Such a transition is important to note as nothing remains constant. As Singapore evolved economically, it also needed to evolve in terms of its national priority focus areas.

The Singapore transition has also been quite profound in other ways. For example, in the early stages of economic development the country relied heavily on multinational companies to produce knowledge and transfer technology. Today the emphasis has shifted towards supporting indigenous innovation capabilities and the creation of locally based hi-technology companies within a National Innovation System - which the country calls a 'National Framework for Innovation and Enterprise' (NFIE). Singapore has found that the achievement of high levels of education alone is insufficient and that establishing an NFIE is important as it provides a system which enables the new knowledge being created by universities and R&D institutions to be exploited by laboratories and then commercialized by firms resulting in the dynamic growth of new smart enterprises.

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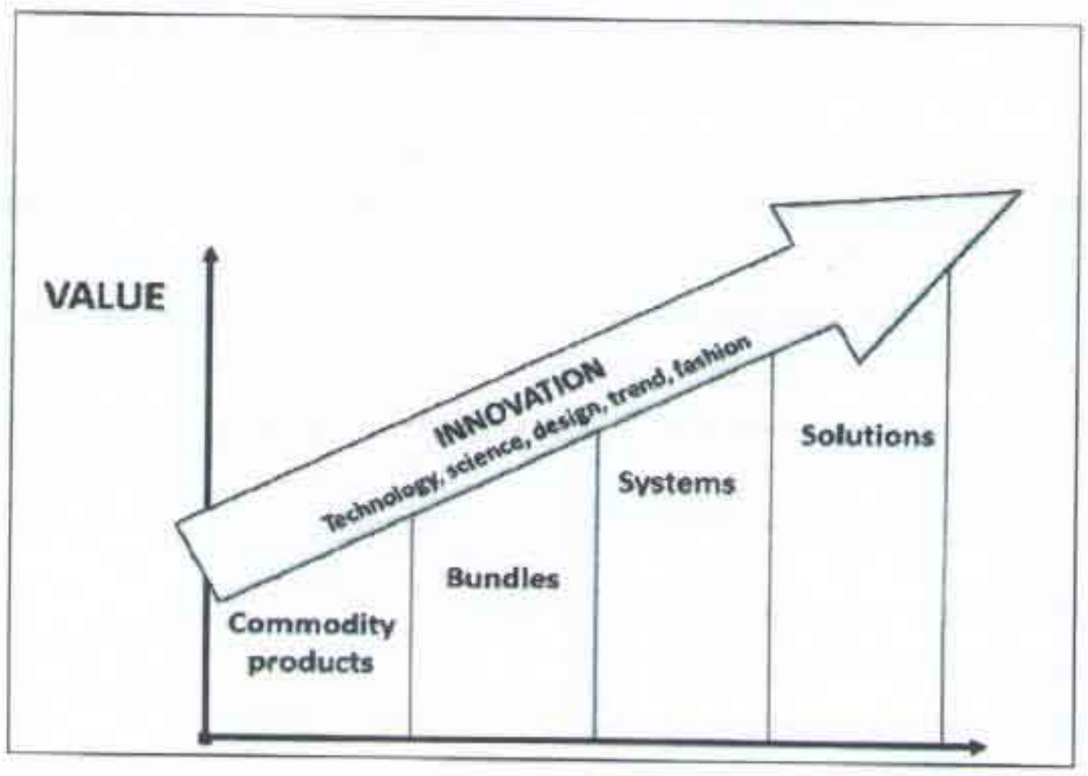
[8] http://www.indexmundi.com/g/r.aspx?v=67

The main objective of the NFIE is to derive a high level of value from the country's STI and R&D investments in the following ways:

- By encouraging and supporting academic entrepreneurship at the country's universities.
- By creating enterprise support structures that cover areas such as:
  - Proof of concept.
  - Technology incubators/business incubators.
  - Venture capital funding.
  - Support to attract international executives associated with high-tech high growth companies.
- Enhancing technology transfer and translational R&D grants by:
  - Promoting the use of IP.
  - Providing innovation vouchers for SMEs to procure R&D services.
- Supporting Innovation Policy studies.

In other words, the country has followed the value adding pathway illustrated in Figure 7 by setting up an integrated framework that turns knowledge into higher-end commercial added-value.

Figure 7: Applying knowledge to create value ([9]

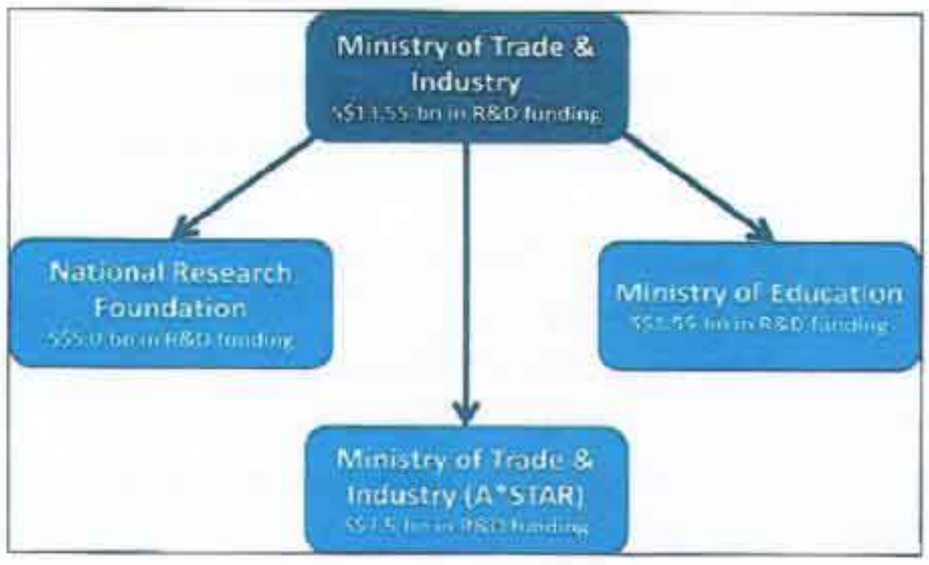


Structures & Priorities

The overall responsibility for Singapore's STI sector direction falls under the Ministry of Trade and Industry. This Ministry formulates the country's Science and Technology Plan and is the vehicle through which the state R&D funding is channeled. In 2010 the total funding allocation was S$ 13.55 billion and this was distributed through the three pathways shown in Figure 8.

[9] NEXT Archives

Figure 8: The three pathways through which Singapore's public R&D funding is allocated ([10])



The structure for Singapore's STI sector is totally integrated and is led by a Ministerial Committee on Research and Development (MRDC) which is chaired by the Prime Minister. The MCRD provides the lead vision and direction for Singapore's STI sector. That vision is then converted into policies and STI sector strategies through the Research, Innovation and Enterprise Council (REIC) which includes a balanced mix of public, private and R&D sector representatives. This committee is also chaired by the Prime Minister.

At the same time, the STI sector structure is aligned closely with the country's economic development direction. This is set and overseen by the national Economic Development Board (EDB) which is strongly trade and enterprise focused. In other words, there is a strong alignment between national economic development, STI policy and strategy and implementation and the prioritization of public investments into the STI sector. In addition, the EDB plays a role in attracting private sector R&D investment through an entity called A*STAR (Agency for Science Technology and Research) into national economic priority areas. It also encourages international collaborative initiatives that support the activities overseen by the primary STI sector implementation agency, the National Research Foundation (NRF).

In overall terms the main actors in S&T in Singapore are:

- The Ministry of Trade & Industry
- The Ministry of Education
- The National Research Foundation
- The Agency for Science, Technology and Research
- The three main science universities – Nanyang University and the National University of Singapore (NUS) plus the National Technology University (NTU).

The NRF

The NRF is part of the Prime Minister's Office and was set up in 2006 to set the national direction for R&D by developing policies, plans and strategies for research, innovation and enterprise. It also funds

[10] http://www.sea-eu.net/asia/info/9/singapore.html

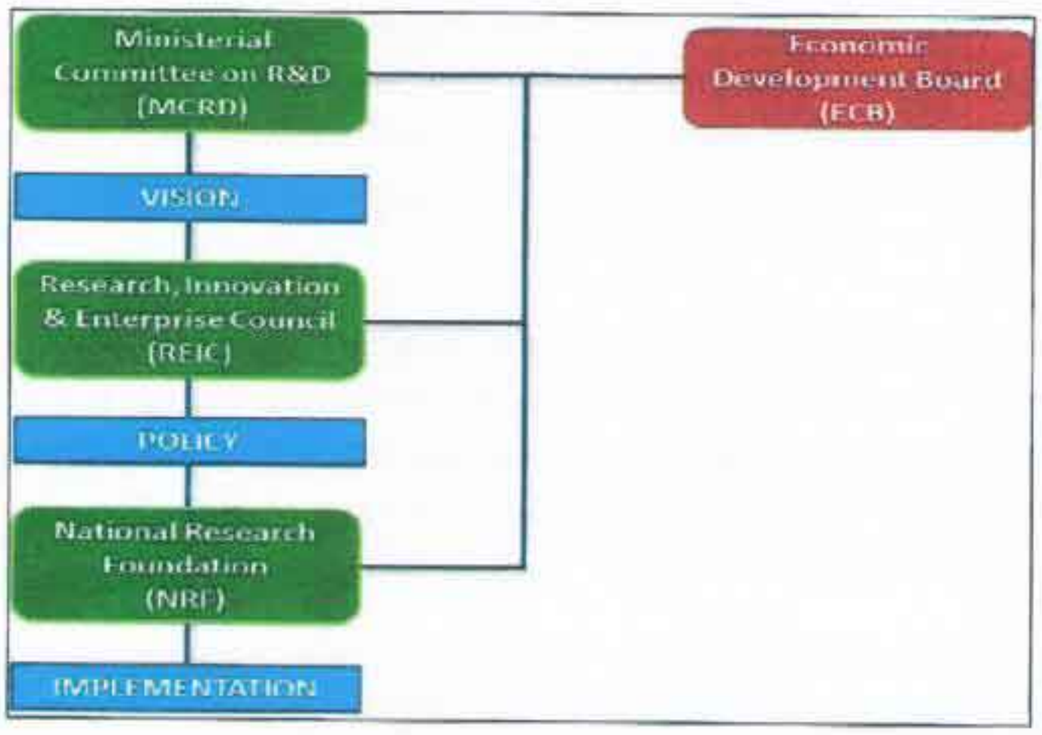
strategic initiatives and helps build R&D capacities and capabilities through a combination of nurturing local talent and attracting foreign talent. It also acts as the secretariat for the REIC. Its primary objective is to 'transform Singapore into a vibrant R&D hub that contributes towards a knowledge intensive, innovative and entrepreneurial economy and make Singapore a talent magnet for scientific and innovation excellence'.

The NRF oversees and implements five strategic STI focus areas:

1. To provide more resources for R&D and ensure the sector continues to receive high level attention.
2. To focus on selected areas of economic importance (priority areas).
3. To balance investigator-led and mission-oriented research.
4. To encourage more private sector R&D.
5. To strengthen linkages between R&D and business.

The position of the NRF in Singapore's STI sector is shown in Figure 7.

Figure 7: The position of the NRF in Singapore's STI sector

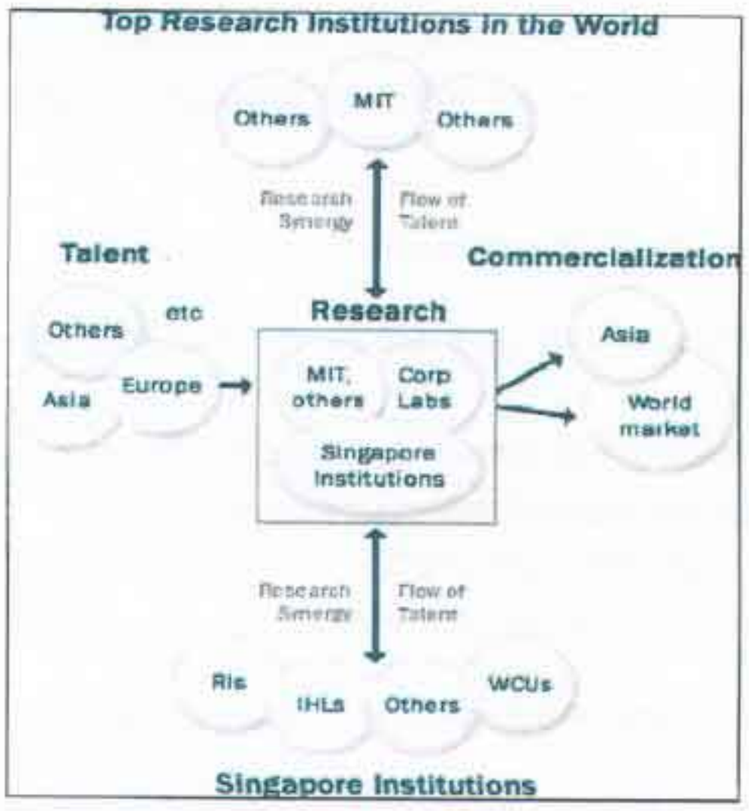


The NRF has identified three strategic priority R&D areas which it believes offer Singapore a competitive advantage over the longer term in a global context as follows:

- Biomedical Sciences.
- Environmental and Water Technologies.
- Interactive Digital Media.

In order to help deliver the end outcomes expected from the country's STI agenda, the NRF has set up an entity called CREATE (Campus for Research Excellence and Technological Expertise) which essentially leverages centres of research excellence in Singapore through a series of collaborative alliances with offshore centres of excellence. An overview of the CREATE ecosystem is shown in Figure 8.

Figure 8: The Singapore CREATE ecosystem



The most important aspect of CREATE is that it is a high-powered strongly collaborative model that embraces both onshore and offshore stakeholders in the fields of research, talent, and commercialization in association with Singapore based R&D institutions. In other words Singapore has adopted a highly focused international collaborative approach to help the country achieve its primary national goals.

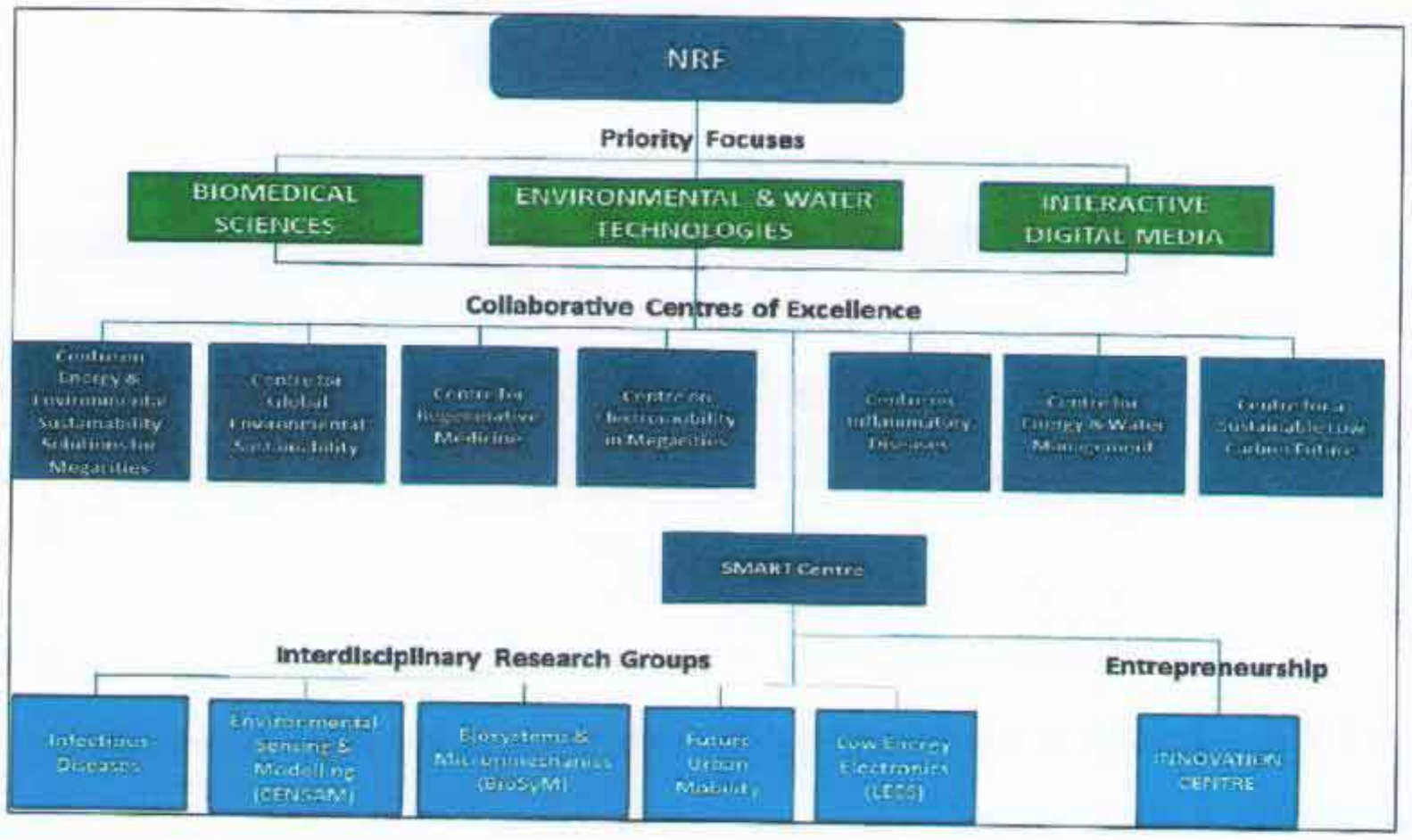
As is the case with everything in Singapore, the initiatives undertaken within the CREATE ecosystem are aligned with the three main priority areas described previously. Thus all the relevant R&D projects and programs related to these three theme areas are undertaken by centres of excellence within CREATE which are reinforced through a number of high profile international alliances with leading edge STI and R&D institutions internationally including:

- The Shanghai Jiao Tong University-National University of Singapore (NUS) Centre on Energy and Environmental Sustainability Solutions for Megacities.
- The Massachusetts Institute of Technology through a collaborative initiative called 'SMART', which aims to encourage the exploration of leading edge frontier science and technology fields.
- The Singapore – ETH (Swiss Federal Institute of Technology Zurich) Centre for Global Environmental Sustainability (SEC).
- The Technion-Israel Institute of Technology, NTU and NUS Centre for Regenerative Medicine.
- The TUM (German Institute of Science and Technology) – CREATE Centre on Electromobility in Megacities.
- The Hebrew University of Jerusalem's Research Centre on Inflammatory Diseases.
- UC Berkeley's Berkeley Education Alliance for Research in Singapore (BEARS) Research Centre.
- Ben Gurion University, Hebrew University of Jerusalem, and NTU Research Centre for Energy and Water Management.

- Singapore-Peking University Research Centre for a Sustainable Low Carbon Future.

An overview of the main NRF Research Centre linked alliances and focuses in shown in Figure 9.

Figure 9: The major NRF Centres of Excellence



The NRF is closely associated with academic institutions when it comes to delivering the country's S&T agenda. In addition to these international academic linkages the NRF is associated with public private R&D initiatives, such as the country's Environment and Water Industry Program which aims to make Singapore a centre of excellence in all things to do with water. International private sector partners include Siemens, Black and Veatch, KX Technologies and academic alliance partners include Peking University, Oxford University and the University of Delft.

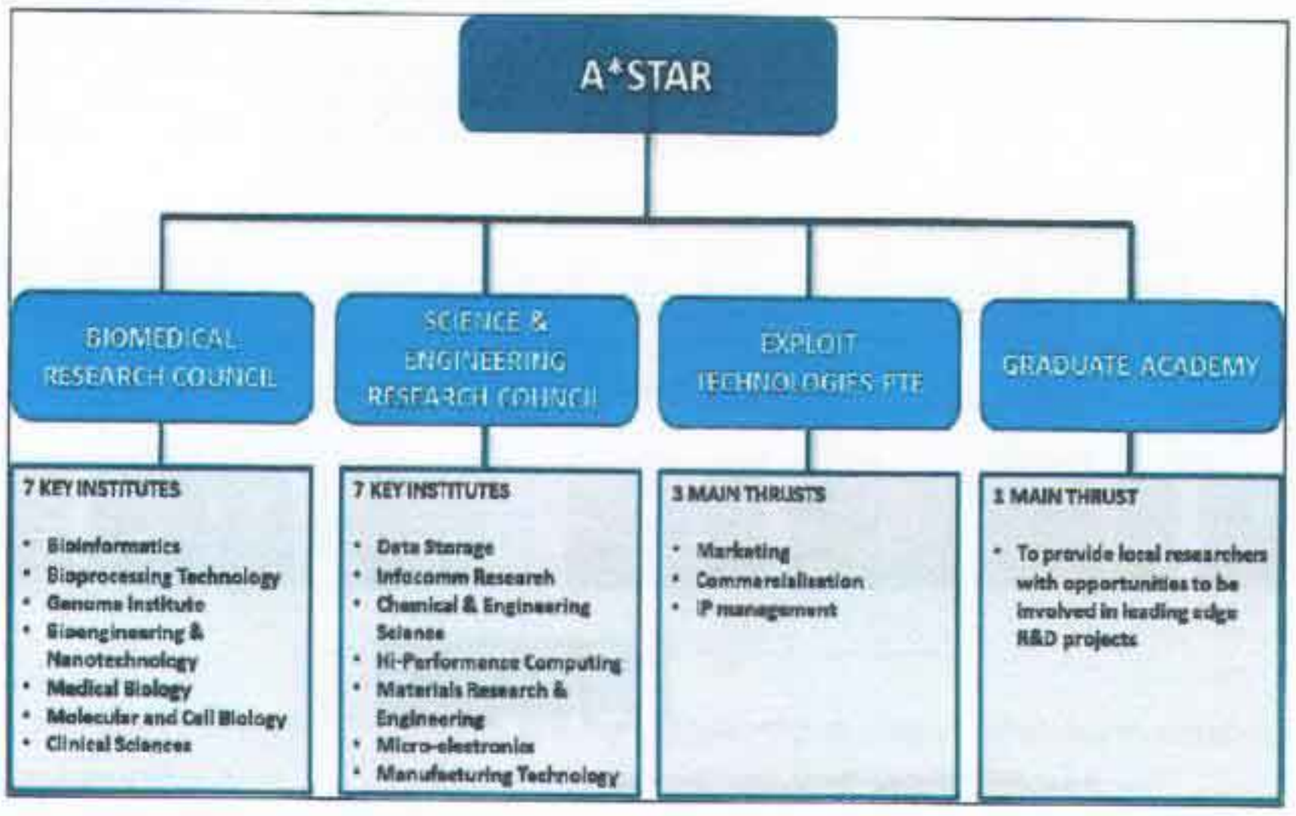
A*STAR

In addition to the NRF STI sector thrust, there is a parallel more commercially-oriented R&D component that comes under the A*Star umbrella. This agency plays a major role when it comes to encouraging collaborative programs with offshore stakeholders and does this within a 50% 'pro-local' and 50% 'pro-foreign' human resources context. An overview of the structure of the A*STAR S&T and R&D involvement is provided in Figure 10.

Once again, the strong alignment of all the different institutes within A*STAR towards the three national priority areas is obvious. In addition, the structure supports marketing, commercialization and IP management to derive value from the country's R&D investments. Finally, an important aspect of A*STAR is to provide opportunities for locally trained scientists and R&D personnel to work

collaboratively with offshore specialists and help strengthen Singapore's home-grown STI capacities and capabilities.

Figure 10: The A*STAR structure



The NRF and A*STAR programs and initiatives are all closely aligned and largely complementary.

Monitoring and Evaluation

The structure for monitoring and evaluating the benefits generated by Singapore's STI and R&D investments is not clearly stated in the literature. However, in 2011 the country ranked number three internationally in the GII rankings ([11]), which suggests that the country's investments into STI are generating positive benefits for the country.

There are appointed Boards, such as the Scientific Advisory Board and the RIEC, which provide guidance when it comes to allocating resources and measuring the outcomes of investing such resources. However, the primary responsibility appears to lie with bodies such as the NRF and A*STAR to monitor and evaluate the effectiveness of the initiatives they oversee in association with the various institutions and organisations that are engaged in the country's STI sector projects and activities.

Ken Erskine, a Director of The ICEHOUSE in New Zealand (one of the world's most successful small country business incubators), is of the view that the current Singapore STI approach does have several flaws when it comes to translating high-level R&D into commercial opportunities. One such flaw is the potential future liability that the government may face if start-up ventures backed by state agencies to deliver commercial outcomes from such R&D fail to perform. In such cases the government may end up owning some of these companies by default and then face the prospect of being responsible for their on-going management and compliance with statutory requirements.

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11 http://www.globalinnovationindex.org/gii/main/analysis/rankings.cfm?vno=#CGI.SCRIPT_NAME#

Key Points

The approach that Singapore is taking towards generating value from its STI and R&D sector can be summarized as follows:

- It is led from the top (Prime Ministerial level).
- It is delivered within a National Innovation System (the NFIE).
- The overarching STI sector bodies play a major policy, governance, budgetary and funding allocation role. They also play a limited monitoring and evaluation role but do not undertake R&D as part of their activities.
- Singapore focuses on developing opportunities in three well-defined priority areas that are part of the country's long-term strategic plan.
- Within those three broad areas are a number of more specific focus areas.
- It is focused on developing global opportunities.
- It has a strong emphasis on university and business-linked centres of excellence.
- It provides a strong support system to facilitate the commercialization of R&D work through business incubation, funding support (grants and the matching of funding from private sector sources), marketing and a range of other relevant activities.
- It is based upon strong public private partnerships.
- It is built upon high level international collaborative initiatives with some of the world's leading institutions and companies.
- It has a particular focus on supporting the development of SMEs.
- It encourages and supports human resource exchanges between Singapore and other nations with the long-term objective being to raise the STI & R&D capabilities of Singaporean nationals through collaboration and mutual learning approaches.
- The country's monitoring and evaluation system for measuring the contributions derived from the country's public R&D investment is not clear and appears to still be in a formative phase.

The approach being taken is ambitious with a focus on the long-term. The one weakness with the Singapore model may be that the government could possibly end up with some unwanted future liabilities as the result of the R&D commercialization approach it is taking. However, Singapore has a good track record in dealing with such situations and it seems likely that some form of action will be taken to address such a weakness before it becomes too onerous.

An important context point from a Jamaican perspective:

- In 2011 Jamaica's nominal GDP per capita was estimated at US$ 5,376.00 and, on a Purchasing Power Parity (PPP) basis, US$ 9,004. Thus the total national GDP equated to US$ 14.7 billion and US$26.4 billion respectively on a nominal and PPP basis ([12]).
- **Singapore's R&D investment alone in 2010 totaled US$ 10.8 billion** i.e. 73.5% of Jamaica's total GDP on a nominal basis or 40.9% on a PPP basis.

[12] http://knoema.com/tbocwag#Jamaica

Thus, what Jamaica can realistically achieve in the STI sector relative to Singapore will clearly be far more modest as the country simply does not have the financial resources to pursue the high-level, high-risk approach that Singapore is currently pursuing.

Denmark

Overview

The Scandinavian countries are amongst the wealthiest in the world in terms of GDP per capita. Sweden, Finland, and Denmark in particular feature regularly in the top 10 countries globally in the GII rankings. However, the approaches taken by Sweden and Finland towards STI investment and economic development have resulted in both countries becoming vulnerable in today's global markets. This is because both countries 'bet big' on backing major corporations such as Electrolux, Volvo, Berol Noble, Nokia, Ikea and a number of other entities that have now become global operations. As their global success has grown, so has their independence from their countries of origin. This has led to a decline in the number of employment opportunities and economic contributions towards the countries which supported their development and success.

As a consequence, both Sweden and Finland now face a real challenge as they have largely failed to encourage the development of the SME sector. Their economies are now characterised by a group of large multi-national corporations and numerous small and micro-enterprises - but little in between. Sweden is now focusing particularly strongly on developing its SME sector.

In contrast, Denmark has developed a more resilient high value based economy by encouraging the development of clusters around areas of strength in the country over many years. It is a country that the internationally renowned expert on national competitive advantage, Michael Porter, has used often when assisting countries to identify their strengths and weaknesses (e.g. [13], [14]). Because of this, the way in which the Danish STI sector has and is evolving is of particular interest which it comes to best practice models.

The country has a highly focused national political vision and in 2007 set up a single overarching innovation action plan which oversees 70 different national initiatives 'to turn Denmark into one of the most innovative and competitive countries in the world'. Realising the vision is built around three key planks:

- All Danish enterprises, including SMEs, need to become more innovative and remain so.
- The knowledge transfer between public research and private enterprises has to be strengthened.
- A greater focus needs to be placed on SMEs. They were previously largely ignored.

These three planks that the Danes have identified are of special relevance to Jamaica as the issues raised are identical.

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[13] On Competition, M E Porter, Harvard Business Review Book, Revised 2008
[14] Upgrading New Zealand's Competitive Advantage; G T Crocombe, M J Enright, M E Porter, Oxford Press, 1991

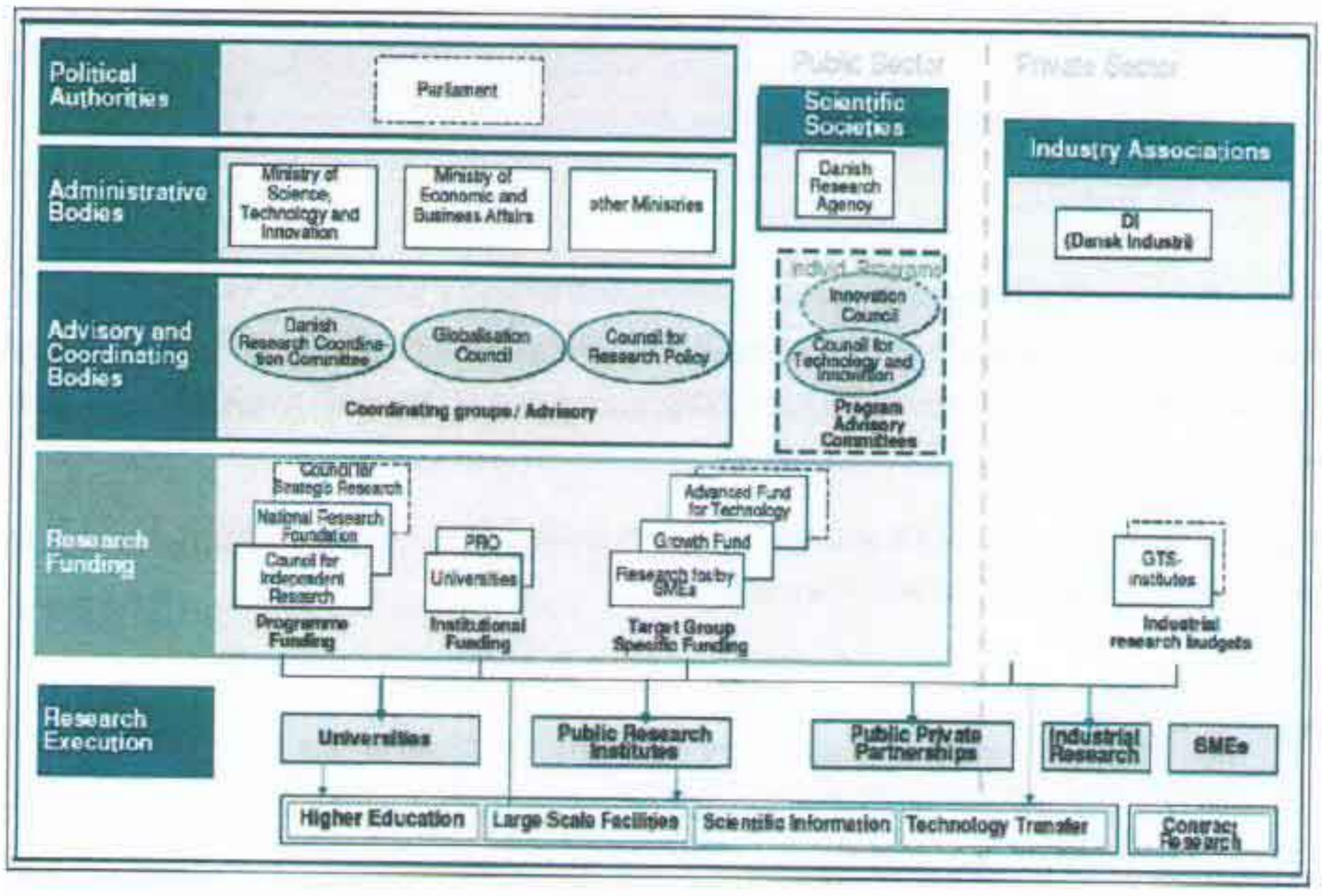
The pillars upon which the Danish vision is being built are:

- A world class education system.
- Strong and innovative research.
- More entrepreneurs.
- More innovation and change.

Structures & Priorities

A 'big picture' view of the structure within which STI and R&D initiatives are conceived and delivered in Denmark is called the Danish Research and Innovation System and shown in Figure 11.

Figure 11: Structure that facilitates the Danish Research and Innovation System ([15])

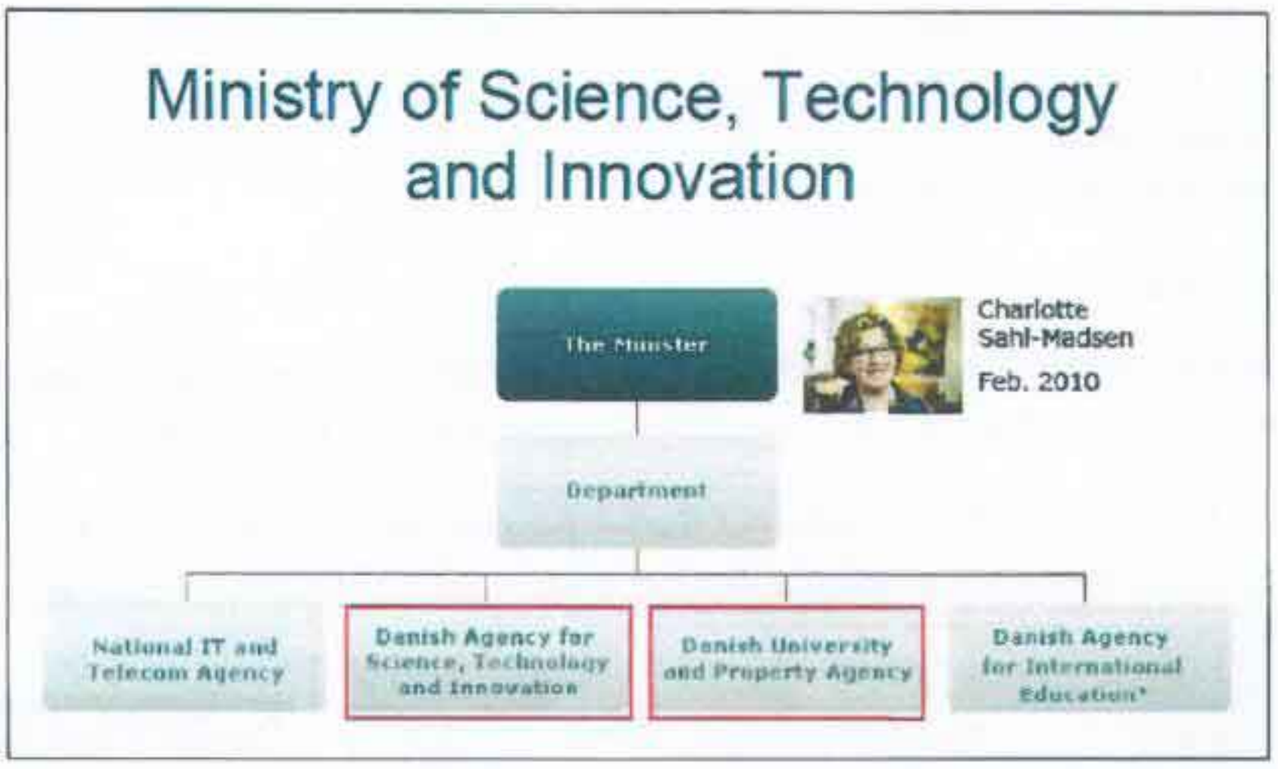


What is of greatest interest are the inter-linkages between the main national stakeholder groups i.e. key government Ministries (in particular Science Technology and Innovation and Economic Development), research agencies and institutions and the private sector. The structure is typical for successful National Innovation Systems i.e. the alignment of all the key stakeholders towards common national goals as well as strong public private sector partnerships. Also of particular note is the Danish focus on supporting the development of SMEs.

In terms of the public sector STI structure, an overview at Ministerial level is provided in Figure 12.

[15] http://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_denmark.pdf

Figure 12: The Danish STI Ministry Structure ([16])



Of particular interest is the sub-set of agencies within the Ministry of Science, Technology and Innovation because they embrace key infrastructural, educational, academic and R&D components. There is an alignment of key areas that are an integral part of any National Innovation System, in particular the 'Innovation Engine" component.

In overall terms, Denmark has an STI and R&D focus in three broad national priority areas within an overall theme called 'eco-innovation'. They are:

- Biotechnology.
- Nanotechnology.
- Information and Communications Technology.

More specific focuses within these broad theme areas are defined within the projects and initiatives specific agencies oversee and support and are described in more detail in the following sections.

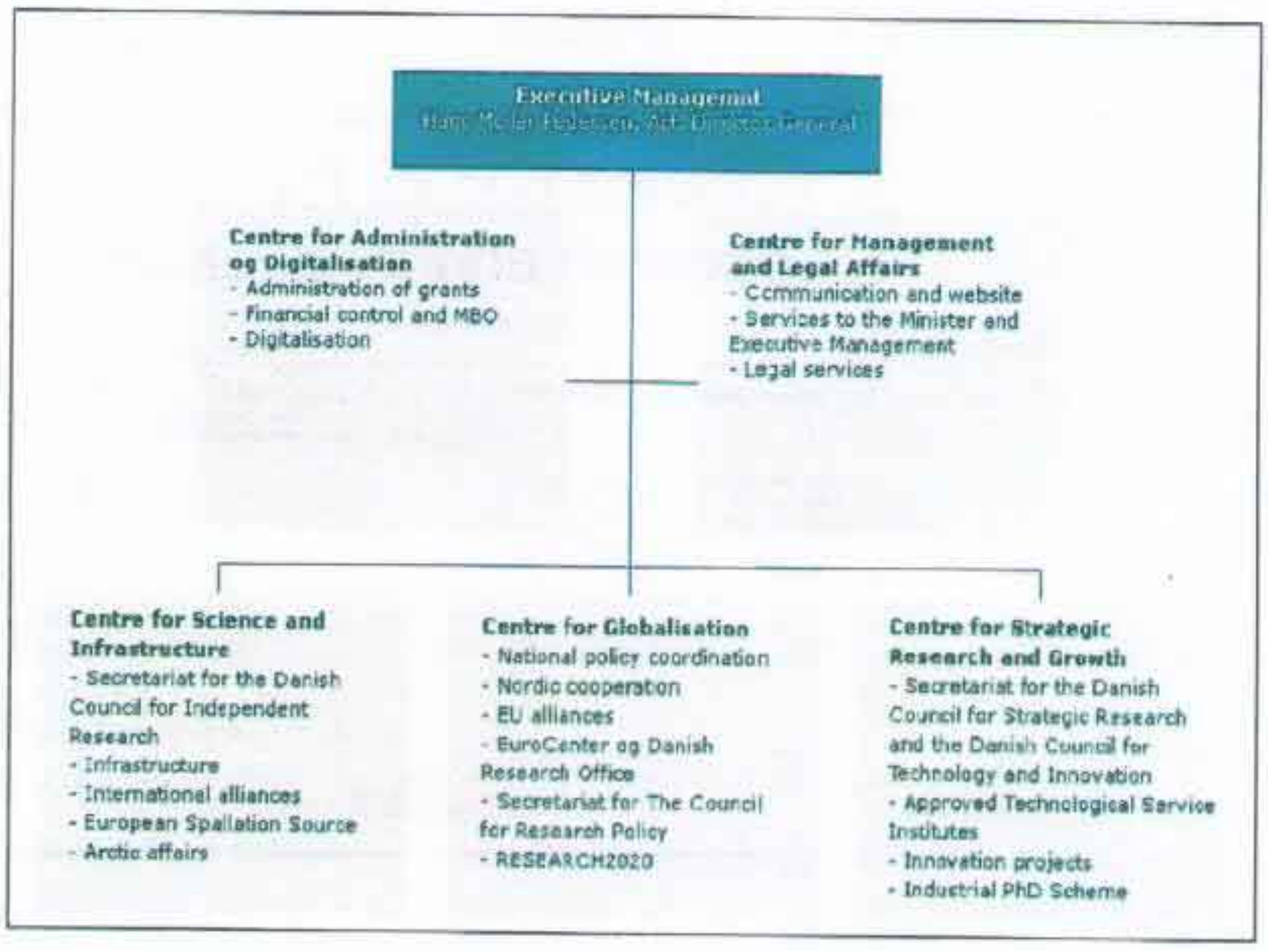
The Danish Agency for Science, Technology and Innovation (DASTI) plays the lead role in how the sector is funded, managed and evolves. Its particular mandates include:

- Administering public R&D funding for R&D and supervising the allocation of those funds.
- Supporting communications and coordination between knowledge institutions and businesses.
- Supporting the development of international R,D & I partnerships.

In fact, coordination and communications is the primary role of DASTI. The organizational structure of the DASTI is illustrated in Figure 13.

[16] http://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_denmark.pdf

Figure 13: The organizational structure of the DASTI ([17])



Of particular note is the focus of this agency on areas that support the realization of value from the country's STI and R&D investments, namely:

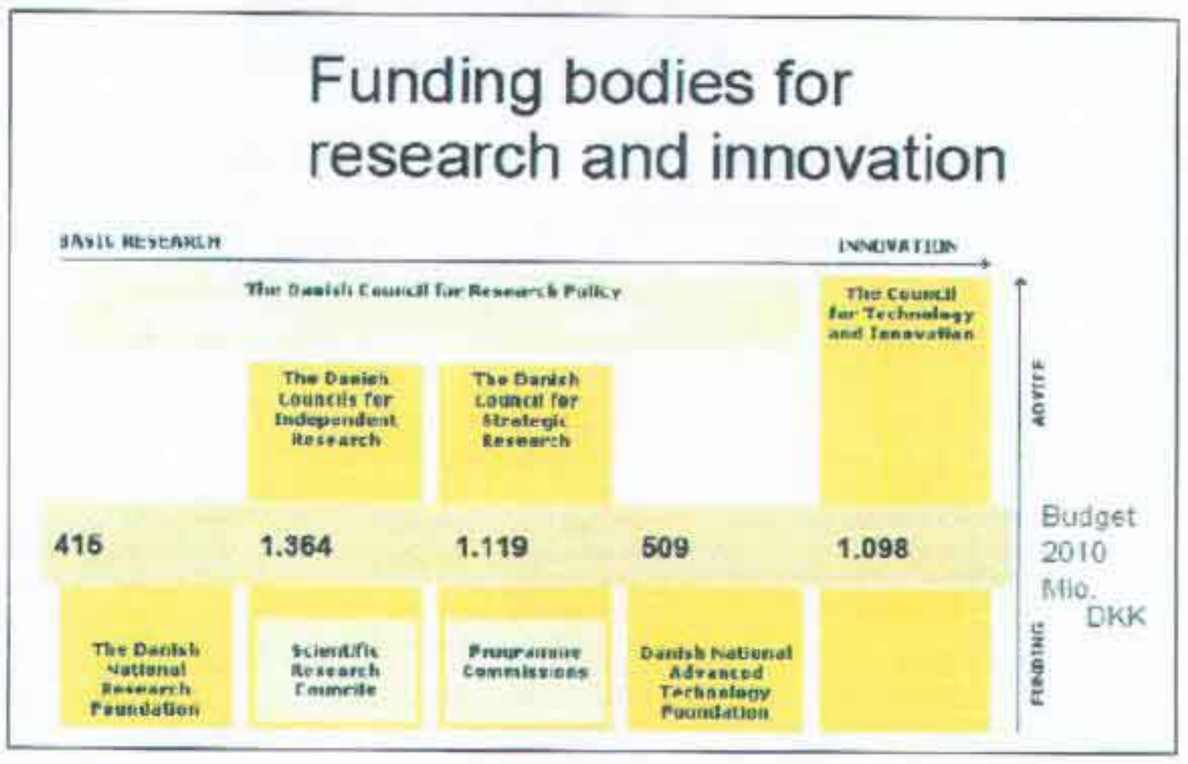
- Supporting infrastructure.
- International alliances and globalization.
- Strategic research aligned to innovation areas with growth potential.

In terms of R&D funding, the public sector contribution in 2010 was around 1% of GDP with a further 1.8 % invested by private sector interests. Figure 14 illustrates how the public R&D funding was allocated.

The Danish National Research Foundation funds large scale research activities initiated by the academic community as well as the development of centres of excellence which have a strong private sector component (e.g. Vestas and wind energy). Most members of the Foundation come from the public sector but private sector representatives are sometimes invited to contribute ([18]).

[17] http://en.fi.dk/the-agency/organisation
[18] http://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_denmark.pdf

Figure 14: The Danish Public STI Funding Model through the Ministry of Science, Technology and Innovation



The Danish Council for Independent Research supports and funds projects and activities based on bottom up ideas from academia following researchers' own initiatives. However, these are aligned with the national research priority focuses reflected by the themes associated with the country's Scientific Research Councils which are mainly made up of members of academia. Those Council themes areas currently include ([19]):

- The Danish Council for Independent Research | Humanities.
- The Danish Council for Independent Research | Medical Sciences.
- The Danish Council for Independent Research | Natural Sciences.
- The Danish Council for Independent Research | Social Sciences.
- The Danish Council for Independent Research | Technology and Production Sciences.

The Danish Council for Strategic Research supports and implements research projects based upon political priorities and encourages public private sector interactions as well as inter-disciplinary research. The Council also evaluates applications from sectoral Ministries for research funding appropriations.

The 2011 government national strategic priority areas were:

- Health, Food and Welfare
- Sustainable Energy and Environment
- Strategic Growth Technologies
- Education and Creativity
- Transport and Infrastructure

[19] http://en.fi.dk/international/european-cooperation/eus-7th-framework-programme-for-research-fp7/international-collaboration-in-the-eus-seventh-framework-programme-fp7/danish-research-councils-2

- Individuals, Disease and Society
- SPIR - Strategic Platforms for Innovation and Research

In addition, the Council supports international R&D collaborative initiatives such as:

- Danish-Chinese research collaboration (The Program Commission on Sustainable Energy and Enviroment).
- Danish-Brazilian research collaboration (The Program Commission on Health, Food and Welfare).
- Danish-Indian research collaboration (The Program Commission on Individuals, Disease and Society).

Each application for funding is assessed upon the basis of a 'strategic quality' assessment which includes:

- The relevance of the research.
- The potential impact of the research.
- The quality of the research – originality and projected achievements on an international scale.

The Danish National Advanced Technology Foundation plays a quite specific role and funds projects that promote economic growth and employment in three primary focus areas – biotechnology, nanotechnology and information and communications technology. Its Board is made up of a mix of private sector representatives and leading academics. Of particular relevance is the way in which funds are allocated. Allocations are based upon the evaluation of funding proposals in four key areas:

1. The commercialization potential.
2. The participation of cooperative partners including at least one public research centre and at least one private sector enterprise.
3. The transformation of science and technology into practical use.
4. The co-financing of contributing partners.

The Foundation maintains an active role in following up on projects it invests in through project managers and project steering committees. It also focuses on the investment portfolio and willingness to take a risk. In this regard they encourage the formation of public private collaborative efforts to develop 'technologies and later reap the rewards'. It looks at the competitiveness of companies in which they invest in a global context and how this is likely to provide a basis future growth and employment.

In summary, the basic framework for projects that the Foundation supports is shown in Figure 15.

Figure 15: The framework for projects supported by the Advanced Technology Foundation ([20])

The Danish Council for Technology and Innovation is overseen by a Board made up of representatives from both academia and the private sector. It advises the Minister of Science, Technology and Innovation and also administers a range of initiatives covered by Denmark's Act on Technology and Innovation. Major areas that are the responsibility of this Council include:

- Technology services.
- Technology incubators.
- An industrial researcher scheme.
- Innovation consortia.
- Technology foresight.

The innovation policy and program focus areas include:

- Collaboration between companies and research institutions (innovation networks and innovation projects).
- Access to a highly skilled workforce (industrial PhD and innovation pilots).
- Technological services (for approved technological service institutes).
- Commercialisation and entrepreneurship (proof of concept, innovation incubators).

Monitoring and Evaluation

Denmark is still trying to develop an effective monitoring and evaluation system to measure the impacts of its STI and R&D programs. In some cases there are empirical measures which provide some indication of such impacts. One example is associated with the country's innovation programs where private

[20] http://ec.europa.eu/dgs/jrc/downloads/events/201104-budapest/20110405_budapest_kjaer_madsen.pdf

companies are involved. In this case two measures have been used to determine the success of specific initiatives:

- The Industrial PhD program – hosting companies see an increase in average patenting activity and are characterized by high growth in gross profit and employment.
- The Danish Innovation Consortium Scheme – significant increases in the growth of gross profit and employment in firms participating in the program.

When it comes to monitoring and evaluating the impacts in public research funding, there have been challenges in finding a way to measure economic impact. This remains a 'work in progress' in Denmark.

Key points

- Parliament and the STI Minister play a primary role in directing the Danish STI sector.
- The country's public STI investment is delivered within an overarching National Research and Innovation System.
- The overarching STI sector bodies play a major policy, governance, budgetary and funding allocation role. They also play a limited monitoring and evaluation role but do not undertake R&D as part of their activities.
- Private sector R&D investment funding is almost twice that of the public sector.
- Denmark focuses on developing opportunities in three broadly defined priority areas that are part of the country's long-term strategic plan.
- Within those three broad areas are a number of more specific focus areas.
- Denmark is focused on developing global opportunities and develops extensive international networks to help facilitate this.
- It has a strong emphasis on university and business-linked centres of excellence.
- It provides a strong support system to facilitate the commercialization of R&D work through technology and business incubation, funding support (grants and the matching of funding from private sector sources), capacity building, global connectedness and a range of other relevant activities.
- It is based upon strong public private partnerships.
- It is built upon high level international collaborative initiatives through some interesting alliances in emerging economies showing strong growth e.g. Brazil and China.
- It has a particular focus on supporting the development of SMEs.
- It encourages and supports human resource development through public private partnerships.
- Denmark has a partial monitoring and evaluation system in place but it largely measures the impacts of innovation initiatives through commercially-linked projects. The country is still trying to develop an effective monitoring and evaluation system to determine the impacts of its public funded R&D investments.

As is the case in Singapore, Denmark's public sector investment into R&D is huge compared to Jamaica and amounts to more than US$ 3 billion. When combined with private sector investment the total

approaches US$ 8.5 billion – **equivalent to 58% of Jamaica's nominal GDP or 32% of the country's PPP GDP.**

South Korea

Overview

The reason for including South Korea as an international best practice example is because of that country's particular focus on measuring the value being generated through the country's investments into STI and R&D. South Korea is one of the top investors into STI and R&D in the Asian region and allocates well in excess of 3% of GDP annually in this area. South Korea also has a National Innovation System which incorporates an Integrated Innovation System.

Rather than going into great detail about the South Korean STI and R&D sectors, much of this section focuses on the country's efforts to monitor, measure, and evaluate the outcomes of, and returns from, national STI and R&D investments.

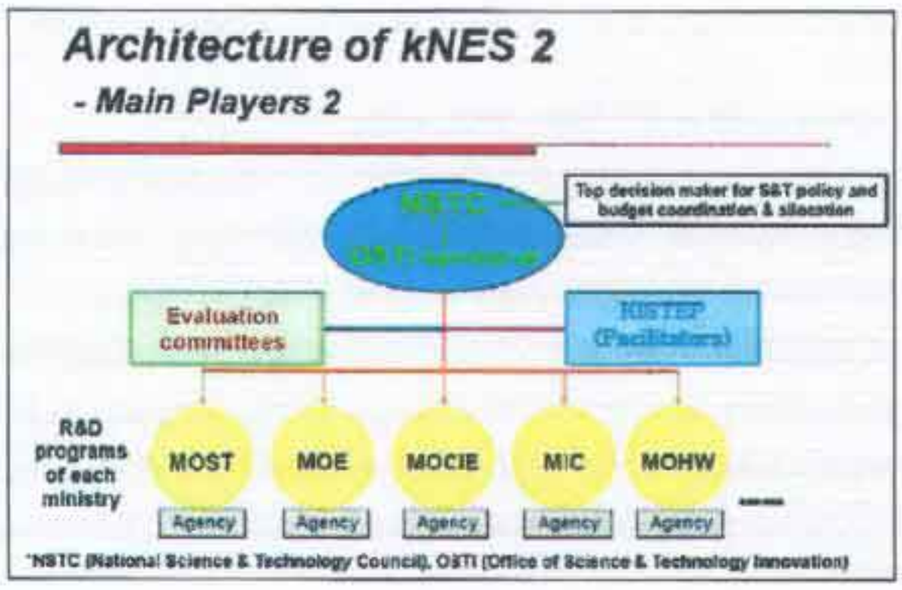
Structures & Priorities

South Korea has three broad priority focus areas for R&D funding:

- Green technologies.
- State of the art fusion industries (such as IT fusion, robotic applications and biomedicines).
- High value added services industries (healthcare, education services and tourism).

The country has invested heavily into education and leading-edge infrastructure (such as high speed wireless broadband) that provides a high level of capabilities and enablers to support the ongoing development of a hi-tech innovative economy.

Figure 16: The Korean National Evaluation System (kNES) for Public R&D ([21])



[21] http://www.kistep.re.kr/eng/document/view.jsp#/eng/document/view.jsp

In order to ensure that the STI sector delivers the best possible outcomes, South Korea has set up an inter-Ministry structure somewhat similar to that which New Zealand set up in the early 2000's (see the next section) but with a much greater focus on overseeing the optimization of the various activities being conducted by different Ministries and their R&D and educational agencies through monitoring and evaluating inputs and outputs. An overview of the oversight structure is provided in Figure 16. This is the public sector policy, investment, and management structure which also delivers the national STI and R&D programs.

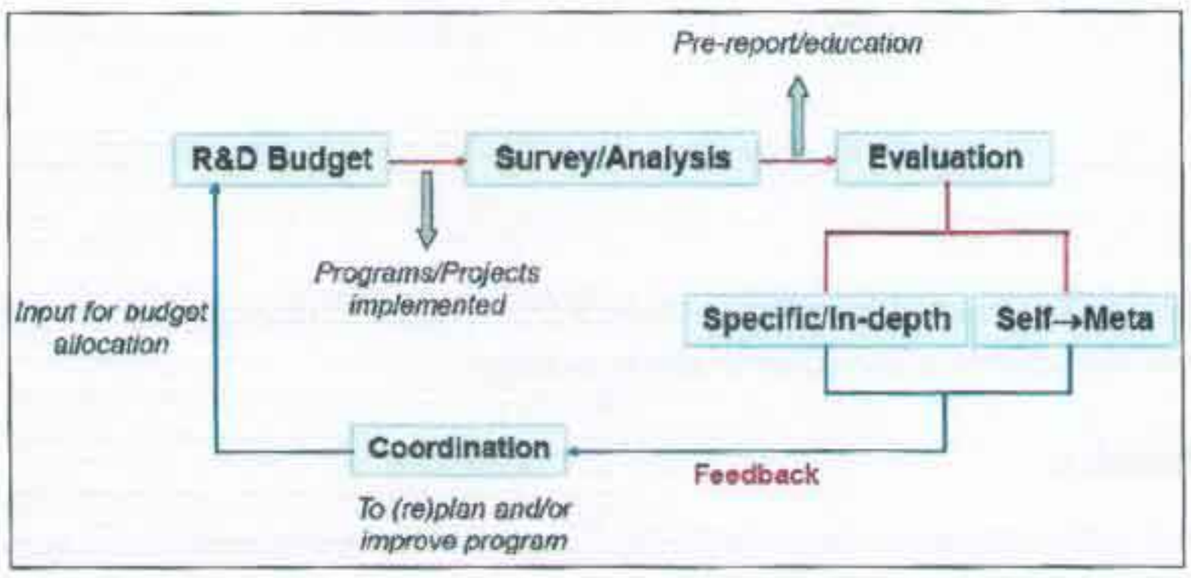
Monitoring and Evaluation

In Figure 16, there are four main player groups that are responsible for delivering, monitoring and evaluating the country's STI and R&D investments. They are:

- The National Science and Technology Council (NSTC) – which is the top decision-making body for S&T policy and budget coordination and allocation nationally. It approves the national master plan for STI as well as assessing the results of evaluation processes and allocating budget.
- The Office of S&T Innovation, Secretariat of the NSTC (OSTI) – which has the responsibility for designing the master plan for evaluation and budget allocation.
- Korea Institute of S&T Evaluation and Planning (KISTEP) – which facilitates all the evaluation activities, including evaluation of R&D programs and program budget reviews.
- Ministries and agencies with R&D activities – which must prepare and submit evaluation materials, accept evaluation results and act where necessary.

An overview of the monitoring and evaluation procedure used by KISTEP is shown in Figure 17.

Figure 17: The architecture for the KISTEP M&E procedure



Of greatest importance in this architecture are the two evaluation components:

Specific/In Depth Evaluation.

This is an external evaluation of R&D funding initiatives which takes place once every three years and involves the following criteria and processes:

- Selected based upon project size, term, special factors, etc.
- In-depth evaluation for selected programs (usually 3 -5 per evaluating committee).
    - Step 1: Evaluation materials are submitted by each Ministry through which R&D projects are conducted using a standardized reporting system (KORDI).
    - Step 2: Preliminary report to inform the evaluation committee (KISTEP).
    - Step 3: A first evaluation based upon submitted documents which may require follow up requests for more information.
    - Step 4: A second evaluation which includes an interview process and may include an actual project on-site inspection..
    - Step 5: Submission of the interim findings by the evaluation committee to each Ministry for reappraisal (if required).
    - Step 6: A third evaluation and final results which are provided on a five grade scale (A for excellent through to E for poor).

The evaluation parameters include the following:

- 'Plan' (clearness of goal and vision).
- 'Plan' (effectiveness of the implementation system).
- 'Do' (differentiating and connecting related programs).
- 'See' (supplementing goals and indicators).
- 'See' (reinforcing outcomes and management).

In a recent evaluation of 51 R&D programs in Korea, the project grades were as follows

A	0%
B	19%
C	63%
D	16%
E	2%

This evaluation provided a valuable overview of how the country's R&D projects were performing and showed that only 19% could be considered 'above average'.

Self-Meta Evaluation

This is an internal evaluation process designed for the ministries overseeing R&D projects to monitor performance. These are carried out each year by each ministry. The evaluation steps are as follows:

- Step 1: Self-evaluation materials (submitted by each ministry).
- Step 2: 1st meta-evaluation with documents (final results, if any).
- Step 3: 2nd evaluation with interview (final results, if any).
- Step 4: Request for a re-evaluation of each program.
- Step 5: 3rd evaluation and final results (3 grades).

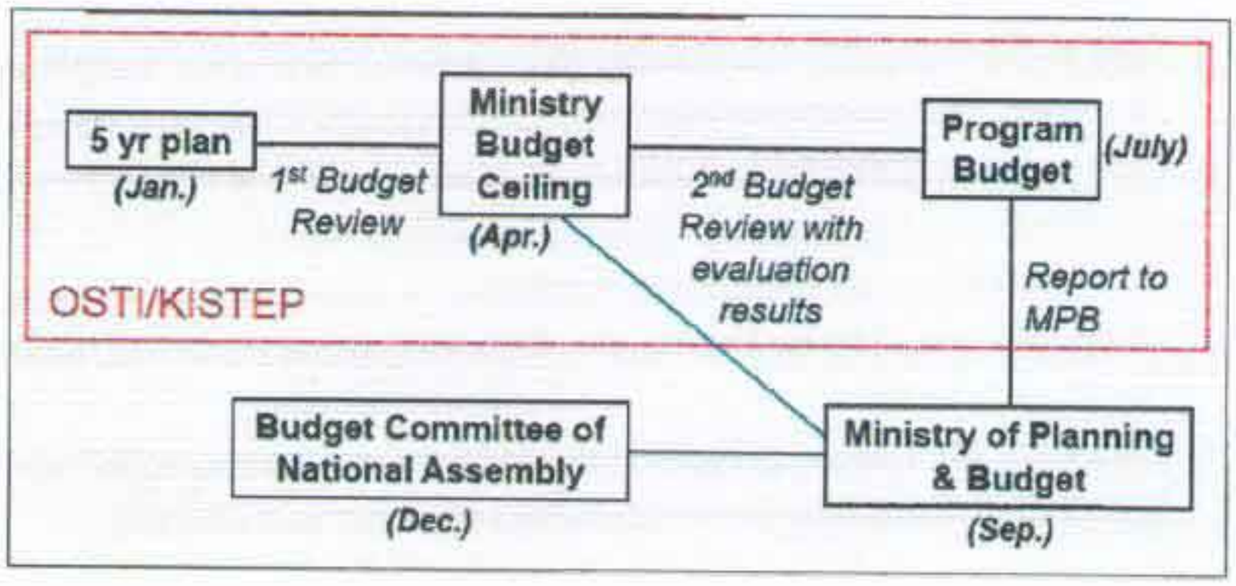
The five grade system for initial evaluation used for the Specific/In-depth evaluation is also used for the Self-Meta-evaluation process – both for each Ministry and the projects run by each Ministry. They are finally categorized into three overall grades:

1. Appropriate.
2. Appropriate with conditions.
3. Inappropriate.

In a recent internal evaluation of 154 programs, 52.6% were rated as being 'Appropriate', 29.9% as being 'Appropriate with conditions' and 17.5% as 'Inappropriate'.

In 2005 South Korea passed the R&D Performance Based Evaluation Law which makes it a legal requirement for these evaluation processes to be used to coordinate and allocate R&D budgets. This is a formal process and is described simply in Figure 18.

Figure 18: How the evaluation process influences budget funding allocations



The evaluation process feeds into the national budget review process which then sets the amounts and allocation of STI and R&D funding for each fiscal year.

The whole kNES approach is designed:

- To provide direction for improving R&D programs.
- To enhance the efficiency and effectiveness of such programs.
- To monitor the performance of each program.
- To improve the transparency of public R&D expenditure.
- To enable better allocation of public R&D resources and budget.
- To minimize duplication of effort in R&D programs.
- To improve the working relationship between the evaluation and budget review committees.

However, there are some challenges which the Koreans have identified that need to be considered:

- Having a pool of evaluators with the right expertise and an ability to make fair judgments.

- The balance between technical and evaluation methodology expertise.
- The role of independent facilitators to manage the process.
- Reinforcing the connection between evaluation results and budget allocation in a systematic way.
- Linking the evaluation process with the planning of programs and budget allocation.
- Communication between the main stakeholders (OSTI, the ministries and their agencies, researchers, KISTEP, etc.).
- Education in communications and evaluation processes.

Key Points

- South Korea delivers its national STI and R&D programs within a National Innovation System.
- The country has three major priority focus areas.
- The R&D sector is well-structured and integrated with several high-level STI bodies playing a key role in setting the direction and evaluating the outcomes of the country's public R&D investment.
- The overarching STI sector bodies play a policy, governance, budgetary and funding allocation, conduct a comprehensive monitoring and evaluation role, and do not undertake R&D.
- The monitoring and evaluation system is well developed and provides an empirical grading system.
- That system is used to promote continuous improvement in the country's R&D programs and determine the basis for the national R&D budget and the annual allocation of funds provided for within that budget.
- There are still some challenges in the M&E process that Korea has identified which require addressing in order for the M&E process to be fair and effective.

New Zealand

Overview

The reason that the New Zealand experience has been included in this report is because it provides some valuable lessons for small countries endeavouring to transition from a commodity-based economy into a modern knowledge-based economy. Following a comprehensive national foresight project in the late 1990's, the country developed a 10 Year Vision in 2003 that aimed to lift the county's nominal GDP per capita ranking from place 20 in the OECD rankings to place 15 by 2013. However, in 2011 the country had actually slipped back to place 23, according to IMF estimates ([22]).

Structures & Priorities

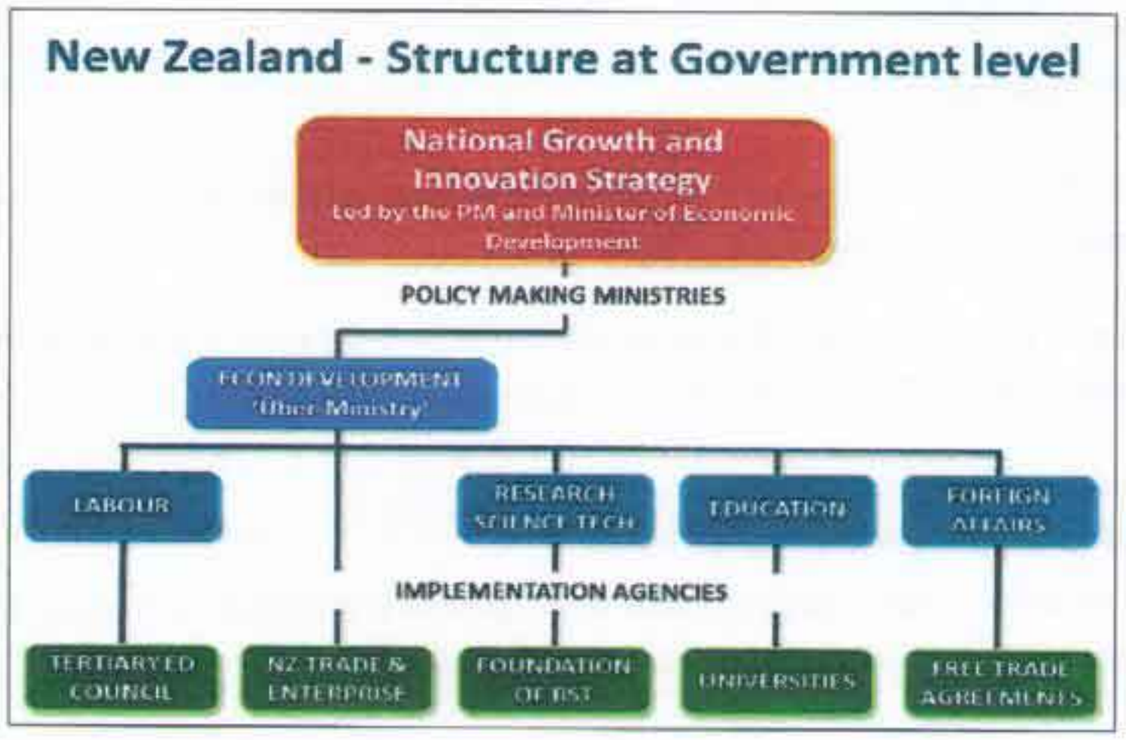
Following a major economic crisis that took place in 1984, a radical change in the country's economic status, and a great deal of analysis, the country began its national economic transition journey in earnest in 2003. At that time the number of government ministries was cut substantially to reduce the number of 'vertical silos' hindering the country's progress. The remaining ministries were also organized

[22] http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29_per_capita

in a way which ensured that there was improved collaboration, alignment towards an overarching national goal, and formal monitoring and evaluation of progress towards the goal. In addition, the restructured ministries were instructed to set up multi-agency committees to help break down the 'vertical silos' that had evolved over many years and encourage inter-agency collaboration and cooperation so that progress towards the 2013 Vision goal could be achieved.

The main reason why the goal has not been achieved in 2012 is because the government in power over much of that period 'lost its way' and so the momentum that was being achieved initially tended to fade away. Irrespective of that fact, the rationalization of the public sector helped change it from being fragmented and predominantly inwardly-focused towards one that delivered a higher level of customer service and pursued a generally more collaborative approach. It is a real challenge to change ingrained cultures in any organization and institution over a short period of time.

Figure 19: The approach to government ministry and institutional integration as part of the NIS in New Zealand [23]



In addition to restructuring the public sector, the government identified three priority areas which they believed offered the country a competitive advantage. These were called 'High Value Priority Investment Areas' and were:

- Biotechnology and agritechnology (because of the country's strong agricultural sector).
- Information and communications technology.
- Creative industries (in particular fashion, film and video and creative design).

In addition to these three main priority areas, the government also identified seven specific niche areas where New Zealand had the potential to 'Enhance Value'. These were:

[23] NEXT Archives

- Food and beverage.
- Wood – for construction and interiors.
- Specialised high value manufacturing.
- Education (for offshore students in particular).
- Services.
- Maori enterprises – leveraging an indigenous cultural resource.
- Tourism.

In 2008 the government (the same government which had initiated the original NIS and priority sectors) decided to adopt a more defined priority niche support approach which focused on:

- Sustainable pastoral agribusiness.
- Innovative foods.
- Applied material technologies.
- Digital content and tools.
- Clean energy.
- Medical technologies.

All were areas in which the country had developed strong capabilities, enablers and capacities and which were beginning to yield dividends.

Three major components of the National Innovation System that were put in place to ensure the country received a dividend from the country's R&D investment were:

- A rationalized STI & R&D sector.
- A national business incubation system.
- The setting up of Trade and Enterprise New Zealand (TRADENZ) to support the development of innovative businesses and their success in offshore markets.

All three components had the intent of supporting the conversion of the country's knowledge into economic benefits for the country with a primary focus on export markets.

Rationalised R&D Sector

Under the original rationalization process, the Ministry of Research, Science and Technology (MORST) was established and had overall responsibility for all aspects of STI and R&D within the country. Prior to its establishment public R&D funding allocation had largely been carried out based upon historical allocation patterns. This resulted in a considerable amount of the funding being allocated to areas in the economy that were losing economic relevance.

When MORST was established, the Foundation for Research Science and Technology (FORST) was also established under its auspices. FORST was the vehicle through which all public sector R&D funding was to be allocated. Around 80% of the total pool for public funding was to be earmarked for R&D projects that were likely to deliver a high level of economic return and benefit in the priority areas identified by

the government in the medium to longer term and were to be allocated through a competitive bidding approach. The balance of 20% was to be allocated for pure research purposes.

One of the issues facing New Zealand was the low level of private sector investment in R&D. The FORST funding process provided a way of encouraging more private sector funding investment in that it favoured R&D funding applications from project consortia that included both public and private sector stakeholders, provided the projects had a high degree of priority sector relevance and offered good prospects for the development of high growth and employment generating new businesses, or extensions to existing businesses.

Conceptually the FORST model was innovative and well thought through. The problems arose when it came to actual funding allocations and follow up monitoring and evaluation. In essence, the 'old school' STI and R&D players hi-jacked the FORST system and much of the funding ended up being allocated towards more traditional academic and lower priority research areas than was intended because of the power of 'vested interests'. Implementing such a model requires a more transparent, robust and independent R&D funding application assessment and allocation process than that which took place in practice in New Zealand.

As a result, New Zealand recently abandoned the MORST/FORST model and, in 2011, established a new Ministry of Science and Innovation that has the aim of generating greater measurable economic benefits from the country's R&D investments. This is still a work in progress.

Of particular interest from the Jamaican perspective is the new Ministry of Science and Innovation (MSI) website (www.msi.govt.nz). Rather than being a typical ministry website, it has been developed more as a portal to assist organisations and businesses to secure R&D funding through a range of competitive bidding initiatives and different sources. These sources include non-public funded sources as well as contributory funding for public private partnership backed projects. It includes a useful 'fund finder' section which lists numerous potential sources of funding for a wide range of STI and R&D related projects and activities ([24]). Competitive bidding for funding, established during the MORST/FORST era, is still a significant feature within the evolving MSI model for shaping New Zealand's STI sector and is likely to grow in importance according to Ken Erskine, Director of The ICEHOUSE Incubator.

It should be noted that there are strong linkages between the activities of the MSI (in terms of R&D and commercialisation) and the Ministry of Economic Development (trade and business development).

In small countries such as New Zealand funding and resources are always a constraint. Finding ways to leverage them in innovative and collaborative ways is something that New Zealand is pursuing with some success. Much of New Zealand's R&D project work is conducted by Universities and Crown Research Institutes which have specific focuses. There are some private research institutions run by large corporations such as Fonterra, New Zealand's largest global dairy production and marketing company.

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[24] http://www.msi.govt.nz/get-funded/fund-finder/FundFinderForm?Sort=&AudienceID=&SubjectID=

The country is currently in the process of setting up a National Network of Centres of Excellence in R&D that will also be aligned with the eight national business incubators that remain 'in business' out of close to twenty that were originally established around 2003.

National Business Incubation System

Innovation is the process of converting knowledge into value generation. Converting knowledge arising from R&D activities into national economic benefits is always a challenge for small countries. For this reason New Zealand established a national business incubation program at the time the National Innovation System was set up in 2003. All the business incubators were associated with tertiary institutions, although the most successful operate largely independently and have their own independent Boards.

The most successful business incubator in New Zealand is The ICEHOUSE which is associated with Auckland University. It has won a number of international awards for the results it has achieved. The ICEHOUSE is open to any entrepreneur with a proposition that has the potential for commercialization and the majority comes from outside Auckland University.

Auckland University itself has developed several strong centres of excellence, in particular in the medical and wireless energy fields. It set up a commercialization subsidiary some years ago called UNISERVICES which in the last financial year generated NZ$ 150 million ([25]) in revenues with one third being generated from offshore clients in over 45 countries.

In contrast to The ICEHOUSE, much of the UNISERVICES revenue is largely derived from IP licensing, contract consulting, and only a small amount through the creation of new enterprises. In this regard many of the benefits flow to businesses and clients in overseas markets and few to the New Zealand economy.

Over the coming year the plan is to further define and strengthen the National Centres of Excellence and Business Incubators and for all to work more closely together to develop greater synergies and a more productive outcome for the New Zealand economy.

TRADENZ

Any state run business development agency is never going to perform at the level that private sector interests expect as such agencies always have to balance a mix of political and commercial agendas. TRADENZ has had its share of controversies. However, it has also assisted many innovative New Zealand companies establish new and expanded business opportunities offshore. Going global is always a challenge for any business located in a small country with a small economy. TRADENZ has facilitated two initiatives in particular that have generated positive benefits for New Zealand businesses:

- Cluster initiatives to develop sufficient sector critical mass and effective value chain structures before going into offshore markets.

[25] NZ$ 1.00 = US$ 0.82 as at 17/04/2012

- The NZTE also set up and runs 'Beachheads' - a global, public-private partnership of independent Advisors and NZTE personnel that helps businesses accelerate international growth ([26]).

'Beachheads' advisors are successful private sector executives and a mix of expatriate New Zealanders and local business people in specific markets. They understand the realities of doing business within such markets and are committed to sharing their knowledge, experience and networks. 'Beachheads' advisor networks are available in North America, South America, Southeast Asia, the Middle East, China, Japan, India, Europe and New Zealand.

The purpose of including the business incubation and trade development components in this analysis of STI best practice is to illustrate that IP on its own has no value unless it can be sold. The ICEHOUSE has a particularly rigorous process for determining whether R&D output, IP, or business concepts have the potential for delivering commercial value to the economy of New Zealand. That process involves three phases:

- 'The Hatchery' – which is essentially a proof of concept and business investment proposition development process that lasts 3 months.
- 'Validation' – which involves market testing of concepts to ensure that there is likely to be a client/customer demand for the concept product or service at a price point that will support the development of a viable business.
- 'Incubation' – a 1-2 year process to commercialise the validated business investment proposition.

In addition to this innovation commercialization activity, The ICEHOUSE also runs a business accelerator program which assists established businesses, typically in the NZ$ 2 million – 100 million annual turnover range, to grow. In the ten years The ICEHOUSE has been operating, 3,500 businesses have participated in this program.

Monitoring and Evaluation

In terms of small countries, New Zealand has one of the best developed economic development monitoring and evaluation processes and systems in the world. It involves a detailed and comprehensive assessment of a range of key performance indicators (KPIs) within the overall hierarchy illustrated in Figure 20. A comprehensive report detailing progress is published every two years by the Ministry of Economic Development ([27]).

Because the country's long-term goal has been to lift its OECD GDP per capita ranking, the indicators provide a measure of whether the country is improving, declining or not changing relative to the average for all the OECD countries. New Zealand has an excellent statistics collection and analysis structure and thus is able to rank itself against such international benchmarks.

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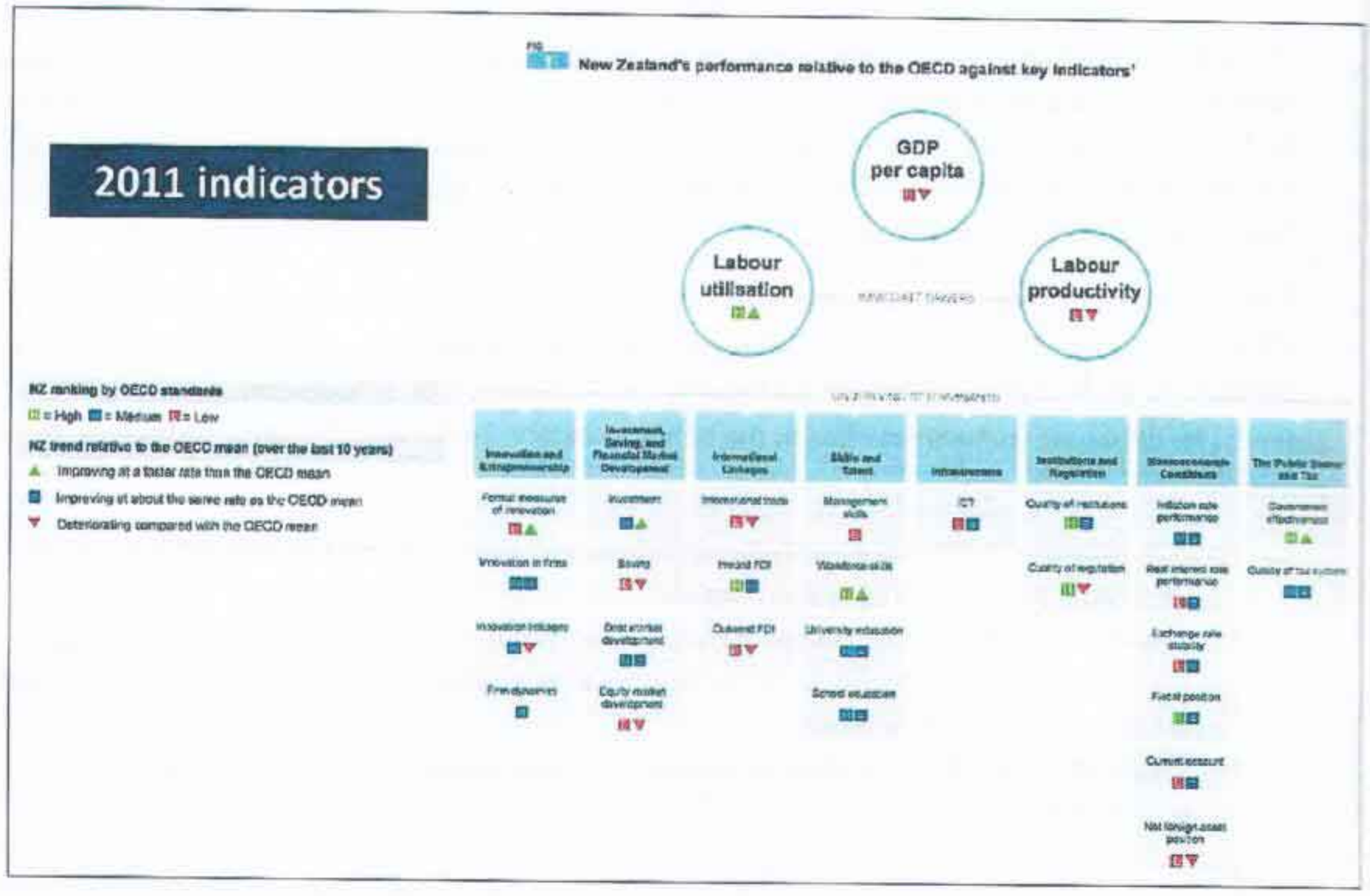
[26] http://www.nzte.govt.nz/access-international-networks/Join-the-Beachheads-programme/Pages/Join-the-Beachheads-programme.aspx
[27] http://www.med.govt.nz/about-us/publications/publications-by-topic/economic-indicators/economic-development-indicators-2011

Figure 20: Monitoring and Evaluation Economic Progress in New Zealand – the KPI Hierarchy



This hierarchy of KPIs includes a number that are strongly linked to the STI sector. Examples include the following:

- Gross Expenditure on R&D (GERD) as a percentage of nominal GDP and average annual growth.
- Business Enterprise Expenditure on R&D (BERD) as a percentage of nominal GDP and average annual growth.
- BERD by size class of firms as a percentage of total industry value added.
- Science and engineering articles per million inhabitants.
- Total R&D personnel per thousand total employment and growth.
- Number of triadic patent families per million of population.
- Rates of innovation activity by type.
- Percentage of business innovating by industry.
- Types of innovation in firms weighted by employees.
- R&D tax concessions for large firms and SMEs.
- Grants and subsidies as a percentage of BERD.
- Share of products from high and medium–high tech industries in manufacturing exports.
- The percentage of R&D carried out by government research organisations and departments that is funded by business.

- The percentage of R&D carried out by higher education institutes that is funded by business.
- Firm 'births and deaths' as a percentage of the population of active firms for the manufacturing and services sectors.
- Rate of high-growth firms by turnover and employment.

All provide some form of measure of the value being generated by the country's R&D and business development initiatives.

Such monitoring and evaluation extends through much of the New Zealand economy and includes the country's national business incubation program. It is overseen by a division within TRADENZ and reflects the strong link between the public sector STI and business developments overseen by the MED and the MSI. For example, such monitoring and evaluation, which must be completed on an annual basis, shows that in the ten years since The ICEHOUSE was set up, it has achieved the following in terms of new venture success ([28]):

- Supported the establishment of 75 start-up companies that remain in business.
- Created 700 jobs.
- Generated NZ$ 50 million in revenues from those companies in 2010-2011 year, 90% which came from export markets.
- Had an overall economic impact of NZ$ 162 million (34% of the total for all eight of New Zealand's business incubators).
- Raised NZ$ 55 million in capital for start-up companies with NZ$ 20 million coming through the ICE Angels investor network which includes 100 high net worth individuals.
- Invested in 117 companies.
- Won international awards for performance and international connectedness.

The total public investment in The ICEHOUSE over those ten years has been around NZ$ 5 million so the annual revenue returns being generated by graduate companies provide a very high return on investment.

In terms of the ICEHOUSE business accelerator activities, the 3,500 companies which have completed the incubator's program since it was founded have raised their earnings before interest and tax (EBIT) by 31% on average as a result of their participation.

Notwithstanding the excellent statistical reporting that New Zealand has developed, the country is still facing challenges when it comes to measuring the specific benefits being generated by the country's STI and R&D investments, as is the case in many other countries including Singapore and Denmark. The greatest issue has been the ability of people to be able to report, monitor and evaluate in a fair, unbiased and non-self-interested way. That was the greatest failing of the FORST program.

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[28] The ICEHOUSE. Providing Innovative growth solutions to owners of small and medium businesses. Power Point presentation supplied by Ken Erskine, Director, The ICEHOUSE, April 2012.

Key Points

- The Prime Minister and key government Ministers play a lead role in shaping the countries STI and R&D sector.
- There are strong linkages between the STI and R&D and business and trade development ministries and sectors in New Zealand.
- The country is prioritizing resources towards a limited number of selected niche areas in which New Zealand has particular strengths.
- Those niche areas have transitioned from being somewhat broad and traditional at the early stages of the country's national economic transition process to more defined niche areas which have greater potential relevance in future markets.
- The country is encouraging the development of defined centres of R&D excellence associated with national priority focus areas that are closely linked to business development and business incubation entities. The aim is to increase the value generation from the country's STI and R&D investment.
- The country continues to utilize an overall National Innovation System approach in order to achieve such value generation.
- Competitive bidding for R&D funding remains a strong feature when it comes to allocating public R&D funds.
- The FORST model offered a great opportunity to encourage a greater focus on where public R&D funding should be allocated and the setting up of public private collaborative R&D projects. However, in practice it failed to deliver effectively because of the way projects were assessed and approvals made – largely a governance issue. This does not mean that the model itself was at fault but rather the implementation and management of the assessment, funding allocation and M&E processes were insufficiently robust.
- New Zealand has also focused strongly on building international links, networks and R&D and business relationships through both the R&D (e.g. UNISERVICES) and business development sectors (e.g. The ICEHOUSE and TRADENZ).
- The country has an excellent monitoring and evaluation system in place with well-defined KPIs. However there are still some issues when it comes to monitoring and evaluating the overall economic impact of the country's public R&D investments and the general feeling is that it is not as high as it should be. In the view of Ken Erskine, too much of the public R&D investment continues to be allocated towards projects which tend to be academic researcher 'pet themes' or into historically traditional research areas that do not support the generation of high growth high value opportunities for the country.

Oregon

Overview

The US State of Oregon is included in this best practice review primarily because of its excellent scorecard approach towards monitoring and evaluation the impact of the state's STI and R&D investments and the way in which it benchmarks the state's scores against those for all other US states.

Monitoring and Evaluation

Oregon has adopted a novel innovation scorecard approach to monitor and evaluate STI and R&D progress and delivery in this US State. An example of the 2009 scorecard is shown in Figure 21.

Figure 21: The 2009 Oregon State Innovation Scorecard

Indicator	1-yr Trend	5-yr Trend	Relative to Competitor States/U.S. Av (Latest yr)	Latest National Ranking
Invention				
Invention Disclosures	▲	▲	▼	23rd (2007)
Patents	▼	▲	▲	6th (2008)
Patent Citations	▼	▲	▲	12th (2008)
Translation				
R&D Investments	▲	▲	▲	9th (2008)
SBIR/STTR Awards	▼	▼	▼	17th (2008)
University Licenses/Options	▲	▲	▲	16th (2008)
University Licensing Income	▲	▲	=	24th (2008)
Commercialization				
Venture Capital Investments	▼	▼	▲	18th (2008)
Kauffman Index of Entrepreneurship	▲	▲	=	13th (2008)
New Company Creation	▼	=	▼	14th (2008)
University Startups	▲	▲	▲	6th (2007)
Economic Prosperity				
Average Wage	=	=	▼	27th (2008)
Technology Sector Employment	▼	▲	=	12th (2008)
Foreign Exports	▬	▬	=	7th (2008)
Innovative Environment				
Educational Attainment	▲	▲	=	19th (2007)
Science & Engineers in Workforce	▲	▲	=	19th (2007)
High Speed Internet Lines	▲	▲	▼	21st (2008)
Renewable Energy Usage	▼	▼	=	2nd (2007)
Greenhouse Gas Emissions	▲	▲	=	7th (2008)
Energy Intensity	▲	▲	▼	21st (2008)
2009 Innovation Score (out of 100)				**71**
2009 Innovation Grade*				**B**

The most noteworthy aspect of this scorecard is the range of parameters used to measure progress within the overall STI context. They embrace far more than just R&D and include infrastructural, commercial, economic, human resource, invention and environmental KPIs. This reinforces a common theme that is seen in countries that have made or are making substantial economic and social progress – that the approach to STI must be within an overarching framework that embraces not only R&D but also its commercialization. Hence the reason why the majority of countries making real progress in this area have various types of National Innovation System initiatives.

Other Best Practice Examples

A very useful presentation titled 'Benchmarking Study on Innovation Policy' was published by Capgemini Consulting in early 2010 ([29]). It provided an overview of the best practices followed in the top ten most innovative countries internationally as measured by the GII. A summary of the key findings in this presentation is provided in Figures 22 and 23.

Figure 22: Best practices followed by the top innovative countries

Figure 23: Best practices followed by the top innovative countries (continued)

[29] http://www.slideshare.net/koen.klokgieters/benchmarking-study-on-innovation-policy-29012010-3527737

The point of including Figures 22 and 23 in this best practice review is because they illustrate the fact that highly innovative countries which are preforming well economically (most of which are small countries with small populations) have many commonalities and they also provide an excellent context within which the STI and R&D sector is positioned.

The presentation reinforces that fact that STI and R&D cannot function effectively in isolation. It is part of a National Innovation System which enables knowledge to be converted into value for a country and benefit citizens from both the economic and social perspectives. That means strong links with the private sector and business development agencies, as well as a range of other relevant key stakeholders, are vital if economic progress is going to be achieved.

Regional STI Initiatives

There are no real initiatives of note that this author is aware of that are of a high degree of relevance to the STI Strategic Roadmap initiative in Jamaica from a go-forward perspective. There has been a great deal of talk and several STI regional policy documents have been developed. The first was a regional STI policy put together in 1988 but it was never implemented. Since 1997, in association with the Caribbean Council for Science and Technology (CCST), CARICOM has developed an updated version of that earlier policy but all that appears to have happened to it is that it has been 'repeatedly reviewed, revised and strengthened'. A revised version was published by the CCST in 2007 ([30]) but, as is the case of much that happens at regional level, nothing much in the policy appears to have been implemented in a meaningful way and no real progress appears to have been made at either the regional or national levels.

What was positive about the revised policy was that it did identify a number of priority areas for the region:

- Agriculture and food sector.
- Biotechnology and biosafety.
- Environmental management.
- Coastal and marine resources management.
- Waste management.
- Integrated water resources management.
- Alternative energy and energy management.
- Disaster preparedness.
- Health.
- Sustainable tourism.
- Development of SMEs.
- Information and communication technologies.

However, these are a mix of public good and commercial opportunity areas and a balanced approach, given the very limited resources available for R&D in the region, needs to be taken to generate real value to the CARICOM countries. It is also an extensive list of priorities which needs to be rationalized at the national level into more relevant and practical national priority focus areas.

In Trinidad and Tobago, NIHERST developed a comprehensive approach for STI in that country as part of the Vision 2020 consultation process between 2003 and 2005. It included expert input from Dr Steve Thompson, a respected New Zealand science sector specialist who has had extensive international experience in the field of STI policy and implementation. He proposed a national R&D funding pool for Trinidad and Tobago which related to national priorities. However, as has been the case with the regional CARICOM STI policy initiatives, it has never been implemented.

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[30] 'Science, Technology & Innovation for Sustainable Development. Caribbean Regional Policy Framework for Action', March 2007; CARICOM, CCST and the CTA. http://ccst-caribbean.org/downloads/ccst-sti-framework.pdf

Dr Henry Lowe, the founder and owner of the Bio-Tech R&D Institute in Jamaica, says that several attempts have been made to rationalize the country's STI and R&D sector in the past but the implementation process failed because the approach recommended was not practical and little was achieved ([31]).

In this author's experience, the region's main university, the University of the West Indies (UWI) has not played a particularly effective role when it comes to working with business development agencies and the private sector to help generate measurable value from knowledge generated within the institution. Whilst the university has had a Business Development Unit at its St. Augustine campus for many years, it has not been able to achieve any significant successes. In fact the Unit has recently been transformed and now provides more of a support role to the university's R&D project initiatives. Commercialisation does not appear to be an agenda item that is given any great importance at UWI.

One of the major regional issues is the lack of a long-term defined overarching vision for both the region and individual countries within which STI and R&D strategies can be developed and implemented. Both Barbados and Trinidad and Tobago developed national development plans with long-term horizons (2025 and 2020 respectively) but neither had the political support of both the main political parties in each country and both also tended to be lacking in foresight. As a result the plans focused on extending what has largely been traditional.

Jamaica's 'Vision 2030' is a more comprehensive document which does have support from both the main political parties. The greatest difference between 'Vision 2030' and the other regional visioning initiatives is the inclusion of empirical targets and measureable KPIs that provide a basis for monitoring and evaluating progress towards the national long –term 2030 goals. However, it also includes quite a strong focus on extensions from the past rather than opportunities for the future. Some of the sector focuses included in the report need to undergo an in-depth foresight analysis to determine whether they are in fact as important to the future of the country as suggested. It is always a challenge to develop such national plans without being influenced by traditional 'vested interests' which often see change as a threat to their 'comfort zones'.

This is reflected by an analysis undertaken by the author in 2009 of national priority sectors that were identified by the governments of CARICOM countries and comparing those with sectors within which entrepreneurs in the region were investing their own time and resources and developing businesses and business investment propositions. In summary, the findings of this study showed that there was a significant disconnect between what governments consider to be a national priority and where Caribbean entrepreneurs are investing there time and resources. This is important as priority setting influences STI policy and associated national development initiatives. An extract from this report follows.

'The author has done a simple analysis of the different sources of priority sector identification by constructing a regional database. In total, 45 different national priority sectors were identified from various sources. This is a very approximate analysis and is not particularly scientific. However, it does

[31] Dr Henry Lowe, pers. comm. 18/04/2012

illustrate a difference in views with regard to priority sectors between the 'top down' (public sector and academic) groups versus the 'bottom up' (entrepreneurial) groups. The results are shown in Table 4.

Table 4: The Top 5 Priority Sectors From a 'Top Down' vs. 'Bottom Up' Perspective (numbers in brackets represent this category as % of all recorded priority sector categories)

Ranking*	'Top Down' Priority Sectors	'Bottom Up' Priority Sectors
1	Agriculture (11%)	Food & Beverage (11%)
2	Tourism (11%)	ICT (9%)
3	ICT (9%)	Agriculture (8%)
4	Financial Services (8%)	Fashion (8%)
5=	Agro-processing (6%)	Health & Wellness (7%)
5=		Creative (7%)

* The top 5 selected from the Caribbean Priority Sector Analysis Excel database were the five highest for each perspective out of a total of 45 different sectors identified by different sources.

What Table 4 indicates is that entrepreneurial individuals and groups in the 'bottom up' category appear to have a significantly different view of where they see opportunities compared to those who are involved in the 'top down' category. The 'top down' category stakeholder groups tend to be dominated by political, academic and public sector stakeholders and agencies.

Only two priority sectors are common to both categories – agriculture and ICT – although there is a degree of possible overlap between the agro-processing and food and beverage sectors, depending upon the definitions used. The 'bottom up' group has a stronger focus on personal consumer needs in areas such as fashion, the creative sector, and health and wellness – which is unsurprising as entrepreneurs generally have a greater awareness of what consumers demand and expect. That's the reason they decide to take the risk of going into or expanding a business.

This illustrates a possible disconnect that is hindering economic development in the Caribbean. The 'top down' categories tend to be predominated by a commodity approach and commodity thinking with little thought about where value can be created by connecting with strong consumer 'want areas' as opposed to 'need areas'. There is a much higher value proposition attached to 'wants' compared to 'needs'. The 'bottom up' category stakeholders appear to have a stronger connection with consumer 'wants' rather than 'needs' and this is reflected in the sectors that predominate with such stakeholders.

This is a real challenge for the region – to be pursuing STI and R&D and commercialisation programs that directly relate to changing consumer preferences and rapidly changing growth demands rather than producing a product and service that has a strong traditional sector linkage and then trying to find a buyer. Many traditional Producer Boards in the region fall into the latter category.

Several other analyses that are relevant to the STI Strategic Roadmap also provide useful reference points. The first is the Global Entrepreneurship Monitor (GEM) Trinidad & Tobago 2010 Report released in 2011 and referred to previously in this best practice review. It is of real relevance because Jamaica is

included in many of the analyses within this GEM report. Of particular importance is the fact that, of the 59 economies included in the GEM Reporting process, Jamaica is classed as having a 'Factor Driven Economy'. Such economies are 'at the lowest level of economic development'. The other two categories include 'Efficiency Driven Economies', which are largely industrial and focus on larger scale production (within which Trinidad and Tobago is categorised), and 'Innovation Driven Economies', which have strong R&D and knowledge creation components that lead to high value high growth entrepreneurial business development. Both Denmark and South Korea are examples of 'Innovation Driven Economies' amongst those countries participating in the GEM process. No Caribbean countries feature in this category.

In summary, the GEM survey says that Jamaica has a below average level of entrepreneurial activity and much of it is 'necessity driven' rather than 'value' or 'improvement' driven. The survey reinforces the reasons for Jamaica's low ranking in terms of the Global Innovation Index, currently place 92 out of 125 countries.

The National Institute for Higher Education Research (NIHERST) in Trinidad and Tobago has commissioned a series of private sector innovation surveys focusing on specific sectors over the past six years. The sectors covered include:

- Food and Beverage ([32]).
- Chemical and Non-Metallic Products ([33]).
- Tourism ([34]).
- Publishing, Printing and Paper Conversion ([35]).

In the Food and Beverage sector survey, 52% of respondents said that innovation was important to increase productivity and 50% to differentiate products. However, only 35% of the 46 companies that participated in the survey had undertaken any R&D. Only two companies used patents to protect their intellectual property.

26 companies participated in the Chemical and Non-Metallic Products survey. Most of the innovation employed focused on improving productivity, reducing costs, and improving products. However, as was the case for the Food and Beverage sector, only 35% had undertaken any R&D.

36 companies participated in the Tourism sector survey. The greatest sources of innovation within these enterprises came from staff within the establishment and customers, not from STI and R&D institutions.

37 companies participated in the Publishing, Printing and Paper Conversion sector survey. The main benefits from innovation were increased service quality, improved productivity, improved competitiveness and improved profitability. 40% of those surveyed recorded growth in product innovation. However, only 22% had undertaken any R&D.

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[32] National Innovation Survey of the Food & Beverage Industry in Trinidad and Tobago, NIHERST, 2006
[33] Survey of innovation in the Chemical and Non-Metallic Products Industry, NIHERST, 2009
[34] Innovation in the Tourism Sector, NIHERST, 2009
[35] Innovation in the Publishing, Printing and Paper Converter Industry, NIHERST, 2010

Based upon various international indicators and the current private sector and economic performance of many of the Caribbean region's economies, it can be concluded that STI and R&D in the region is largely failing to deliver. That apparent failure to deliver is due to a number of factors including:

- A lack of well-defined long term national visions.
- A lack of national innovation systems which align all national stakeholders, public, private and R&D, towards a common national vision and end-goal.
- A lack of clearly defined national priority focus areas that are future focused (rather than historically linked).
- A significant 'disconnect' between the public, R&D, and private sectors.
- A lack of investment into R&D by both the public and private sectors.
- Fragmentation, 'patch protection', duplication of effort, and poor resource utilization.
- A lack of effective monitoring, evaluation and accountability.

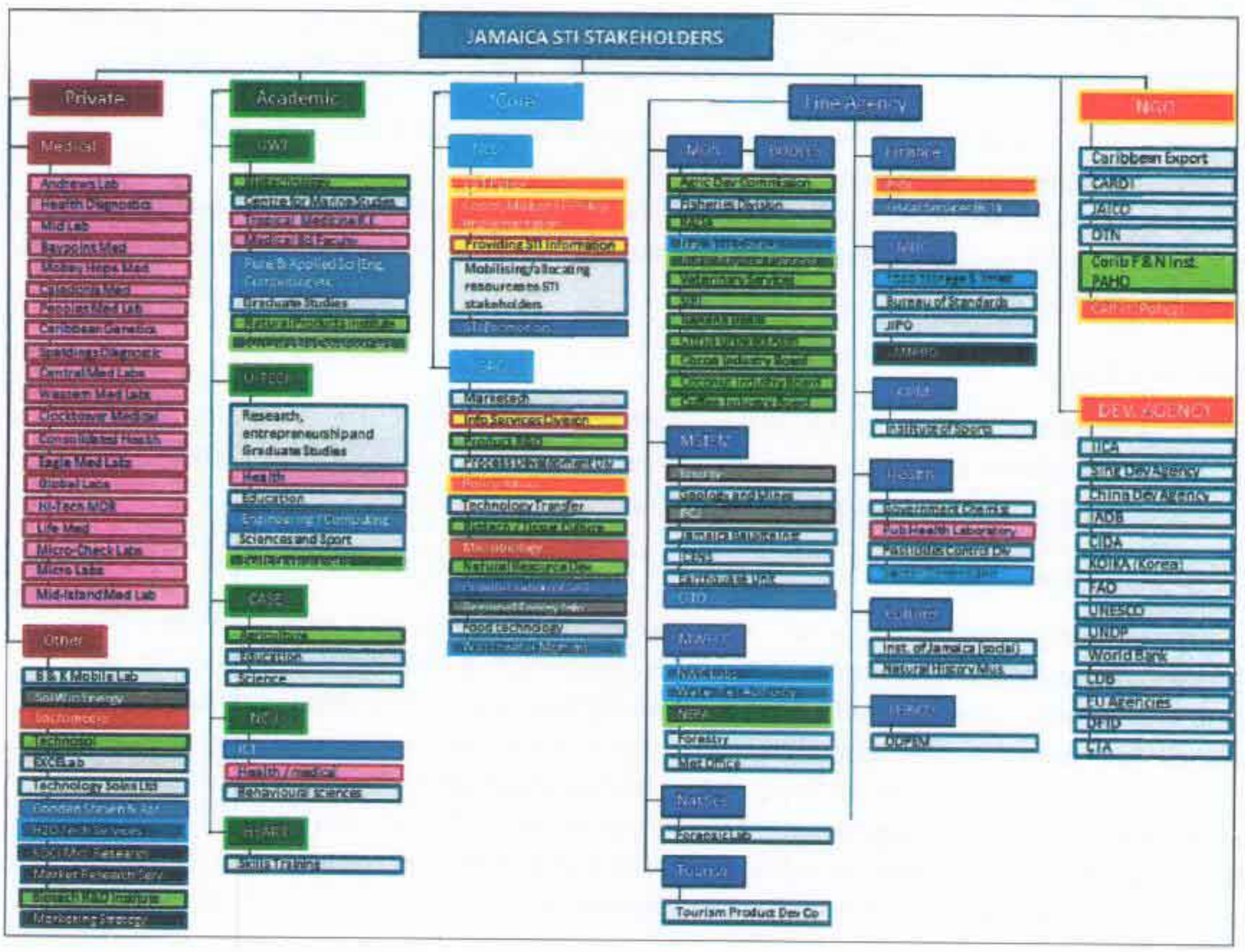
The Current STI Situation in Jamaica

At the time of compiling this section, a number of stakeholder engagement processes have not been completed including a series of interviews and a sector survey. For this reason, this assessment of the current Jamaican STI and R&D sector status can only provide a preliminary view that will need to be amplified further once both the stakeholder processes have been completed.

STI Sector Stakeholders

Based upon an initial consultation process and combined that with desktop research, an overview of a number of sector stakeholders who play a direct role in shaping the STI and R&D sector has been complied and is shown in Figure 24. This is unlikely to be a complete list of all the stakeholders involved in STI and R&D in Jamaica. However, it provides a useful start point for assessing the areas in which each entity is focusing and what capabilities, enablers and resources associated with them may be available in the country.

Figure 24: An overview of the main Jamaican STI sector stakeholders



In Figure 24, the author has colour-coded businesses, agencies, and institutions (or activity areas within them) to provide an indication of those areas where there appear to be common focuses and interests. Those areas with a pale blue fill and dark blue outline are those which have specialist activities that need clearer definition before any potential alignment (if there is an alignment) can be identified.

- On the left side of Figure 24, a number of private sector laboratory service and R&D businesses are listed. Most of these businesses are involved in the medical sector and provide laboratory testing and similar services. However, there are some specialist private sector R&D and laboratory services.
- In the next column titled 'Academic', a list of five higher education institutions and associated R&D institutions, as well as a number of specialist focus areas, is summarised.
- The third column titled 'Core' lists two national bodies that have been designated to play a lead role in designing policy and delivering STI and R&D programs and initiatives in Jamaica.
- The fourth column titled 'Line Agency' lists specialist agencies that are either involved directly in some field of R&D or in shaping and/or delivering R&D programs as well as applying them for national benefit.
- The fifth column lists a number of regional and international NGOs and Development Agencies that have some relevance to the country's national STI sector either directly or indirectly.

The main conclusion that can be drawn from Figure 24 is that Jamaica has a large number of stakeholders involved in various aspects of STI and R&D activities for such a small country. There are indications that a degree of duplication of effort is taking place in a significant number of areas and initial discussions with sector stakeholders indicate that there are several that currently appear to serve little or no useful purpose.

Some Key Issues

There are a number of key issues that have been identified from the desk-top research, material provided by a number of STI sector agencies in Jamaica, and discussions that have taken place to date. These issues are explained in more detail in the following sections.

Direction and Governance

Both the National Council for Science and Technology (NCST) and the Scientific Research Council (SRC) are now under one Ministry. Based upon informal discussions with several key stakeholders, the roles which both agencies were supposed to have been playing have tended to have lost some degree of definition in recent years. Both currently appear to play a role in policy development, sector governance as well as with specific R&D activities and projects. This loss of definition is something that has happened in other countries, e.g. the role of MOST in South Korea ([36]) and FORST in New Zealand, in the past. Unless very clear guidelines are put in place and are adhered to, such agencies tend to become ineffective and are unable to lead the sector in a direction that provides optimum national benefits.

[36] http://homepages.inf.ed.ac.uk/s9904132/NIS.pdf

The NCST website provides little information dated after 2007 (e.g. annual reports). Comments from other sector stakeholders suggest that the NCST is currently playing a minimal role in shaping the STI sector in Jamaica.

Both the NCST and SRC have a policy advisory role. However, how such policies are implemented is complicated by the large number of agencies involved in R&D in the country and a lack of systems to oversee such implementation and measure the results achieved. Thus was illustrated at a meeting with the Minister of MSTEM held in late January which this author attended along with a number of STI sector representatives. The Minister asked several questions about specific R&D projects, a specialized expensive piece of equipment bought from Australia, and a combined environmental-agricultural project. No one present could tell him what sort of outcome had been achieved in both instances and whether the country had gained any economic benefit from the investments made.

This is just one simple example of what appears to be a considerable gap in Jamaica's STI sector – good governance. This means ensuring that there is system of management, monitoring and evaluation, and accountability that ensures that the country gains the greatest benefit from its STI and R&D investments. Good governance can only be achieved if a properly structured system is in place that embraces at least all of the country's public sector investment into the STI and R&D sector (financial, physical and human) and ensures that the maximum value from such investments is being delivered on an ongoing basis.

Based upon the best practice review, there needs to be a clear separation of sector governance from STI and R&D projects and activities.

STI Funding

This is a major issue for Jamaica. Sector stakeholders say there is no single national pool of public R&D funding that is allocated each year using formal processes which ensure that such investment is prioritized into areas which are likely to generate the greatest economic benefits for the country. The country is still rated as having a 'Factor Driven Economy', an economy which ranks lowest internationally in terms of value creation.

Funding appears to take place within individual ministry and / or agency budgets and is not necessarily scrutinized to ensure that it is being directed into areas which are likely to yield the greatest return on investment for the country. In addition, there appears to be no formal independent monitoring and evaluation system in place to determine whether the country's STI and R&D investments are delivering value for the nation.

In other words, the current STI and R&D funding approach appears to have been happening on a rather ad-hoc basis.

Resource Utilisation

Because of the multiplicity of agencies involved in STI and R&D in Jamaica, there are numerous hierarchies in place which all cost significant sums to fund in terms of wages and resources. Some of

these hierarchies are involved in similar areas of endeavor to others and so there are questions that need to be asked as to whether there is a need for what appears to be a significant overlapping of interests.

Because there is a multiplicity of agencies, it seems likely that there are equipment items that have been purchased by one particular agency which are not being utilized effectively and which could be utilized by other agencies on some form of shared basis. The same applies to staff members with specific high-level skills in specialist fields who are possibly not being used at optimum levels from a national standpoint. However, no comprehensive inventory has been completed that provides a solid basis for identifying what resources are available in the country and how effectively they are being utilized. Part of the interviewing and survey process that is underway at the time of compiling this report aims to develop an initial view in this regard.

In 2011 the Public Service Transformation Unit did undertake a limited survey of a number of key state agencies in Jamaica that had an involvement in STI and R&D including:

- The National Irrigation Commission.
- The Physical Planning Division of the Ministry of Agriculture and Fisheries.
- The Hope Analytical Laboratories Network.
- The Petroleum Corporation of Jamaica.
- The Mines and Geology Division, the Ministry of Energy and Mining.
- The Scientific Research Council.
- The Water Resources Authority
- The Pesticides Control Authority.

This survey provided a range of information (which varied by agency) including an overview of each entity's Mission, Mandate and Functions, Current Work Status, Equipment Lists, and Organisational Structure.

This is an initial piece of work that provides a base upon which a much more comprehensive inventory can be built. However, it needs considerable further development and needs to be delivered in a multi-party easily accessible electronic database format.

Return on Investment

Is Jamaica receiving a good return on its STI and R&D investments? This is an issue that a number of countries have struggled to determine. However, it is an area in which South Korea, New Zealand and Denmark are developing expertise and putting systems in place.

Whilst in the 'Vision 2030' document, reference is made to an annual investment in R&D of less than 1% (page 188), a report issued by the Planning Institute of Jamaica in 2008 suggests that the national figure

is likely to be much lower, possibly as low as 0.1 – 0.3% ([37]). An earlier report from the NCST ([38]) suggests a similar figure is likely to be the reality, given Jamaica's recent economic challenges.

There are a number agencies associated with the agricultural sector through the Ministry of Agriculture, tertiary institutions and other entities. In spite of the strong focus, agriculture as a percentage of GDP has declined from 8.5% in 1980 to 5.8% in 2012. In addition, food imports have risen dramatically and in 2011 60% of all food consumed in the country was imported ([39]). The decline in agriculture and the rise of the food import bill over recent decades suggests that the policies and R&D investment approach taken towards the agricultural sector has not yielded a positive outcome for the country. The transition away from a commodity sector to one which adds substantial value has not progressed to the extent that it should have. Both agriculture and the associated value-adding sector should be contributing far more to the country's economy than is currently the case.

It seems likely that much of the R&D funding in agriculture has gone into traditional areas that are not delivering the level of return that the nation should receive, given the small amount of public R&D funding that is available to invest each year. The poor performance of the country's Producer Boards is something that deserves urgent attention. What has been the country's return on investment for supporting these Boards? Could those funds be better invested in other areas with far greater value adding potential? The Boards are still part of a low value creation 'Factor Driven Economy'.

In this regard, there appears to be no formal national process in place in Jamaica today that evaluates the potential value generation that each publicly funded R&D project is likely to generate. In South Korea, such a system is in place and every Ministry has to account for its R&D funding allocations and the value generated from each project under their control through a strict formal process.

National STI & R&D Priorities

Both 'Vision 2030' and the 2011 Manifesto of the People's National Party refer to certain national priority areas.

In the case of Vision 2030 they are:

- Agriculture.
- Manufacturing.
- Mining and Quarrying.
- Construction.
- Creative Industries.
- Sport.
- Information and Communications Technology.
- Services.

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[37] http://www.pioj.gov.jm/Portals/0/Sustainable_Development/Innovation-Jamaica.pdf
[38] http://www.ncst.gov.jm/STIndicatorsReport.pdf
[39] http://www.caribbean360.com/index.php/news/jamaica_news/388534.html#axzz1sDKIgJng

- Tourism.

In the case of the PNP Manifesto, the priority areas alluded to include:

- Energy.
- ICTs.
- SMEs.
- Knowledge-based industries.
- Manufacturing.
- Tourism (with a special emphasis on health tourism).
- Mining.
- Agriculture

The rationale for choosing the priority focus areas seems to be more historical rather than foresightful in both cases. The world of business tomorrow will be quite different to that of yesterday. The priority sector focuses that countries such as Denmark, New Zealand, Singapore and South Korea have chosen are far more future-focused and future-oriented.

One of the challenges associated with transitioning away from a 'Factor Driven Economy' is to move from 'producer-driven' thinking towards 'consumer-led thinking'. Whilst 'Vision 2030' stresses the need to become more innovative and high-tech, it becomes difficult if traditional vested interests use their influence to try and preserve their positions.

Because Jamaica has such limited resources available to invest in STI and R&D, the focus simply must be on areas which offer the greatest future returns to the country. This can only be achieved by using an approach similar to that described in Figure 25 i.e. matching the country's capabilities, enablers and resources with strong future growth consumer driven market niches and identifying the 'best bet' opportunity areas.

Figure 25: The basis for defining national priorities ([40])

[40] NEXT Archive

One important thing that many countries have found when they develop national priorities is that true entrepreneurs have a better sense of what and where the growth opportunities are than state agencies. Thus, any priorities that are set should not be sector oriented but rather thematic. For example, the theme 'Health & Wellness' in Jamaica is relevant not only to tourism but also to agriculture, manufacturing and ICTs. The theme 'Resource Use Efficiency' is relevant to manufacturing, tourism, agriculture, mining, energy – in fact every sector. ICT is not a sector. It is a set of tools and infrastructure. Of greater relevance to Jamaica are those types of unique applications that can be developed by entrepreneurs using ICTs - such as Digital Tanstech's mobile phone lotto platform and InfoGroup's Sickle Cell Anaemia software. Agriculture itself is not so much a priority in itself as is 'Resource Value Adding'. That is something that the Producer Boards have failed to achieve. This applies not just to agriculture but to every sector.

Thus, Jamaica's approach to identifying priority areas needs to be carefully looked at to ensure it does not favour continuation of the 'old' and constrain exploitation of the 'new'. That is what happened in New Zealand to a large extent and led to the failure of the FORST initiative.

Cooperation and Collaboration

Whilst there have been some excellent individual STI and R&D outcomes in Jamaica that have also included international collaboration, such as the cardiac surgery simulation unit developed by Drs Ramphal, Coore and Craven (originally through their roles at UWI Mona), such outcomes have tended to evolve in isolation and have not been sufficient in number and value to help advance the country economically.

Notwithstanding the low level of public funding into STI and R&D in Jamaica, the large number of entities involved in R&D, the fragmented nature of the sector, the uncoordinated approach towards allocating and utilising resources, coupled with limited collaboration and few multi-disciplinary approaches, gives rise to concerns that the country is getting less value for its investments than should be the case. There appears to be no functional overarching governance and policy advisory body which ensures that the STI and R&D sector functions in a highly efficient, synergistic, value creating fashion. In other words there is no integrated system in place in the country, such as a National Innovation System, which ensures that the country generates the maximum benefits from its STI and R&D investments. This is perhaps the most important issue that faces Jamaica.

Because there is no National Innovation System it means that the links between private sector, the educational sector, development agencies, offshore collaborative partners, policy makers, regulatory authorities and all other relevant stakeholders involved in national economic and social developed are not being engaged, managed and leveraged for national benefit in a formalized fashion.

Cooperation and collaboration is not only needed within Jamaica between the public, NGO and private sectors across a broad range of stakeholders (education, business, business development, infrastructure, regulatory etc.) but also between stakeholder groups within Jamaica and key offshore alliance partners through mutually beneficial arrangements. Jamaica needs to 'go global' to a much greater extent than is currently the case if it wants to lift the national GDP. The population of the country is simply too small for the level of GDP per capita to increase to the level envisaged in 'Vision 2030'. If fact, perhaps 90% or more of the value increase required for achieving the 'Vision 2030' goal will need to be derived from international niche markets. This is the level of offshore earnings achieved by the 75 start-up companies that have graduated from The ICEHOUSE business incubator in New Zealand over the past ten years.

There needs to be particularly strong collaboration between the STI and R&D sector, business development agencies, and the private sector (in particular upcoming entrepreneurs and SMEs rather than traditional incumbent private sector interests that have not been particularly innovative) to be able to deliver such outcomes through the application of R&D.

Monitoring & Evaluation

The country has set a series of targets for 2030 including lifting GDP per capita from a current level of around US$ 8,300 to that of a fully developed nation. This is inferred as being a GDP per capita of US$ 20,000 + in the 'Vision 2030' document.

To achieve such an increase, the country needs to move as quickly as possible from being a 'Factor Driven Economy' towards being an 'Innovation Driven Economy' – largely leapfrogging the 'Efficiency Driven Economy' transitional step. This can only happen within the next 18 years if there is a greater focus on ensuring that every investment of public sector provided resources – financial, human and physical – is allocated in a way that generates the greatest future return on investment to the country. Ensuring that this happens requires having a formal target setting, priority funding evaluation and allocation processes, and a progress monitoring and evaluation system in place, such as is the case in South Korea.

Currently, this is something that does not appear to be a formal part of the national STI and R&D sector in Jamaica.

The Essentials for an STI Strategic Roadmap

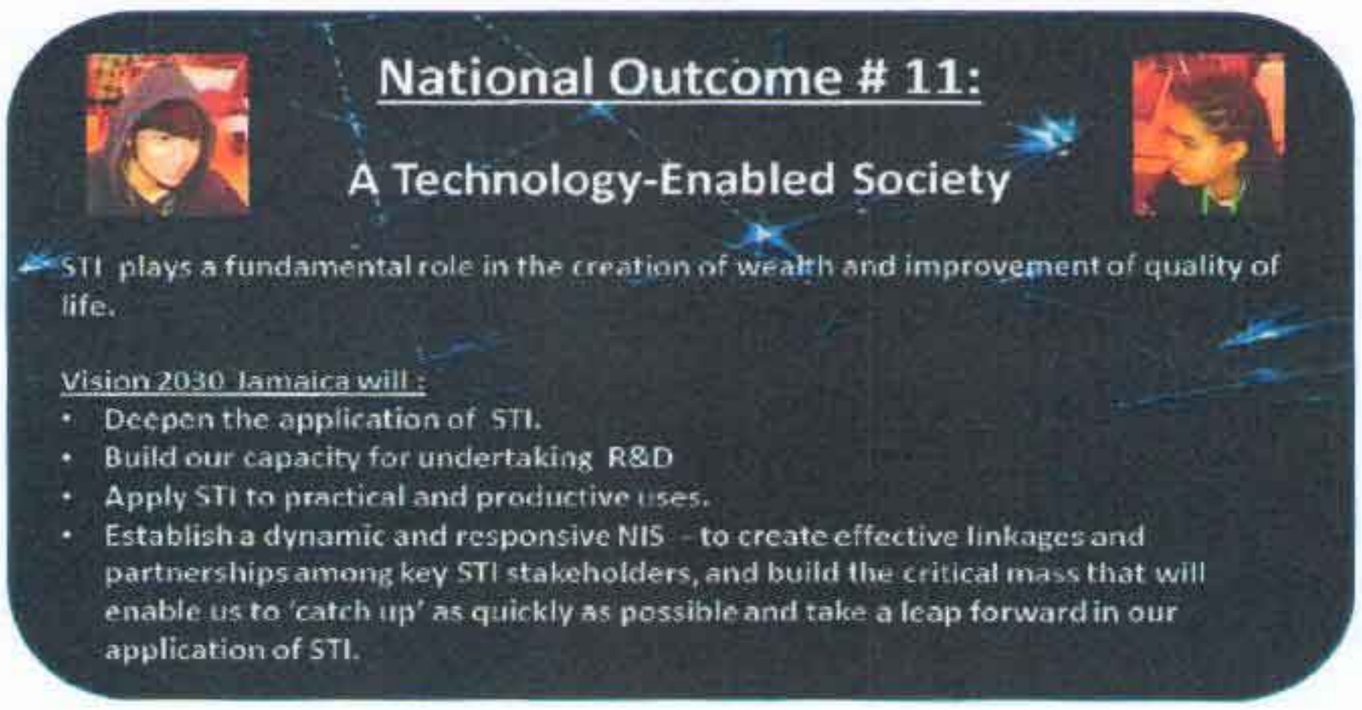
As stated previously, at the time of compiling this report the stakeholder engagement process is still in progress and so the comments and observations included in this section are largely based upon a review of best international practices and an initial evaluation of the STI & R&D sector in Jamaica based upon the information available at the time of compilation.

The start point for developing a national STI and R&D Sector Strategic roadmap requires the definition of an end national goal, which has been essentially (if somewhat indirectly) defined in 'Vision 2030', as shown in Figure 26.

Figure 26: The overarching national end goal with which the STI sector needs to be aligned

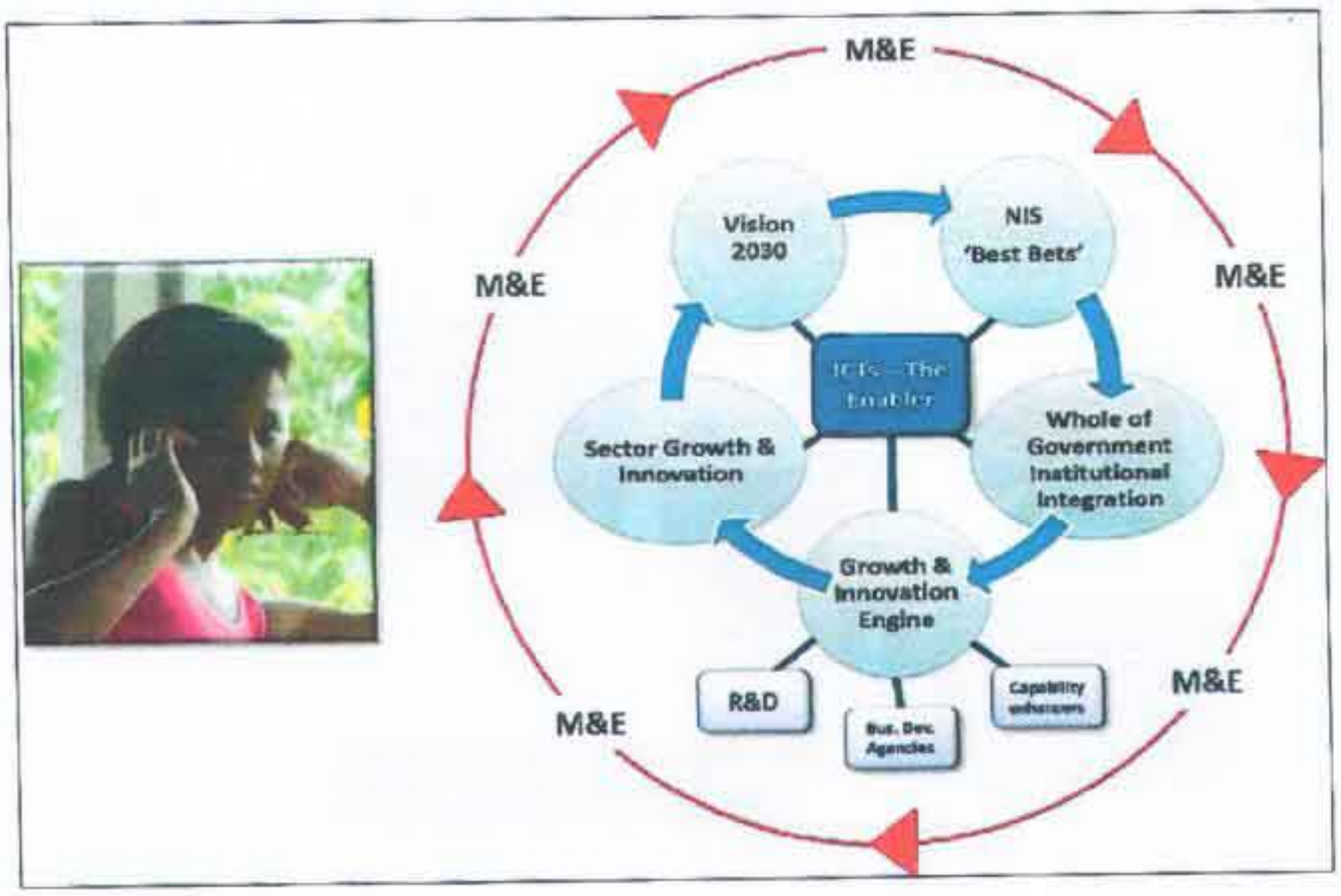
From the STI and R&D perspective, 'Vision 2030' includes a National Outcome for the sector which is summarised in Figure 27.

Figure 27: National Outcome 11 in the Vision 2030 national Development Plan



This National Outcome 11 refers to the establishment of a 'dynamic and responsive NIS' – which will be essential if progress is to be achieved as it is a system that aligns all the national resources associated with the STI and R&D sector – directly and indirectly – towards achieving the national overarching goal. An overview of the structure of a typical NIS is shown in Figure 28.

Figure 28: An overview of the structure of a typical National Growth & Innovation System ([41])



It is important to note that the STI and R&D sector is just one part of such a system – an integral part of the national value generation process within the 'Growth and Innovation Engine'. Thus, the development of the Jamaican STI Sector Strategic Roadmap needs to take place within the context of such a system because it is stated as being something that is essential for the country to progress in the 'Vision 2030' document. It is important that this bigger picture view is used to develop such a roadmap to ensure that the STI sector is aligned with all the other stakeholders which are needed to achieve the country's 'Vision 2030' end goal.

Based upon a combination of the international best practice review, an initial review of the current situation in Jamaica, and feedback from the initial stakeholder workshop on March 13, 2012, a go-forward strategic road map will need to embrace the following areas:

- Leadership at the highest level (PM).
- Alignment of the STI sector with the overarching national goal.
- National priority setting.
- STI sector governance, policy development, structure and alignment with other key non-STI sector stakeholders and agencies.

[41] NEXT Archives

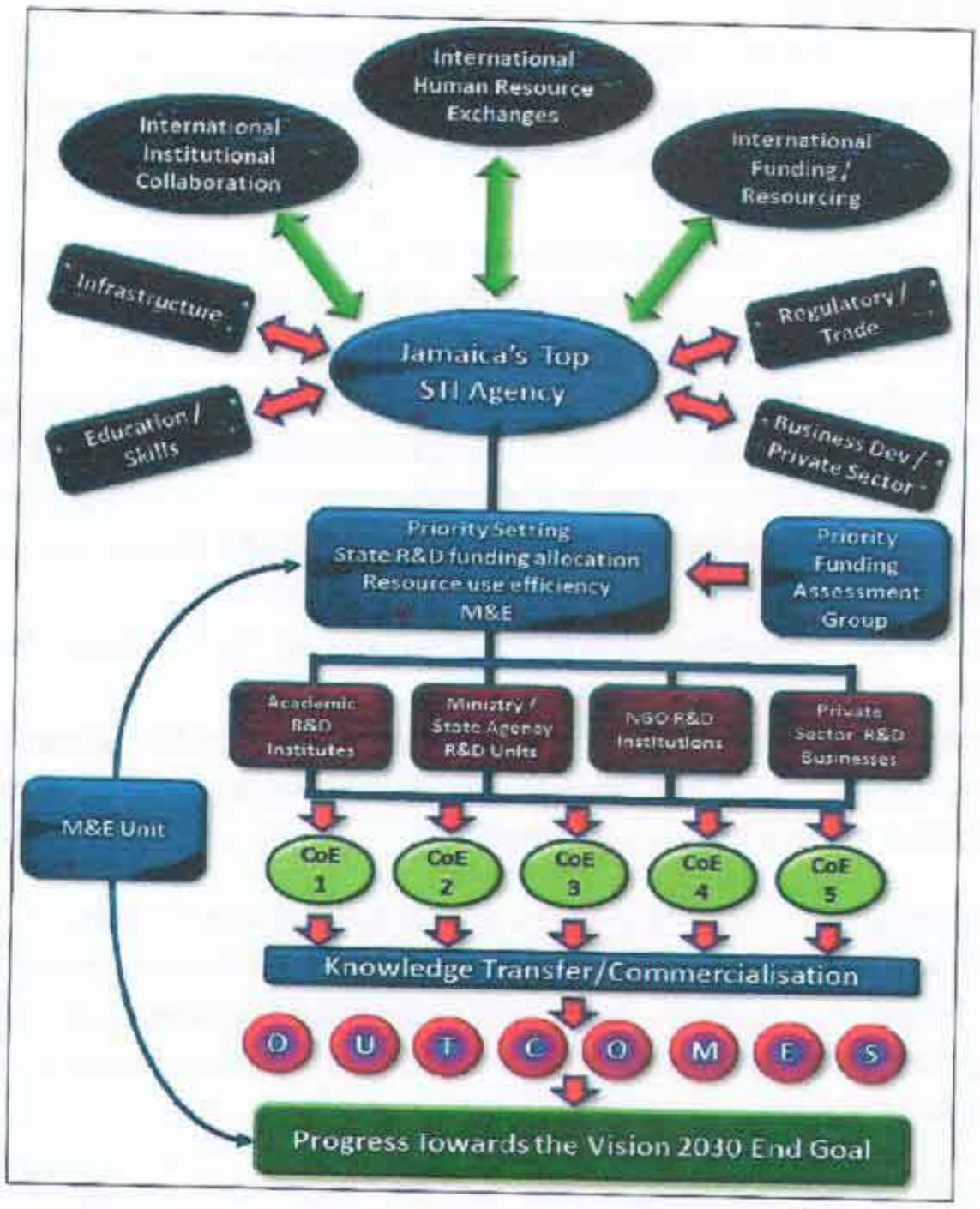
- Capabilities and enablers – and extending these through international relationship building.
- Centres of excellence – a clustering of existing sector entities which are aligned to national priority areas as far as possible.
- Resourcing – determining what is currently available, how effectively it is being utilized, what additional resourcing is needed, and ways in which such resourcing can be enabled within the national constraints that prevail. This requires undertaking a national inventory of the STI and R&D resources available.
- Collaboration and cooperation – national and international. This will require some rationalization of the current agencies involved in STI and R&D in Jamaica.
- Maximising the STI and R&D return on investment – which requires a very close relationship between the STI and R&D sector, business development agencies and the private sector. It also requires a stronger market orientation than currently appears to be the case as well as a streamlining of the sector and the elimination of duplication of effort. In addition, significant funding needs to be provided to assist in the commercialization of R&D through high success delivery initiatives.
- Monitoring and evaluation – a formal system of KPIs and measures needs to be put in place and utilized to improve performance on a continuous basis.
- Addressing personnel fears – anything that threatens the status quo can be unsettling for many staff members. Any roadmap needs to provide an approach that minimizes those fears – 'accentuate the positive and eliminate the negative'.

A concept model for the Jamaican STI sector which embraces all these components is shown in Figure 29. This concept model proposes an STI sector structure which embraces all the areas that need to be addressed within one STI 'system' that is closely aligned with all the other key stakeholders who play important roles within a greater National Innovation System. This must include international as well as national alignments and linkages.

The areas denoted CoE in the model refer to specific centres of excellence which are aligned closely with national priority areas and which embrace clusters of existing STI and R&D sector entities in common collaborative endeavours. The M&E component is a comprehensive monitoring and evaluation unit that measures the impact that the public investment into S&T and R&D is making, whether through a common national pool of R&D funds of through specifically designated pools of R&D funding allocated through specific ministries and agencies.

This concept model is still a work in progress at the time of compiling this report and will require further refinement as the progress and final outcomes of the stakeholder engagement processes become available.

Figure 29: A concept model for generating greater value from the Jamaican STI sector



Final Comments

Jamaica currently faces serious economic challenges. The country's economy is currently largely 'factor driven', the lowest level of economic development. For Jamaica to effectively realize its 'Vision 2030' aspirations, the country's economy will need to become far more 'innovation driven'.

The term 'innovation' has a quite specific definition. In essence it means generating value from an idea or invention. Thus the I part of the STI acronym is of the greatest importance as this is the part which will play a critical role in raising the GDP/capita level for Jamaica and its citizens. More detailed definitions of both entrepreneurship and innovation can be found in the Appendix.

Because resources are a constraint in any small economy, they must be leveraged to a much greater extent than in large economies. For example, studies have shown that the return on investment from public funding in New Zealand business incubators such as The ICEHOUSE is at least $10 for every dollar invested. In the USA and the UK, the return is typically closer to US$ 2 for every dollar invested.

Jamaicans already have to stretch dollars further than citizens living in developed nations – and this is an advantage. However, the potential benefits of such 'stretch' cannot be realized unless there is a system in place that maximizes the generation of such benefits within a long-term context e.g. the overarching Vision 2030 goal.

The greatest challenge in developing and implementing an STI Sector Strategic Roadmap is going to be the perceived threat by staff in existing STI and R&D organisations when it comes to culture and structural change. For this reason, the STI Sector Strategic Roadmap must be developed in a way that minimizes such fears and ensures that implementation proceeds as effectively as possible.

This can only happen if personal, organizational, sectoral and national goals are all aligned in the same direction towards a common end result. And this can only be achieved by ensuring that a National Innovation System is developed and implemented.

The STI Sector Strategic Roadmap will be developed so that both the personal and system requirements are primary drivers of its form and recommended implementation processes.

Appendix: Definitions

Entrepreneurship

Definition of entrepreneurship

Entrepreneurship is a process through which individuals identify opportunities, allocate resources, and create value. This creation of value is often through the identification of unmet needs or through the identification of opportunities for change.

Source: http://www.sregwatson.com/entrepreneurship-definition/

Innovation

Definition of innovation

A process by which an idea or invention is translated into a good or service for which people will pay. To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves deliberate application of information, imagination, and initiative in deriving greater or different value from resources, and encompasses all processes by which new ideas are generated and converted into useful products. In business, innovation results often from the application of a scientific or technical idea in decreasing the gap between the needs or expectations of the customers and the performance of a firm's products. In a social context, innovation is equally important in devising new collaborative methods such as alliance creation, joint venturing, flexible working hours, and in creating buyers' purchasing power through methods such as hire purchase .It may be evolutionary (long-term stepwise improvements), revolutionary (a completely new disruptive product or service) or adaptive (customising existing products and services to better suit a particular need).

Sources: http://www.businessdictionary.com/definition/innovation.html ; NEXT archives.