Government of the Republic of Trinidad and Tobago
Ministry of Science and Technology

National Institute of Higher Education, Research, Science and Technology (NIHERST)

National Institute of Science, Technology and Development Studies (NISTADS), India

Organization of American States (OAS)

Papers of the INSCITED

International Conference on Science and Technology for Economic Diversification

2013

05 – 07 June, 2013
Port-of-Spain,
Trinidad & Tobago

SELECTIVE LISTING OF OTHER NIHERST PUBLICATIONS

Statistical Surveys

- Utilisation of Information Technology by Households (2001, 2009)
- Survey on the Public Perception of Science (2005, 2012)
- National Innovation Survey of the Food and Beverage Industry in Trinidad and Tobago (2006)
- The Survey of Mathematics in Primary Schools (2006, 2007)
- Survey of Environmental Awareness and Practices (2008, 2013)
- Survey of Graduates of Technical Institutions (2008)
- Survey of Innovation in the Chemical and Non Metallic Products Industry (2008)
- Survey of Innovation in the Tourism Sector (2009)
- Survey of Innovation in the Publishing, Printing and Paper Converter Industry (2010)
- Survey of Science in Secondary Schools (2011)
- Survey of Environmental Awareness and Practices (2013)

Foresighting

- Biotechnology Advanced Sector Foresight Project: Best Bet Investment Opportunity Cases (2008)
- Lead Indicators Shaping Biotechnology to 2017 (2007)
- Fashion Advanced Sector Foresight Project: Best Bet Investment Opportunity Cases (2007)
- Lead Indicators Shaping Fashion to 2017 (2007)
- Renewable Energy Sector Global Foresight Review (2008)
- Renewable Energy Sector Best Bet Investment Opportunities (2009)

Icons in Science, Technology and Innovation

- Caribbean Icons in Science, Technology and Innovation (Volume I & II)
- Trinidad and Tobago Icons in Science and Technology (Volume I, II & III)
- The Contribution of Local Chinese to Science, Technology and Innovation
- Caribbean Women in Science and Their Careers

For more information, visit: http://www.niherst.gov.tt/resources/resources-print.html

Papers of the International Conference on Science, Technology and Economic Diversification (INSCITED 2013)

05 June – 07 June, 2013

Hilton Trinidad Hotel and Conference Centre
Port of Spain, Trinidad, W.I.

**National Institute of Higher Education,
Research, Science and Technology (NIHERST)
#77 Eastern Main Road
St. Augustine
Trinidad and Tobago
Telephone: (868) 663-6130 / 663-6988
Fax: (868) 622-0410
Email: inscited@niherst.gov.tt**

Published by

National Institute of Higher Education,
Research, Science and Technology (NIHERST)
#77 Eastern Main Road
St. Augustine
Trinidad and Tobago
Telephone: (868) 663-6130 / 663-6988
Fax: (868) 622-0410
Email: inscited@niherst.gov.tt

ISBN: 978-976-95273-9-3

Contents

Foreword

The first ever International Conference on Science and Technology for Economic Diversification (INSCITED) took place in Port of Spain, Trinidad and Tobago from 05th – 07th June 2013.

The genesis of the idea for INSCITED 2013 came out of a Memorandum of Understanding signed in January 2012 between Trinidad and Tobago's National Institute of Higher Education, Research, Science and Technology (NIHERST) and the Council of Scientific and Industrial Research (CSIR) of India. Based on the MOU, the Ministry of Science and Technology and NIHERST took the decision to host INSCITED 2013 in collaboration with India's National Institute of Science, Technology and Development Studies (NISTADS) and the Organisation of American States (OAS).

The primary purpose of INSCITED 2013 was to promote scientific collaborations between Trinidad and Tobago, India and other countries. Further, to establish a community of shared understanding, using various hypotheses and the experiences of different countries to demonstrate how science and technology, when effectively harnessed, can help countries achieve greater competitiveness and sustainable development.

The conference opened at the Hilton Trinidad Hotel and Conference Centre with several of the world's most respected academics, policy makers and researchers in the field of science and technology in attendance. For three days, they immersed themselves in a unique exercise in networking and sharing of scientific information and experiences.

INSCITED 2013 focused on three themes:

- Science and Technology Policy for Supporting Inclusive Growth, Economic Diversification and Sustainable Development;
- Promoting Technology Transfer in Various Economic Sectors, and Small and Medium Enterprises; and
- And Building Human Capital Development in a Globalised Setting.

The conference aimed to introduce practical policy solutions to some common challenges including weak links between science institutions and the private sector; outdated or non-existent science and technology policies in most countries; brain drain associated with the migration of scientists, engineers and technicians to developed nations; leveraging the diaspora to reverse the problem of brain drain; and weak and thinly spread R&D institutions or centres.

Participants were welcomed by Dr. the Honourable Rupert Griffith, Minister of Science and Technology, with daily opening addresses by Senator Dr. the Honourable Bhoendradatt Tewarie, Minister of Planning and Sustainable Development; Dr. Keilor Rojas Jiménez, Vice Minister of Science and Technology, Costa Rica and Senator the Honourable Fazal Karim, Minister of Tertiary Education and Skills Training.

Feature addresses were delivered by Mr. Jwala Rambarran, Governor, Central Bank of Trinidad and Tobago who spoke on "Inclusive Growth and Economic Diversification"; Dr. Jason Blackstock, University College London, UK who addressed the issue of "Human Capital Development in a Globalised Setting" and Prof. Prakash Persad, Chairman, NIHERST who focused on "Technology and Sustainable Development ".

Among the broad headings under which presentations were delivered were:

- Emerging Patterns of Higher Education - Open and Distance Learning Policies and Systems;
- Leveraging the Diaspora for Reverse Brain Drain;
- Promoting Technology Transfer in Various Sectors and SMEs; and
- Developing High Technology and ICT-Enabled Businesses.

After three intense days of discussion and exploration, INSCITED 2013 ended with a commitment to continue deepening the collaboration. The rich data produced by INSCITED 2013 form the information platform for action and for the work of the next International Conference on Science and Technology for Economic Diversification.

Acknowledgements

NIHERST wishes to acknowledge the organisations that collaborated in the staging of INSCITED - The Organization of American States (OAS) and the National Institute of Science, Technology and Development Studies (NISTADS), India.

We also wish to thank Dr. the Hon. Rupert T. Griffith and his team at the Ministry of Science and Technology for their valuable support and also for delivering the feature address on the opening night. We also owe a debt of gratitude to Senator the Hon. Fazal Karim, Minister of Tertiary Education and Skills Training and our former line minister, for endorsing the idea of the conference and agreeing to be a feature speaker, and also to Senator Dr. the Hon. Bhoendradatt Tewarie, Minister of Planning and Sustainable Development, and Mr. Jwala Rambarran, Governor of the Central Bank of Trinidad and Tobago, for lending their support to the initiative, delivering feature addresses and providing sponsorship.

We are also very grateful for all the distinguished speakers and presenters who generously contributed their time and expertise. In particular, we thank the presenters who submitted their valuable papers which comprise the body of these conference proceedings.

Other sponsors we wish to acknowledge are the Ministry of Trade, Industry and Investment and the Trinidad and Tobago Convention Bureau. We thank the Caribbean Council of Science and Technology (CCST) and the Caribbean Academy of Sciences (CAS) for promoting the conference regionally. We would also like to thank the participants and all other persons whose efforts and engagement have helped ensure the success of this conference.

INSCITED 2013 Planning Committee

- Dr. Rawatee Maharaj-Sharma (INSCITED Planning Committee Chairperson), Lecturer, School of Education, The University of the West Indies (UWI)
- Mrs. Maureen Manchouck, President, NIHERST
- Mrs. Karen Rosemin, Director (Ag.), Distance Learning Secretariat and Higher Education Services Division, Ministry of Tertiary Education and Skills Training
- Mr. Andre Thompson, IT Officer – Systems Engineer, Campus Information Technology Services, The University of the West Indies
- Ms. Joycelyn Lee Young, Registrar, NIHERST
- Ms. Lovaan Superville, Research Officer, NIHERST
- Ms. Joanne Chin Sang, Research Officer, NIHERST
- Ms. Sharon Parmanan, Statistical Officer, NIHERST

Abbreviations

BTU	British Thermal Unit
BP	British Petroleum
CO2	Carbon Dioxide
CSIR	Council of Scientific and Industrial Research, India
EE	Energy Efficiency
EII	Energy Intensity Index
GDP	Gross Domestic Product
GG	Green Growth
GHG	Greenhouse Gas Emissions
GI	Geographical Indications
INR	Indian Rupee
ITT	Indian Institute of Technology
JI	Jagdeo Initiative
JNNSM	Jawaharlal Nehru National Solar Mission
MSME	Medium, Small and Micro Enterprises
NInC	National Innovation Council
NBTB	National Biotechnology Board
NAPCC	National Action Plan on Climate Change
QBTU	Quadrillion BTU
rDNA	Recombinant deoxyribonucleic acid
R&D	Research and Development
RE	Renewable Energy
RCGM	Review Committee on Genetic Manipulation (India)
S&T	Science and Technology
SIDS	Small Island Developing States
TRIPs	Agreement on Trade Related Aspects of Intellectual Property Rights
WTO	World Trade Organization

Feature and Keynote Addresses

1.

Trinidad and Tobago: The Vision

By Dr. the Honourable Rupert T. Griffith
Minister of Science and Technology

As I look around this ballroom filled with such an august gathering of science minds, I am filled with a sense of anticipation for what we are about to embark on over the next three days. In some ways we are creating history. I say this because I feel the focus of the conference organisers and the serious nature of the participants' auger well for the impact of our deliberations on each of our national communities. It is therefore my honour to welcome all of you on behalf of the government and people of Trinidad and Tobago to this inaugural International Conference on Science and Technology for Economic Development.

To our acclaimed international guests, I extend a special welcome to our twin-island Republic. I encourage you to find some time to explore our country. I know that whenever you go to a conference it is difficult. You go from meeting to meeting and the next thing you know is that you get on the plane and you leave. I have done that several times and I encourage you to find some time to enjoy our multi-cultural home with its unique foods and the most infectious laughter anywhere in the world.

Let me also salute the organisers of the conference and thank the OAS and NISTADS for partnering with NIHERST to bring together so many regional and international thinkers. I really want to commend NIHERST for spearheading these high level talks which no doubt will further inform our own national policy on Science and Technology. For 30 years, NIHERST has been striving to foster a national culture of scientific inquiry, increase awareness, literacy and engagement and spur capacity-building in Science, Technology and Innovation. It is dedicated to non-formal science education and consistently supports national capacity-building in Science, Technology and Innovation. NIHERST is currently engaged in researching and drafting what will become Trinidad and Tobago's first Science and Technology Policy and thus will emerge as a leader both nationally and regionally.

Science and technology have ushered us into a world in which innovation is the prime path to creating new industries, expanding GDP and opening up new avenues for generating wealth. However, each of us is aware that even the most powerful nations are faced with depleting natural resources and more robust international competition. Successfully combatting these global changes requires a transformation of the national imagination and shifting of collective mindsets away from traditional notions of development and sustainability. In Trinidad and Tobago, we understand that the future depends on diversifying the national economy away from its dependence on the energy sector.

What may be less clear to the average citizen, however, is that the diversification process increasingly requires that Science, Technology and Innovation play a central in the development process. I have taken note of the work that Malta is doing to get the message out to citizens about the importance of Science and Technology in any developed nation and I think the same applies here.

Decades ago, the late Lloyd Best, celebrated economist and son of Trinidad and Tobago, challenged Caribbean governments to "display the vision to compete in the global order". Today his words still ring true. No nation in the world can avoid the new and consistent shifts in the global balance of power, the striving for competitive advantage, new markets and leveraging of technological capacity. All these have caused a level of dynamism but also uncertainty in the world.

Here at home, there has historically been a consistent and costly lag of Science and Technology and I submit that there are signs of this even across the Caribbean. However, this is no longer our reality in Trinidad and Tobago. The vision of my Government is for the incorporation of Science, Technology and Innovation as critical components of sustainable diversification in our country. The Ministry of Science and Technology is the driver of this vision as it works to eliminate the gaps of the past and chart a successful future for each and every citizen. An interesting fact is that we have already shown interesting leadership in Science, Technology and innovation. It is simply that we didn't call it that. When you take an oil drum, put it in some fire and heat it up, pound it there, shape it and turn it into a steel pan, an internationally respected musical instrument, then that is science; that is innovation.

Knowledge, creativity and the commercialisation of these are the foundation upon which knowledge–based productivity is predicated. Without creativity and innovation informed by indigenous strengths, there can be no process of commercialisation. By extension, without creativity, sustainability, economic growth, improved productivity and increased competitiveness in the global market, job creation and enhanced living standards cannot happen. Our vision, therefore, involves harnessing the creativity that is intrinsic to our people as a means to propel us forward. Incorporating Science, Technology and Innovation into the development process is also a means of allowing us to realise national developmental goals such as poverty eradication, improved health care for citizens, the development of a highly skilled workforce, improved personal security and safety and, indeed, environmental protection. Our youth are at the forefront of this vision.

Ladies and gentlemen, I am pleased to let you know that we look forward to establishing a state-of-the-art and completely innovative Science City here in our country. This Science City is integral to the Government of Trinidad and Tobago's commitment to creating a diversified, knowledge-based economy fuelled by the creative abilities of our citizens. The Science City will therefore boast a world-class learning environment, exhibition spaces and scientific and technological infrastructure. It will encourage the exploration and uptake of scientific knowledge and, more importantly, it will inspire our people.

Our rural communities are another important element of this vision. Practical and unique solutions such as broadband access for all, community-based ICT centres for training, e-learning and access to e-government services such as grant applications and bill payments constitute part of our overall plan to leverage Science, Technology and Innovation for Trinidad and Tobago's continued positioning as a serious participant in the global economy.

We recognise that our vision must also be facilitated by a strong e-legislative framework. At the Ministry of Science and Technology, we are partnering with our agencies and consulting with the people of this country to ensure that amendments to the Telecommunications Act are shortly brought before our Parliament. We recognise our need to protect our citizens and our business community. Therefore, high on the Government's list of priorities is the legislation to deal with cybercrime, electronic evidence and electronic transfer of funds to further enable development and to make business between our nation and others faster and simpler. We are now developing platforms to make it easier to access our services and conduct fruitful business exchanges.

This month, we are celebrating our first anniversary as a Ministry of Science and Technology. For the first time in the history of this country there is one harmonised unit, combining all the organisations responsible for this sector under one Ministry, focused on economic diversification and sustainable development. Coming together helps us to enable industry, communities and citizens from T&T and across the diaspora. During this conference, we will have the benefit of hearing the experiences of countries such as India, Costa Rica, Malta, Mexico and Panama that are making headway in building capacity in Science, Technology and Innovation. We know that together we must find ways to leverage and strengthen the linkages between academia and industry, policy and people. NIHERST, NISTADS and the OAS have set a very comprehensive and impressive agenda to help us examine these key areas of concern.

The opportunity to make a difference is in the hands of all of us gathered here over the next three days and I firmly believe that we can. It has been a great pleasure sharing with you my vision as Minister and that of the Government of Trinidad and Tobago. I will have the opportunity to speak with you individually as well.

Ladies and gentlemen, at this time I am pleased to declare open the International Conference on Science and Technology for Economic Diversification. I thank you and may Almighty God bless us all.

2.

The Malta Experience

Dr. Jeffrey Pullicino Orlando
Chairman, Malta Council for Science and Technology

I have gone through the programme for the coming days and I was pleased to see that most of the topics that are actually going to be covered during this programme are within the remit of the Malta Council for Science and Technology.

Background

Malta is the smallest member state of the European Union located at the southernmost tip of Europe. We have an open economy which is heavily reliant on international trade. Our estimated GDP in 2012 was 6.75 million euros. We are a very small nation with a population of 400,000 and we are trying to focus as much as possible on the research and innovation sector to make us ever more competitive.

Our Science Council collaborates very closely with the office of the Prime Minister, although the Council now falls under the Ministry of Education and Employment which, once again, makes our work more relevant to the employment sector. Our offices are basically housed within a nice summer palace overlooking the Grand Harbour. The British chose to extend it onto the Knight Summer Palace and converted it into a naval hospital early in the 19th century. We were established in 1988 as a government advisory body with responsibility for national strategy and policy in the field of Research and Innovation (R&I). We also administer and manage the National Research and Innovation Funding Programme and more recently introduced the Commercialisation Programme. We are also the national contact for the organisation of the EU's Research and Development Programme and have been entrusted with Science Communication and Science Popularisation as opposed to more formal science education.

Malta's gross expenditure on Research and Development in 2011 was 0.73 per cent of the Gross Domestic Product. A total of 0.49 per cent came from business, 0.02 per cent came from government and 0.22 per cent came from higher education. The number of researchers in Malta is the full-time equivalent of 755 persons.

I will briefly go through our roles. One good thing about being small is that it makes us more manageable. Our remit is relatively vast. The separate units that fall within my remit act synergistically with regular meetings between the directors, which helps to get feedback from the separate units as regards their respective work.

Our Research and Innovation policy framework states that R&I should be at the heart of the Maltese economy to spur knowledge-driven and value-added growth and wealth. We have established a mission which should be achieved over this time period. The time period for the national strategy plan for R&I was between 2007 and 2010 and the goal was to build and sustain an R&I enabling framework. Sixty-six measures were identified for implementing seven strategic principles, most of which were very highly business driven. We are now awaiting the draft national R&I strategic plan which would take us up to the year 2020, and which contains the mission, vision and business focus. It retains the increased focus on innovation-support measures including non-technological innovation.

We are currently working on the Smart Specialisation Framework Programme with finalisation of the Smart Specialisation strategy due by October 2013. It is ex-ante conditionally linked to the unlocking of European Union funding for the years between the 2014 — 2020 programming period. The Smart Specialisation Strategy aims to focus investment on key areas of competitive advantage with policies and measures which adequately address the needs of the private sector for economic development. It is backed by the highest level of political endorsement to ensure coherence and common vision across the board. Very, very intense work has gone into the strategy which draws on economic analysis consultations with the public and private sector, including one-to-one meetings, focus groups and continuous communication with the experts who were assigned to us by the European Union.

A number of issues have emerged in this respect. It is always important to retain a good degree of flexibility between economic diversification and smart specialisation. There is also the need to strengthen the local R&I eco-system which is relatively young and still requires some important building blocks to be put in place, such as support for IP protection and post-doctoral support schemes. A lot of emphasis is being placed on these horizontal enablers. There also has to be capacity-building in infrastructure and last, although definitely not the least, greater access to finance. I will explain how we have gone about trying to get that.

We have worked over the past couple of years on a Health R&I Strategy, which is very strong and which was launched earlier this year. The steering group included medical experts, policy experts and economists. The methodology, which helped us to get to the final version of the strategy, involved the bottom-up approach which included public consultation. Notable among the recommendations were the establishment of a national governance framework and support system for health and R&I and increased funding for health R&I.

Among the other strategies on which we have worked is the Manufacturing Research Strategy. Value-added manufacturing has been identified as a priority research area for Malta which has a very active manufacturing sector with products ranging from micro-electronics to pharmaceuticals, medical devices and several other sectors. The manufacturing sector includes very high level and well-known international firms.

The aim of the strategy is to put together a plan for encouraging the manufacturing sector to further embrace research and innovation in order to migrate up the value chain and achieve greater sustainability. Obviously the higher the level of investment within this sector, the greater the possibility of certain international friends remaining on our island. The strategy also proposes the creation of technology platforms to strengthen and focus on particular niches within the manufacturing sector.

The Council has also done substantial work on increasing the level of involvement by Maltese researchers, referred to as COST – the European Co-operation in Science and Technology. We are the contact organisation for COST, which has 35 member countries. It is one of the longest-running collaborative initiatives in Europe, going back to the early 1970s. It is a very effective initiative, which promotes transnational co-ordination of nationally funded research. There are currently over 150 persons based in Malta who are participating in various COST activities. When I took over the remit there was only one.

We are currently engaged with a particularly interesting institution, the European Institute for Innovation and Technology, which was set up as an agency of the European Union in 2008. It aims to address Europe's innovation gap. It is the EU's flagship education institute and is designed to assist innovation, research and growth in the EU. It provides grants to what is referred to as Knowledge and Innovation Communities or KICs in short. The first three KICs were selected in 2009. KICs are basically consortia and we are actually in the process of preparing to submit an application to participate in a KIC initiative in 2014 with an investment volume of 1.6 billion euros.

The lead institution for this application is the Leuphana University of Luneburg, Germany which is well-known in the innovation sector in Germany. Other partners include the International Consortium for Health Outcomes Measurements (ICHOM) with its shareholders Katrolinksa, Harvard and the Boston Consulting Group, Sclavo vaccines, and Association of Italy with the Novartis Vaccines Institute for Global Health, the Medical University of Gottingen and the University of Zurich which, let me add, includes Albert Einstein among its alumni. He graduated in 1905. The proposal addresses the challenge of the progressively ageing population in Europe and beyond. The aim of this project will be to unlock the economic growth potential of this economic community, primarily through big data, in order to allow people to lead active lives well into old age. The experience that the Science Council is gaining by collaborating with high level institutions is second to none and is an experience in itself.

We have spoken about the 7th Framework Programme (FP7) for Research Technological Development, which is the main funding instrument for the EU. The EU gives a great deal of importance to this sector. In fact, 54 billion euros were allocated in the period 2007 — 2013 on the usual competitive basis. The four pillars of FP7 are cooperation, people, ideas and capacities. Most S&T areas are covered including the environment, ICT, health, the social sciences and areas that improve the career prospects of researchers. The Malta Council for Science and Technology (MCST) is also a National Contact Organisation for FP7. This involves managing a network of Programme Committee Meetings, National Contact Points who liaise with Maltese researchers, the EU Commission and their counterparts abroad to foster collaboration of FP7 programmes.

Malta's participation in FP7 has led to the participation of 150 Maltese participants who have sought to tap into FP7 funds. Of them, 130 have been successful, which is a relatively high number because it is a very, very competitive fund and involves a labour intensive process. Even the application form itself is very intensive. Malta participates in projects that mainly focus on ICT and aviation. The strongest participants are SMEs and the University. We have tapped into just over 13 million euros in funds and are ranked sixth among the EU's 27-member states in terms of the number of FP7 participants per capita.

Horizon 2020 is the follow up programme to FP7 for the period 2013-2020. It should be noted that even though the EU is insisting on cost-cutting, when it comes to a number of sectors, the budget is going to be increased by 30 billion euros over the period 2013 — 2014 under the FP7 programme. Through Horizon 2020, MCST would aim to increase Malta's success in terms of funds per capita. The focus will be on health, well-being and demographic change and food security, marine research and secure, clean and efficient energy. There is also a national R&I fund which has been given by the central government to MCST to administer. At the moment, it is composed of two separate initiatives: the national R&I Programme, which has been in place since 2004 and the more recently introduced Commercialisation Programme.

Over 50 applied research projects have been financed through collaborations between industry and academia. The aid under this fund has supported a focus on Health and Biotechnology, Advanced Manufacturing, Energy and Environment and ICT. The Commercialisation Programme seeks to support the commercialisation of technologies through funding for patent checks, IP registration, market research and business plans. I am pleased to report that funding has quadrupled over the past four years. Just to give you an idea of some of the funded projects: one project dealt with the desalination of sea and brackish water by solar energy units. We have a lot of sea available to us so it is a good thing that we try in most situations to utilise that water. There is something that is particularly prominent in Malta and it is the hours of sunlight and sea. We have also funded projects focusing on cleaner flight operations into Maltese air space as well as projects dealing with the investigation of chaperone modulators as regulators of diabetes, cancer and stem cell expansion.

A more recent initiative by the Science Council are competence tandems, which are focused on establishing pure academic research groups. This will attempt to prevent the "brain drain" which is unfortunately endemic to a number of less developed countries. This is a particular problem and we are trying to address it as well as other measures including competence tandems. This will encourage partnering between leading local and international academics who are willing to undertake research on a full-time basis on Malta's priority areas.

We have been encouraged by the present Prime Minister to establish a venture capital fund. We have looked into a number of possibilities and have concluded that a hybrid venture capital fund would have the greatest chance of success. Basically we are thinking that this will be along the lines of setting up a venture capital facility which will involve government and private sector participation and investment and target investors who wish to move beyond the property market. New technology opportunities promise a better return for these investors. The property market has been the mainstay of the Maltese economy for a number of years notwithstanding the property slump of most of our EU neighbours and member states. The property market has been relatively strong and it is still considered a safe investment largely because of Malta's finite space. We are a very small country so we will be encouraging investors by means of this hybrid venture capital fund to venture into the R&I sphere. The fund will enjoy credibility because of the substantial government funding involved.

I was speaking to the President of NIHERST and agree with her on the importance of explaining to the public why we should invest more in science, technology, research and innovation which are often perceived by the average person to be inaccessible topics. In this regard, one of the initiatives that will probably emerge in the coming months is a Dragon's Den type production done in collaboration with the public broadcasting service. As I have indicated, the purpose would be to address the public's lack of awareness of Maltese technological developments in contrast to the media exposure given to developments abroad.

This aim of this initiative is to popularise local technology in R&I by generating and broadcasting local content together with imported programmes. The TV programme will probably involve local business angles and evaluate local entrepreneurs with innovative business ideas with the intention of financing them. We are actually considering incorporating this to a certain degree with the hybrid venture capital fund, which will also involve disbursement of public funds with input from MCST to ensure accountability.

As I said earlier, one of the topics that falls under our vast remit is Science Communication. The Science Popularisation Unit, SPU, was set up in 2010 under my chairmanship. It is focused on an ESF-funded project which was called the Science Popularisation Campaign. This involved two large-scale S&T festivals, six science-in-the-community events in conjunction with a local council, a media campaign, a TV mini-series and radio spots, a training course in science animation and a mobile science fair that we found was very popular among school children and which went from one school to another as part of our effort to popularise science.

As indicated earlier, we are currently engaged in the biggest project ever embarked upon by the Malta Council for S&T. It is a very interesting project and is now referred to as the National Interactive Science Centre. We will probably issue a public call for a more attractive name for it. The Centre will be run along the lines of the NEMO Centre in Amsterdam. It is a partially EIDF-funded project and will involve a total expenditure of 26 million euros. The aim of the project is to encourage more students to take up S&T subjects as their main study areas. It will provide a consolidated environment and setting where students and the general public can immerse themselves in a unique interactive science experience, as we focus on making science fun both for children and their families, and more relevant to their day-to-day experiences. It also aims to promote better communication in science in Malta, especially at the primary and secondary school levels, by making it more relevant, hands-on and fun. Work is expected to begin at the end of this year (2013) and it should be up and running by 2015.

The whole BV Peninsula will be transformed into an attractive site with thousands of square miles of interactive and attractive science. The planetarium is partially accommodated in one of the demolished buildings in the BV to give a link between the old and the new, which will be a kind of statement—an architectural statement—which will be visible even from across the Grand Harbour.

3.

Inclusive Growth and Economic Diversification

Mr. Jwala Rambarran
Governor, Central Bank, Trinidad and Tobago

The OAS, NISTADS and NIHERST must be commended for bringing together such an excellent group of leading professionals in science and technology, higher education, training and labour markets to exchange views with us on critical socio-economic transformation issues facing developing countries.

This INSCITED Conference is particularly timely since it is set against the backdrop of global policymakers searching for the holy grail of economic growth after nearly half a decade of battling a global financial crisis. Many green shoots of recovery have sprouted and withered over the past five years—a stark reminder that the path to sustainable economic development is neither straight nor smooth.

The IMF's most recent forecast suggests that the world economy is gradually strengthening. Global activity is expected to increase from below three per cent in the middle of 2012 to three and a quarter per cent in 2013. The IMF is more optimistic about prospects for 2014, projecting a modest acceleration of growth to four per cent for the world economy. But we still are not seeing economic growth anywhere near the levels prior to the onset of the crisis in 2008 that would offer policymakers sufficient opportunity to rebuild buffers without resorting to more painful austerity measures.

In fact, we are now witnessing what the IMF's Managing Director has labeled a "three-speed" world economy. Emerging markets and developing countries are doing well as the main driver of world growth, even though their output has slowed compared with the pre-crisis period. Some advanced economies like the United States are on the mend, but further policy uncertainty could derail the gains made. Others such as Japan and those in the Euro area still have some distance to travel in restructuring their economies and regaining fiscal sustainability.

Notwithstanding the fallout from the global financial crisis, we should acknowledge that the world has still seen some milestones of major progress. Perhaps the most laudable of these milestones is that the first Millennium Development Goal to "halve the proportion of the world population" living in extreme poverty by 2015 was met five years ahead of time. In 1990, almost 45 per cent of the developing world lived on less than US$1.25 a day. In 2010 – 20 years later - the global poverty rate dropped to just over 20 per cent.

Buoyed by this success, the World Bank boldly committed two months ago at its Spring Meetings to work with countries to end extreme poverty worldwide within a generation by 2030. According to the World Bank's President, for the first time, an expiration date has been set for global poverty.

We should also acknowledge the fundamental positive transformations that have taken place in developing countries over the past few decades. Please allow me to highlight just four of these changes.

First, the UNDP's March 2013 Human Development Report notes that, in the last decade, all countries accelerated their improvements in education, health and income dimensions as measured in the Human Development Index (HDI), to the extent that no country had a lower HDI ranking in 2012 than in 2000. The pace of HDI progress has been fastest in countries in the low and medium human development categories.

Second, for the first time in history more than half of the world's population is living in cities. We reached this tipping point in 2008. By 2040, two in three people are expected to live in cities and the developing world will be home to 29 of the biggest megacities with populations of 10 million or more.

Third, people are becoming more connected through disruptive innovations in technology, which is creating a smart, mobile world. In the insightful words of futurist Ramez Naam, "More than three-quarters of humanity, in the span of one generation, have gotten access to connectivity that is greater than any U.S. President before 1995. A reasonably well-off person in India or Nigeria has better access to information than Ronald Reagan did during most of his Presidential career."

Finally, global economic power is shifting faster from the North to the South than most could have imagined just a few years ago. By 2020, the combined economic output of three leading developing countries alone - Brazil, China and India - will surpass the combined GDP of Canada, France, Germany, Italy, the United Kingdom and the United States. This fundamental shift in the world's economic centre of gravity is likely to induce a deep-seated change in the governance of international institutions, including the United Nations, the IMF, the World Bank and the World Trade Organization, to promote a fairer, more equal world.

Against this backdrop, Caribbean small island states appear to be gradually recovering from the global crisis but, unfortunately, the region's recovery lags that of other small states, and reflects part of a worrying longer-term trend in which the Caribbean's growth performance has been weakening over the past three decades. According to World Bank data, in 1980 the Caribbean's average per capita income was twice as high as that of the average developing country. Today, the region's average per capita income is only a third higher than the developing world.

In effect, the Caribbean has been losing its comparative advantage due to a variety of external shocks for which the region was not well prepared. The Caribbean has grappled with the drying up of aid flows, dismantling of traditional preferential trade arrangements for sugar and bananas, interventions related to anti-money laundering and combating the financing of terrorism, and, of course, the international financial crisis.

The Caribbean has also earned the unenviable reputation as one of the most natural disaster-prone and high debt regions in the world. Sir Dwight Venner, Governor of the Eastern Caribbean Central Bank, captures the interaction between natural disasters and debt quite vividly: "Almost every year, we [St. Lucia] have a hurricane season, which can destroy the country's GDP. In some countries, it can also lead to high debt levels. Their infrastructure is destroyed before they paid for it, so they borrow again. Then it is destroyed a second and sometimes even a third time."

The brutal reality is that the Caribbean must find new sources of growth in a very uncertain external environment. In the words of the Honourable Prime Minister of St. Lucia, Dr. Kenny Anthony, addressing the 24th Meeting of the CARICOM Heads of Government in February 2013, "We need a big conversation about the future of our economies." A credible growth and diversification strategy is not merely a desirable policy option, but absolutely necessary for the region's very own survival.

It is in this context that I would like to highlight three potential frontiers of opportunity that, in my respectful view, Caribbean policymakers can leverage for inclusive growth and economic diversification. Each new opportunity would require the support of science and technology.

The first new opportunity relates to unlocking the tremendous potential of the "Blue Economy" – the Caribbean Sea and its coasts–from which the Caribbean region draws its name, identity and economic sustenance. The Caribbean Sea is the second largest sea in the world, after the Mediterranean. It is a natural asset whose resources provide an endowment of goods and services. The following examples are worthy of note:

- The Caribbean Sea is home to one-tenth of the world's coral reefs and has an outstanding biodiversity of seagrass beds and mangroves, all of which are attractions to almost one-third of the world's tourists;
- Seafood accounts for more than 7 per cent of the animal protein consumed by the people in the Caribbean;
- Fishing is a significant provider of jobs and income in the Caribbean. More than 1.5 million people in the Caribbean rely for their livelihood on commercial fishing, which generates more than US$1 billion annually in export earnings;
- Marine and coastal tourism form the lifeblood of many Caribbean economies. According to the World Travel and Tourism Council, in 2011, tourism accounted for 13 per cent of total regional employment, 14 per cent of the Caribbean's GDP and 17 per cent of total export earnings;
- The Caribbean Sea is one of the principal waterways in the world, harbouring in excess of 80,000 ship calls per year, and is classified as having one of the most intensive maritime traffic in the world; and
- The sea floor of the Caribbean Sea may yield many important minerals available for extraction, including silver, gold, copper, manganese, cobalt, and zinc. Technology is emerging to commercially tap new sources of marine-based renewable energy from the Caribbean Sea as well as medicines that can improve many millions of lives.

Notwithstanding its importance, in common with ocean regions across the world, the Caribbean Sea has seen over-exploitation and degradation of its marine resources over the past three to four decades. Reports from the Food and Agricultural Organization (FAO) suggest that the sustainability of fisheries in the Caribbean Sea is in jeopardy and that precautionary management is critical. Coastal fish stocks depletion has been worsened by the threats of ocean acidification and pollution associated with both marine and land-based activities. Today, these problems are compounded by climate change.

In effect, the livelihoods of communities, national economies and the biodiversity of the ecosystems of the Caribbean Sea are threatened. If Caribbean countries can make the institutional reforms needed to reduce open access to its marine resources and to provide secure incentives for responsible husbandry of these resources, there is significant potential for the Caribbean Sea to contribute even more to food security, livelihoods and inclusive economic growth for the region.

Science and technology have a key role to play in helping to capture some of the economic opportunities likely to arise from investing in a healthier Caribbean Sea. Some areas are as follows:

- Promotion of responsible fisheries and aquaculture in a green economy;
- Adoption of green technologies and investments to lower fossil fuel use to dramatically reduce the carbon footprint of the sector;
- Harnessing the potential of marine-based renewable energy (wind, wave and tidal); and
- Improving the understanding of deep-sea minerals ecosystems which are a possible new revenue stream.

The second growth frontier for the Caribbean lies in taking advantage of "Green Economy" opportunities to reduce its vulnerability to climate change.

Caribbean countries are expected to be among the earliest and most severely impacted by climate change in the coming decades. Warmer temperatures are likely to fuel stronger hurricanes in a region already battling frequent natural disasters. Increased ocean temperatures are also leading to coral deaths. Recent studies suggest that some 80 per cent of living coral in the reefs of the Caribbean have been lost in the past 20 years.

More than half of the Caribbean population lives within 1.5 kilometres of the coast where houses, hotels and other infrastructure are at significant risk from stronger winds, more forceful wave surges and heavier rains. Sea level rise would deal the region's tourism industry a deadly blow.

And these devastating impacts are likely to occur regardless of the fact that Caribbean nations produce extremely low levels of global greenhouse gas emissions that drive climate change.

A 2008 study by the Stockholm Environment Institute and Tufts University found that for just three categories - increased hurricane damages, loss of tourism revenue, and infrastructure damages - the Caribbean's annual cost of inaction is projected to total US$22 billion by 2050 and US$46 billion by 2100. These costs represented 10 per cent and 22 per cent, respectively, of the 2008 GDP of the Caribbean economy.

The Caribbean, therefore, must redouble efforts to support inclusive green growth and climate smart development. This requires increased investment in mitigation. We need to identify renewable energy projects that can help conserve foreign exchange and ultimately improve fiscal space. It also requires ramping up investments in adaptation. We need to identify "bankable" adaptation projects.

At the same time, tailored support is needed to help Caribbean countries and other small island states access climate-related funds, especially those offered by the Global Environment Facility (GEF) and the Climate Investment Funds (CIF).

Here again, science and technology can help to leverage economic opportunities in the Green Economy. Some areas are as follows:

- Devising engineering solutions such as sea defences, hurricane-resistant buildings, and the provision of water storage;

- Developing technological solutions such as using more resilient crops to protect critical biodiversity conservation;

- Creating new incentive mechanisms such as payment for ecosystem services; and

- Facilitating the transition to a low-carbon economy.

The third frontier of growth opportunity relates to the "Silver Economy." Population ageing is a global phenomenon, which is having major implications on all aspects of human life in every society. This process is enduring and irreversible. In the Caribbean, people are also living longer than ever before but not healthier. At the start of the 21st century, the elderly in the Caribbean - persons 60 years or older - represented at least one-tenth of the population, larger than ever before in the history of the region.

World Bank research warns, however, that Non-Communicable Diseases (NCDs) are rising rapidly as the Caribbean population ages. Today, the four leading causes of death in the Caribbean are all NCDs – heart disease, cancer, stroke, and diabetes. In the Caribbean, five times as many people are dying from NCDs as from all other illnesses combined. In fact, these findings have spawned the creation of a rather interesting World Bank blog entitled "Is fried chicken setting back development in the Caribbean?" alluding to the fact that unhealthy eating habits are a major risk factor for NCDs.

The expansion of NCDs is increasing the economic burden on families and on already strained public health systems in the Caribbean. In Jamaica, for instance, an average individual suffering from NCDs spends approximately one-third of household income on healthcare services and medicine purchases. In the Eastern Caribbean, the annual cost for treating a diabetic is more than the annual per capita spending for health care in the six countries of the Eastern Caribbean.

Again, there is a unique opportunity for scientists and economic policymakers to take advantage of the growth opportunities that arise from reducing the future burden of NCDs, promoting healthy ageing, and increasing the potential benefit from the demographic transition in the Caribbean. And they must do it while ensuring that out-of-pocket health expenses do not inflict severe financial hardship on families, and while narrowing the gap in access to health services and public health protection.

In closing, ladies and gentlemen, let me say that I have faith in the ability of the Caribbean leadership to move beyond talk about the "big conversation" to actual action - seizing opportunities in the Blue, Green and Silver Economies. Science and technology would, of course, be critical to successfully actioning these opportunities. Success will also depend on putting in place sound policy frameworks and effective institutional arrangements. And, in some cases, it may require strong commitment and funding from the international community.

I look forward to this INSCITED Conference becoming a model platform for stimulating new thoughts and ideas on how science and technology can help contribute to generating more inclusive economic growth.

I also look forward to further collaboration among the OAS, NISTADS and NIHERST that will be of benefit to science, society and state.

I thank you.

S&T Policy For Supporting Inclusive Growth, Economic Diversification and Sustainable Development

4.

Economics and Policy Issues in Energy and the Environment

Prof. Gordon MacKerron
University of Sussex, United Kingdom
gordon.mackerron@sussex.ac.uk

Introduction

Energy and the environment is a vast topic area, especially in Trinidad and Tobago (T&T) where hydrocarbon-related activity accounts for almost 50 per cent of GDP and over 50 per cent of Government revenue. This paper offers a brief account of some recent experience in the EU on energy/environment issues and asks how far they may be relevant to the different T&T context. It then more tentatively makes some suggestions about possible policy directions for T&T and concludes with some thoughts on implications for science and technology policy.

Energy and environment policy objectives in the EU

Energy and the environment are closely coupled policy areas. The energy system is responsible for a wide range of environmental problems (*Scrase and MacKerron* 2009 Chapter 1). However the two topics are not identical. There are large parts of energy policy that do not connect with the environment: for example, energy security and affordability. Equally, some environmental issues arise outside the energy system, especially those deriving from non-energy forms of land use, including agriculture as well as biodiversity loss.

In the EU, much of environment policy is now heavily focused on policy for climate change mitigation, and here the coupling between energy and environment is almost complete; in the EU well over 80 per cent of GHG emissions (primarily carbon dioxide) are from energy sources. While this focus on the energy system's role in combatting climate change is necessary and desirable, it means that other elements of policy, especially for the environment, have been given less prominence in recent years. A clear example in the UK is that while urban air pollution remains a significant and in some cases growing problem for human health, it attracts relatively few resources.

Within energy policy, the desire for a high degree of energy supply security has risen up the political agenda in recent years and now is arguably at least as significant as climate change. (UK DTI 2007). However the issue of energy supply security is not pursued further in this paper. This is because, for T&T, the security issue in the energy system is primarily about security of demand for T&T's hydrocarbon-based exports, especially LNG.

EU energy policy

For some time, and formally since 2007, the EU has used the idea of an energy policy triangle. The three axes are climate change; security of supply; and affordability/competitiveness (the latter ambiguously defined). Policies designed to pursue any one of these objectives may conflict with the achievement of other objectives. For instance, promotion of domestic coal may help security but conflict with climate change, and subsidy for renewables or nuclear power will conflict with affordability and so on.

The European response was the so-called 20:20:20 agenda (European Commission 2007). Here the objectives for 2020 are to have a

- 20% share of renewables in the energy system as a whole (not just electricity);
- 20% improvement in energy efficiency (energy use per unit of output); and
- 20% reduction in GHG emissions (or more if international agreements were reached).

These "20s" were aimed at simultaneously meeting climate change and security objectives. Affordability/competitiveness were potentially adversely affected, for example, by relatively high costs of renewables.

These bold statements of intent existed in a slightly uneasy relationship with the "flagship" EU climate change policy, the European Emissions Trading Scheme (EU ETS), which since 2005, had been in existence as a way of trying to minimize the costs of carbon dioxide emissions across the whole of the EU (Sorrell 2009). The "uneasiness" results from the fact that successful promotion of renewables (which are outside the EU ETS) would simply make the ETS trading price lower because less effort and expense would be needed to control emissions in the ETS segments of the economy.

Lessons from Europe?

The EU has been keen to promote and advocate emissions trading on the back of the EU's ETS experience. This is not surprising because if the EU ETS can be successfully linked to other emission trading schemes, the overall costs of compliance should fall. However, emissions trading is complex, has high initial transactions costs, and then high monitoring/verification costs, and needs large and diverse economic structures if it has any chance of producing low cost emission reductions (Sorrell 2009). It is therefore an unlikely candidate for application in T&T or the wider Caribbean – even if climate change mitigation is a major policy objective, which is itself not clear.

The energy security issue for T&T is, at least in the medium-term future, not at all to do with supply, given the presence of relatively low-cost oil and gas reserves, but rather about energy demand. T&T has achieved rapid expansion in LNG capacity and trade over the last decade and much of the output goes to the USA. Given the shale gas "revolution" in the US and the consequent sharp reduction in gas prices there, there is clearly a threat to T&T, and a wider range of alternative markets will probably be needed.

Climate change is a difficult issue for countries like T&T, which – despite relatively high average income levels – still experience significant characteristics of a developing economy, including a skewed distribution of income and significant poverty. With very high per capita GHG emissions of over 36 tonnes (*http://data.worldbank.org/indicator/EN.ATM.CO2E.PC*), the T&T Government is interested in climate change mitigation, but this can only be achieved at significant cost, conflicting with affordability. And with a population of under 1.5 million, even strenuous efforts to achieve mitigation will have a wholly negligible effect on world emissions. T&T might therefore be more interested in climate change adaptation given the threat to small island states that climate change poses. Adaptation is an issue to which Europe is now giving significant attention, as well as some resources, and will have implications for science and technology policies in the future in T&T.

One important area where T&T is engaged in activity very similar to Europe is the promotion of the combined cycle form of gas turbine electricity development (*Ministry of Energy and Energy Affairs http://www.energy.gov.tt/resources.php?mid=9*).

In the T&T case, this is largely conversion of single cycle gas turbines to the combined cycle, with operating efficiencies rising from around the 30-35 per cent range to 50-55 per cent range. This is good for affordability (the higher efficiency compensates for the extra investment) and very good for emissions (higher electrical output derives from the same gas input as before).

Oil and Gas

It is impossible to discuss energy in T&T without reference to hydrocarbons and their prospects. A fundamental economic issue is how much more hydrocarbon resources can be extracted profitably (Renwick 2010). This is an inherently difficult issue because the extent of future reserves depends partly on technology, while profitability also depends on the inherently unknowable question of future world and regional hydrocarbon prices.

In Europe, most energy policies rely on the assumption that hydrocarbon prices will on average rise strongly. In producer countries like T&T, there is the opposite worry: that prices may fall while extraction costs rise, thereby curtailing reserves, via economic rather than geological factors. For T&T, there is the current and added worry about the sharp fall in US gas prices.

Diversification and energy efficiency

There are major and long-enduring debates in T&T about the need for diversification away from oil and gas (and their directly related, feedstock-dependent, industrial activities) (Artana et al. 2007). Other hydrocarbon-rich countries have had varying experiences in the use of rents that Government can raise. In the UK most of the rents have been consumed and treated as current income; while in Norway, nearly all were saved and invested for the long term. T&T clearly has scope, some already realized via the Heritage and Stabilization Fund, for making investments which will help counteract the effects of falls in oil and gas production.

Diversification is clearly difficult in a small economy heavily dominated by oil and gas. Artana et al (2007 p. 30) report that T&T ranks lowest in the Latin American and Caribbean economies in its scope for non-hydrocarbon diversification.

There are two major ways in which the effects of resource depletion can be counteracted: economic diversification into low-hydrocarbon activities, and improved energy efficiency, having the effect of making existing hydrocarbon reserves last longer. In practice, these two activities may often be connected.

Diversification into other sectors

Economic diversification raises many issues outside energy and environment, including natural and human resource endowments. Here, the only issue considered is the need for such diversified activities to have a low hydrocarbon-intensity. The T&T Government has been considering diversification issues for some time and the current and past areas of priority clearly meet the criterion of relatively low hydrocarbon-intensity. Examples of these priorities are: tourism; food/beverages; printing/packaging; merchant marine and yachting; music/entertainment; and fish/fish processing.

Energy efficiency

This is clearly recognized by the T&T Government as a major priority area, both within the current hydrocarbon-related and energy system, and more widely across the economy. The major policy approach to improving the (hydrocarbon) efficiency in the energy system—aside from the move to combined cycles already referred to—is the promotion of renewable energy, substituting directly for gas. A T&T Renewable Energy Committee (REC) has considered these issues and recommended that the main priorities should be wind power and solar photovoltaics (PV) (Ministry of Energy and Energy Affairs 2011).

However, the prospects for renewables making much impression on hydrocarbon use, even within the electricity system, let alone the wider energy system, are very limited for some time to come. The REC suggested that wind might constitute 5 per cent of electricity (60 MW) by 2020. It also suggested promotion of PV technology but provided no quantitative targets. At present, the electricity system is virtually all gas-using and some 7 per cent of all T&T gas production goes to electricity. This means that if the 5 per cent wind target is met, then the reduction in natural gas use in electricity would imply a reduction in T&T gas production of less than 0.5 per cent%. The picture is slightly better if we count only gas use in T&T, but even here the reduction in gas use would be less than 1 per cent.

None of this suggests that promotion of wind power, as the most promising of the renewables, is not a potentially sensible idea for T&T but, it does demonstrate that renewables cannot be a major contributor to the attempt to become less dependent on hydrocarbons for quite some time to come. In the meantime, wind power will need subsidy as it will be more expensive than gas-based power on a market price basis. And other renewables, such as biomass, have quite limited prospects in T&T.

End-use energy efficiency

This leaves the question of energy efficiency on the demand side of the economy (end-use efficiency).

Implications for science, technology and innovation policies

The kinds of energy and environment policies outlined here have wide-ranging implications for science and technology. These implications will sometimes require R&D, but there will be a need for wider scientific and monitoring services as well. Examples of implications are:

- monitoring and assessment of climate change adaptation needs in areas like health, agriculture and coastline management;
- scientific and technological/engineering assessment of areas where end-use efficiency can best be pursued, including energy audits and local innovations, including social innovation (e.g. car-sharing arrangements);
- social science activity in policy design/transfer, economic assessment and community engagement; and
- improving adaptive capacity to absorb inward technology transfer, especially in areas of economic diversification but also in the energy system e.g. wind turbine design and adaptation of combined cycles to high temperature environments.

Conclusions

Energy policies are inherently difficult and often involve politically complex trade-offs. For example, the "simple" action of reducing energy subsidies could improve energy efficiency but might provoke widespread political resistance and worsen the situation of those in poverty.

European experience in energy and environment policy has limited relevance to T&T. For example, emissions trading is unlikely to work in the Caribbean, and worries in Europe about security of supply have limited relevance to T&T, at least for some years to come.

However, among all the potential policy options, the outstandingly beneficial one is likely to be promotion of end-use efficiency improvements. These tend to be low cost, have large impacts on hydrocarbon uses, and do not in most cases contradict other policy objectives like affordability.

The implications of the policies outlined in this paper for science, technology and innovation are quite wide-ranging, and the priorities will often be in monitoring and survey work rather than basic R&D. Training of people to be engaged in energy efficiency improvements is probably a significant priority area.

References

Artana, D. and Auguste, S. et al (2007). *Trinidad and Tobago: Economic Growth in a Dual Economy*. IDB Research Report.

European Commission (2007). *An Energy Policy for Europe,* CEC (COM(07)1), Brussels.

Meeting the Energy Challenge: a White Paper on Energy, Cm 7124, UK Department of Trade and Industry (2007).

Ministry of Energy and Energy Affairs (2010). http://www.energy.gov.tt/resources.php?mid=9.

Ministry of Energy and Energy Affairs (2011). *Framework for Development of a Renewable Energy Policy for Trinidad and Tobago*. A Report of the Renewable Energy Committee.

Renwick, D. (2010). "Can Trinidad and Tobago reverse the production decline in oil?" Published in *Centennial Energy Digest*, Trinidad and Tobago Chamber of Industry and Commerce.

Scrase, I. and MacKerron, G. (eds.) (2009). *Energy for the Future*, Palgrave Macmillan, London.

Sorrell, S. (2009). "Carbon Trading", Chapter 11, in Scrase and MacKerron, op. cit.

The Rebound Effect (2007). United Kingdom Energy Research Centre Technology and Policy Assessment, London.

World Bank (2010). http://data.worldbank.org/indicator/EN.ATM.CO2E.PC

5.

Evaluation of Innovation Clusters in India and CARICOM: Policy Frameworks and Institutional Mechanisms

Dr. Debashis Bandyopadyhay
Council of Scientific and Industrial Research - CGCRI, India
debashis.kolkata@gmail.com

Abstract

Innovation has emerged as the major determinant in economic development. Globally, the cluster concept is practised with the aim of maximizing outcomes. The typology and evolution of clusters are nevertheless significantly diverse, and show large variations between developed and developing countries, between large and small countries and between countries differing in their Science and Technology policy and institutional frameworks.

This paper explores the status of innovation and innovation clusters in India and the countries of the Caribbean Community (CARICOM). It evaluates the policy framework, organization and nature of clusters, technology focus of the innovation players and the unique institutional mechanisms that are in place.

It is apparent that while both India and the CARICOM have endeavoured to evolve policies consistent with bolstering economic competitiveness through energising the National Innovation System, significant work needs to be focused at the implementation level. India, with its relatively stronger S&T institutions, can play a key role in catalysing a co-learning eco-system that would leverage innovation in both India and the Caribbean. Europe's innovation clusters could be used as possible benchmark, albeit with reasonable caution.

Keywords: **Innovation clusters, India, CARICOM, cluster policy, S&T policies, institutional frameworks**

Introduction

Towards the end of the last decade, UNESCO had pioneered the cause of "globalization with a human face", a strategic model for bridging the growing divide between the rich and the poor (*UNESCO Science Report, 2010*). Science, technology, innovation and institutional mechanism, are recognized as chief instruments of this model that has been visualized as an empowering force, an equalizing force and as an enabling instrument as well. Furthermore, innovation is also recognized as the key to competitiveness.

Innovation systems are strongly linked to the process of technological development, which in turn fuels economic development and growth. National Innovation Systems, which primarily provide the eco-system, had previously been more restricted to the dynamics of the national framework. These are being increasingly subjected to the international dynamics as a result of globalisation. Firms attempt to respond to such rapid changes by trying to accommodate the push-pull dynamics.

This is done by not only linking themselves to the evolving production systems but also to one another and to other knowledge institutions, thereby creating clusters. Policy framework has thus assumed a seminal role in the whole process.

Regions across the world are differentially geared in their capacity to adapt and disseminate new technological paradigms that drive development. Such regional variations are the reason why some regions in the world are more successful in capitalizing on the powers of innovation than their counterparts elsewhere.

In this discussion, we have focused on two geographically isolated, yet ethnically connected regions, namely India and the Caribbean, in an attempt to identify these regional similarities and differences. The parameters for such a comparison are sufficiently general so as to enable us to put forward an implementable model that captures the specific differences while retaining the regional flavour. This unique aspect motivates us to analyse the policy framework in the two regions that has evolved over time (in many cases quite independent of the present context in which they are considered), and also for identifying key players fuelling the innovation dynamics (by way of a plethora of institutions) for building a rather generalised model of co-operation, co-learning and co-creation. We propose a proactive and customised cross-country linkage to leverage the clusters of both regions.

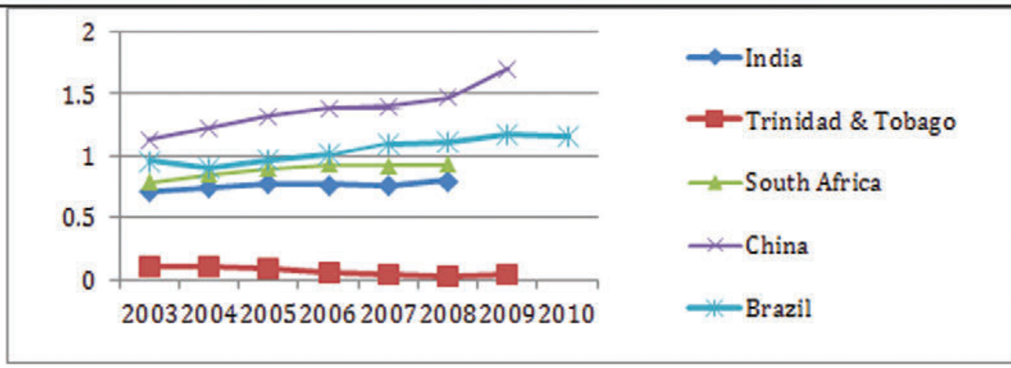
Background and Framework

Region Facts: India

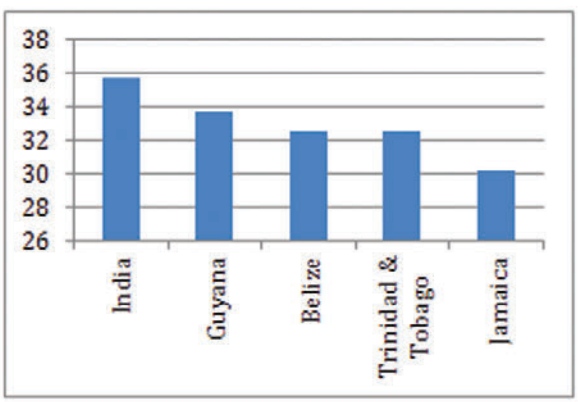
India is the second most densely populated country of the world (with 1.2 billion inhabitants) and ranks 11th in GDP (with US$1,310 billion). It is ranked as a lower middle-income country and comes second after Sri Lanka in per capita GDP in the region. India exhibits a labour productivity growth of 4.5 per cent (rank = 21st) and high-tech exports account for 6.34 per cent of GDP (global ranking – 32nd). India ranks 4th in export of computer and communication services, 9th in creative goods exports, 29th in creative services export and 35th in R&D infrastructure. Put together, India is ranked 62nd in the Global Innovation Index; 1st in the region; and 8th in its income group after China, Moldova, Jordan, Thailand, Vietnam, Ukraine and Guyana.

CARICOM:

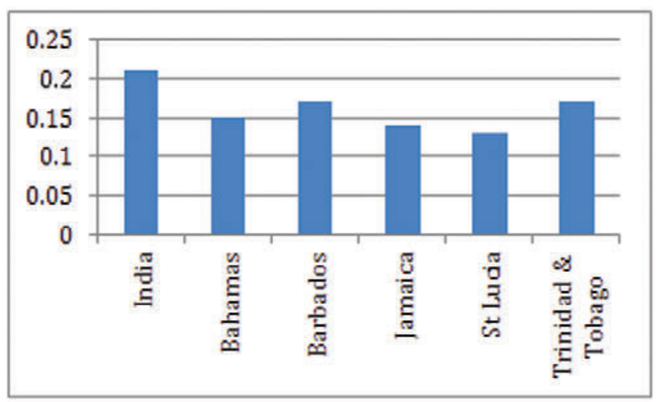
The Caribbean Community (CARICOM) is comprised of fifteen member states and five associate members, and encompasses most of the Caribbean region. The member states include Antigua & Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St Lucia, St Kitts & Nevis, St Vincent & Grenadines, Suriname and Trinidad & Tobago. The associate members include Anguilla, Bermuda, British Virgin Islands, Cayman Islands and the Turks & Caicos Islands. Detailed information and data for many of the countries are unavailable. CARICOM economies were significantly affected by the 2008 global economic



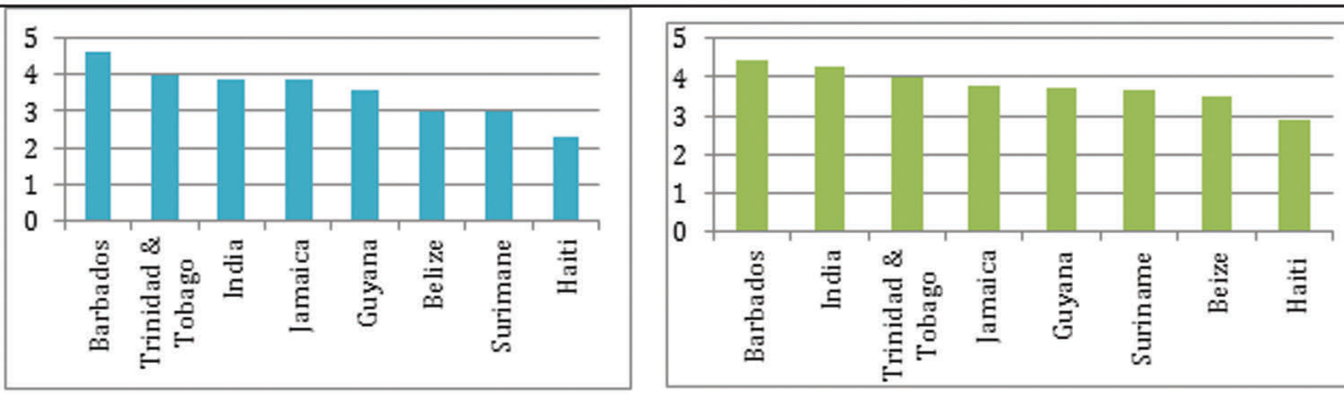
A: Comparison between investment for R&D in India and the Caribbean: GERD as percentage of GDP. China, Brazil and South Africa are shown for comparison



B. Ranking of India and selected CARICOM countries in the Global Innovation Index, 2012. Rankings are India (64), Guyana (77), Belize (80), Trinidad & Tobago (81) and Jamaica (91)



C. Network Readiness Index of India and selected Caribbean countries. NRI ranks countries on their abilities to exploit the opportunities associated with increased technological connectivity and thus a yardstick of technological preparedness.



D. Competitive Industrial Performance Index 2009. CIP Index shows the performance of countries on producing and exporting manufactured goods in a competitive global market.

E. Global Competitiveness Index 2011-12. Absolute rankings are Barbados (42), India (56), Trinidad & Tobago (81), Jamaica (107), Guyana (109), Suriname (112), Belize (123) and Haiti (141).

recession. Countries such as Antigua & Barbuda, Bahamas, Barbados, Grenada, Jamaica, St Kitts & Nevis and St Lucia were projected to have negative growth during 2009 (*Sala-i-Martin, 2009*). Thus, the post-recession period witnessed a significant erosion of competitiveness that needs to be restored.

Comparison of Some Relevant Indicators

India and the CARICOM countries have significant commonalities, although economic and innovation indicators show similarities and differences of varying degrees. Some of the relevant indicators include the Global Innovation Index, Network Readiness Index, the Competitive Industrial Performance Index and the Global Competitiveness Index. Figure 1 summarises the above indicators as observed for India and selected CARICOM countries.

Figure – 1: Some Innovation Indicators for India and Selected Caribbean Countries

Broad similarities between India and the Caribbean economies include similarities among various indicators; relatively weak value chains; preponderance of Micro, Small and Medium Enterprises (MSMEs); limited pools of specialized inputs (in terms of R&D, technologies, human resources, etc) and relatively weak intellectual property regimes.

The Cluster Approach: Context, Evolution and Typology

Clusters have emerged as a pivotal mechanism for achieving economic development. The inspiration of development of clusters stems from the fact that in the rapidly globalizing world, it is quite impossible to sustain competitive pressures without developing a close-knit ecosystem with the participation of multiple players.

Weber (1909), Marshall (1925) and Schumpeter (1994) have laid the foundations for agglomeration economies based on the observations that firms locate together so as to reduce transaction costs, to increase flexibility and to maximise information flow. Such agglomeration economies are driven by clusters where firms of a particular type are located in close physical proximity.

Studies have shown that flow of knowledge occurs fast under local settings (*Monsoon, 2011*). Thus, innovation happens readily when its various components interact with one another locally. It is therefore important to co-locate firms, R&D institutions and innovation supporting institutions in a way such that they might undergo a close and continuous interaction among themselves. Innovation clusters thus form geographic groupings of institutions and firms that catalyse the eco-system of innovation and focus on products, processes, technologies and/or service delivery. Table 1 lists some of the major types of clusters along with the relevant characteristics.

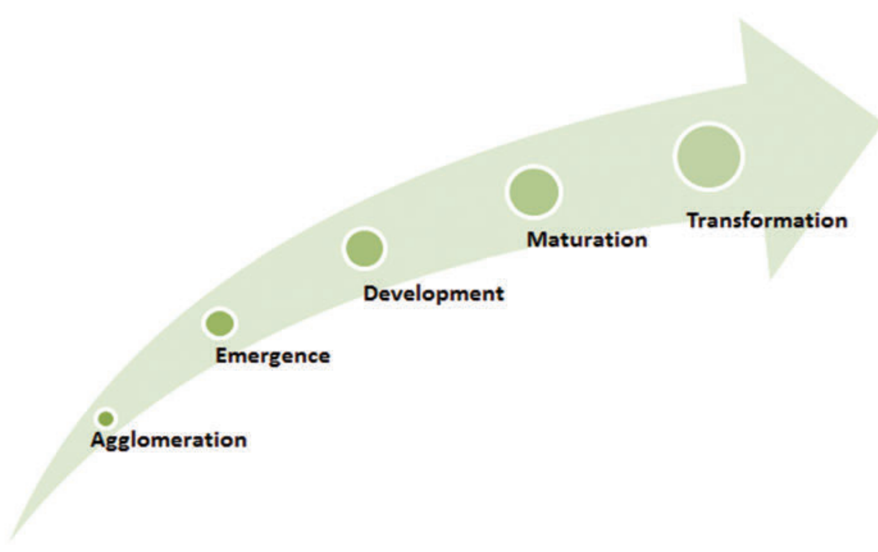
Agglomeration economies have given rise to a specific cluster life cycle model that is shown in Figure 2. The main actors in such life-cycle are the firms, government, academia and R&D institutions (these three form the so-called Triple Helix), plus financial actors and the glue organizations (that hold the cluster chain together). It is through such a basic framework that innovation clusters have emerged evolved and operated globally.

Table – 1: Major Cluster Types with Characteristics

Type	Characteristics
Cohesive	Local pool of production, labour; high degree of internal production
Clusters	Linkages Mostly small firms Located in town, cities
New Industrial District	Mix of large and small SMEs Outside cities Enduring relationships Macro-global trading
Innovative Milleux	Mostly SMEs; located out of town; high degree of embeddedness
Proximity Clusters	SMEs and MSMEs ; micro-global trading ; un-embedded

Source: D. Hart (2000): University of Reading Working Paper

Figure – 2: A simplistic depiction of Cluster Life Cycle



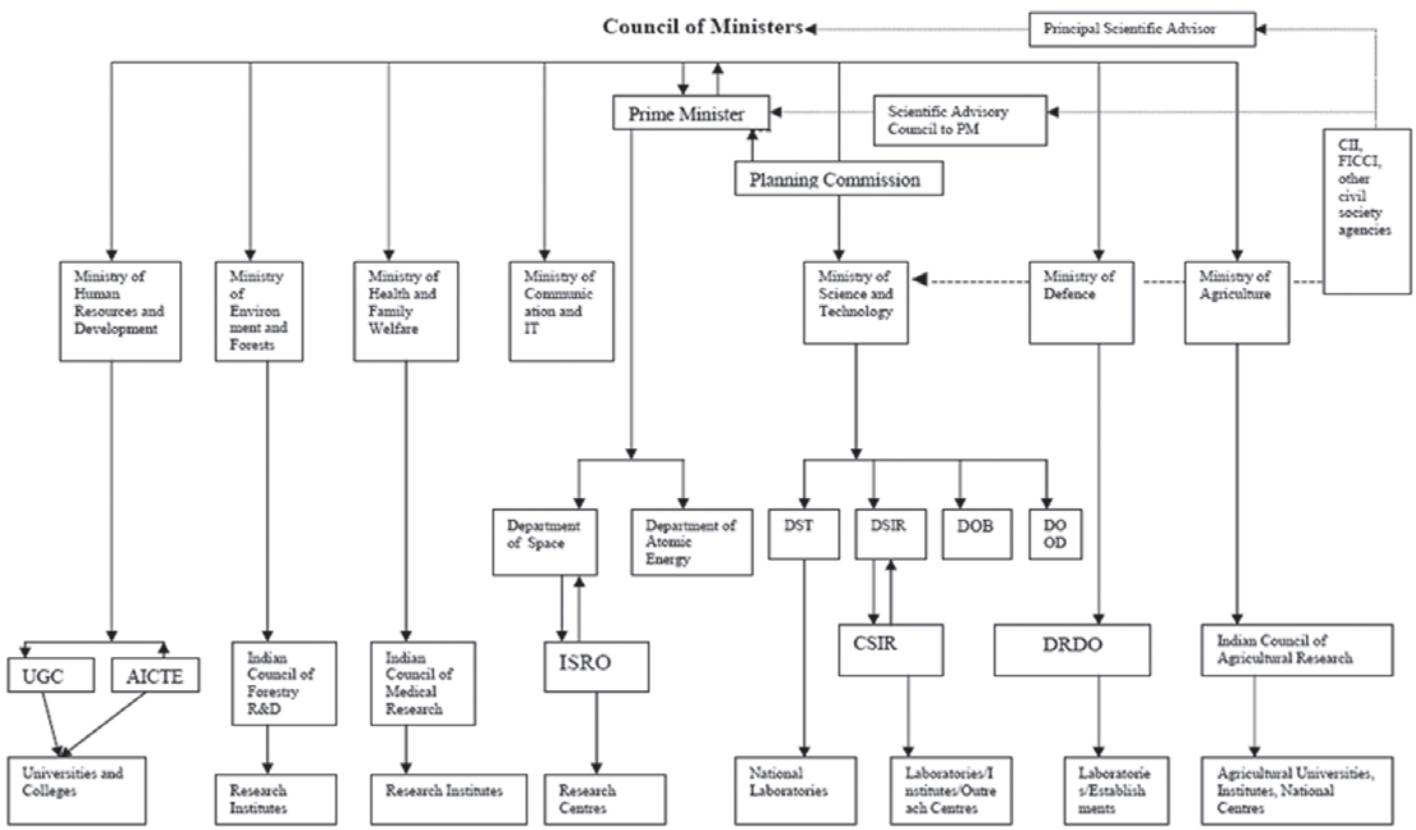
Methodology and approach

The present study takes a qualitative approach towards evaluation of innovation clusters in India and the CARICOM and focuses on two elements, namely the policy frameworks that govern the cluster processes and the institutions that drive the cluster processes. Comparative insights from both regions have been taken whenever possible. Policy frameworks have been evaluated against the broader macro S&T policies as well as approaches and strategies for innovation. Institutional mechanisms have been studied through review of specific examples.

Results: S&T Framework and Governance in India

The Science, Technology and Innovation eco-system in India is complex. It comprises players from the central government ministries and S&T departments, central government socio-economic and other ministries, state government S&T departments, S&T in non-governmental organizations, independent research institutions and in-house R&D in private industries. The governance structure represents essentially a grid with interactive systems covering a large number of players **(Figure 3).**

Figure – 3: S&T Governance Grid in India



S&T in India has evolved through successive policy instruments that were put in place since independence (Department of Science and Technology, 2013). The instruments span the sectoral areas as well as the interface of science and technology. These include:

- Science Policy Resolution (1958) – The first post-independence instrument that was envisaged to foster, promote and sustain scientific research in pure, applied and educational domains; ensure adequate supply of research scientists; and ensure that the benefits accrue from acquisition to application of scientific knowledge.
- Technology Policy Statement (1983) – This instrument was the first provision to bolster technological competitiveness of India and endeavour to promote technological competence and self-reliance; use traditional skills and capabilities making them commercially competitive; develop internationally competitive technologies; and develop such technologies so as to reduce the demands on energy and make them environmentally sustainable.
- Science and Technology Policy (2003) – This policy statement focused on ensuring food, agriculture, energy, water, health and energy security; tune S&T for alleviating poverty; foster scientific research in universities, and develop high-end S&T infrastructure as well as inculcate trans-disciplinary R&D.
- Science, Technology and Innovation Policy (2013) – This newest instrument aims to position India as a global leader in science; link scientific research output with economic growth and enhance public-private partnership in scientific and technological research.

Thus, over the past 45 years, India's science policy has evolved from an instrument for developing basic scientific competence and catering to basic social needs to that of an enabler of economic prosperity and global competitiveness. The outcome of such changing priorities can be found in a concomitant growth of collateral policies to develop and sustain innovation.

India's Policies on Innovation

Driven by the enabling provision of the S&T policies, the national policy instruments have focused on catalysing, nurturing and accelerating innovation. The decade 2011-2020 has been identified in India as the 'Decade of Innovation'. The Planning Commission has adopted a formal roadmap by incorporating innovation for the first time in its Approach Paper for the Twelfth Five Year Plan (Planning Commission, 2012). The focus of India's innovation strategy includes the following:

- Frugal Innovation: In contrast to the west, where innovation's success is assessed through the level of focus on inputs through science, technology and R&D, India's focus is on frugality i.e. the efficiency of innovation through outcomes that benefit people, particularly the poor. India's focus of innovation is thus essentially on inclusive growth.
- Collaboration and Clusters: Indian innovation initiatives are designed to catalyse collaboration among entities and organizations into clusters. Clusters in India are focused on two broad types, namely physical clusters and virtual clusters.
- Financial Mechanisms: India's new innovation policies focus on providing a supportive financial mechanism that benefits innovators. Although India has traditionally used venture funds and private equity funds to promote innovation, these are focused mainly towards safer investments, thereby belying the very concept of frugality. A new financial mechanism has been introduced with the establishment of the India Inclusive Innovation Fund.

S&T Policies and Frameworks in the CARICOM

With the exception of Trinidad & Tobago, Barbados and Jamaica, science, technology and innovation are less powerful in the CARICOM region. A formal S&T policy framework for the region began with the drafting of the Regional Science & Technology Policy (1958), which was developed to integrate and harmonise national policies in S&T. The Caribbean Council of Science & Technology was tasked with steering and implementing the policies and came up with the Regional Policy Framework in 2007 (*Caribbean Regional Policy Framework, 2007*). The framework identified 12 priority areas and 9 institutions to energize the innovation ecosystem of the region. These CARICOM priority policy areas as well as the identified sectoral focus of the CARICOM clusters are summarized in **Table 2.**

Table – 2: Priorities and Sectoral Focus in CARICOM Clusters

Priority Policy Areas	*Sectoral Focus*
a) Agriculture and Food b) Biology and Biosafety c) Environment d) Coastal Resources e) Waste Management f) Alternative Energy g) Disaster Preparedness h) Health i) Development of MSMEs j) Information and Communication Technologies	a) Traditional Manufacturing (Textiles, Furniture) b) Resource based Industries (Bauxite, Timber, Fruit) c) Complex Product Systems (Auto-parts, Aeronautics) d) Specialized Supplies (Software)

Source: Author's elaboration from Regional Policy Framework in Action: CARICOM (2007)

As shown in the table, significant overlap exists between these identified areas of CARICOM and those of India. This provides a basis for developing a more rewarding collaborative milieu between the two regions.

Intellectual Property Rights Regimes

Intellectual Property Rights (IPR) regimes constitute another policy determinant that drives innovation. The advent of the World Trade Organization (WTO) and the TRIPS (Agreement on Trade Related Aspects of Intellectual Property Rights) has resulted in a substantial equalization of the frameworks that govern IPRs, albeit often with significant bottlenecks. As a signatory of the TRIPS, India has effected major amendments to its IPR laws and achieved a reasonable level of compliance to provisions of the TRIPS in three stages between 2000 and 2005.

All Caribbean countries with the sole exception of the Bahamas are members of the WTO. However, substantial variations between the IPR instruments exist among CARICOM countries and there is a preponderance of *sui generis* regimes with limited GI protection.

Both India and CARICOM share substantial similarities by the fact that their IPR regimes are relatively weak and fraught with regional externalities and both have an inherent predisposition to *sui generis* systems. Given the fact that both regions are rich in biodiversity and plant resources, with a significant portion of their innovation clusters having evolved around natural resources and/or traditional skills, weak IPR regimes often pose a serious threat to protecting the interests of indigenous innovators and innovation. Cluster growth is thus significantly influenced by the IPR provisions in place and by the way they interact with cross-country settings.

Clusters in India and the CARICOM
Indian Clusters

Clusters in India can be categorised on the basis of locational factors as well as on operating themes. In terms of location, clusters may be either physical or virtual. Physical clusters are those where the cluster components are actually in close proximity with one another. In virtual clusters, the enterprises are geographically separated and connected through technological means. Operating themes organise clusters into the so-called thematic clusters (e.g. automobiles, biotechnology, leather, etc.) Additionally, India possesses regional clusters.

While clusters in India have been formed around both large and small firms, significant importance is attributed to the clusters comprising of MSME, since they are known to account for more than 50 per cent of the GDP. MSME cluster categories range from industrial clusters to those involving traditional skills e.g. handicrafts and handloom. Services have also been recently incorporated into this group. A representative table of MSME cluster categories in India is provided in **Table 3.**

Table – 3: MSME Cluster Categories in India

Cluster Type/Category	Products
Industry Clusters	Footwear Jewellery Agro-implements Metal-ware Engineering equipment
Handloom Clusters	Sarees Dress materials Shawls Household furnishings
Handicrafts Clusters	Khadi Agarbatti Coir Utensils Spices Carpentry Dress making
Micro-enterprises Cluster	Cane and bamboo Embroidery Lacquer-ware Earthen-ware Furniture Wood carving
IT Clusters	Software development Application development Website designing
Service Clusters	Nature Tourism Wildlife Leisure

Source: Adapted by author from base data of Cluster Observatory

CARICOM Clusters

CARICOM clusters are essentially thematic and are classified as either traditional or resource-based clusters. The former focuses on domains such as handicrafts, apparel, tourism, music, etc while the latter focuses upon naturally occurring products e.g. fish, eggs, agro-produce, etc. Additionally, CARICOM has a set of horizontal clusters that are composed of locally-owned small and medium enterprises (SMEs). Interestingly, organic and regional clusters are absent in the Caribbean, probably as a result of the small island composition of the region.

Clusters are relatively more dynamic in India, especially in view of the larger number and wider distribution of markets. Indian clusters thus occupy almost the entire spectrum of the cluster life cycle. In contrast, CARICOM clusters are more in the maturation phase. Interestingly, geographic proximity seems to be minimally effective in such clusters. The unique exceptions of the Caribbean region, namely the small island economies, high public debt, high emigration, poor regional linkages and government-controlled strategies, have significantly influenced the nature and dynamics of CARICOM clusters.

Institutions Driving Cluster Development in India

Knowledge initiatives have fuelled knowledge institutions that are instrumental in sustaining and driving innovation clusters. In India, there exist a number of institutions that drive cluster development. As with many other developing economies, government machinery and institutions take a lead role in the process. In India, knowledge institutions span central government entities (Ministry of MSME, Ministry of Science & Technology – DSIR/CSIR and DST, Khadi Village Industries Centre etc); national institutions (e.g. NABARD, SIDBI, NInC-CSIR combine, CAPART, etc); state governments and other institutions such as UNIDO and Gramin Development Services *(*See note on Page 43 for description of each*). The fundamental scheme of operation is a multi-institutional participation across multiple umbrella organizations resulting in the delivery of effective support to clusters.

Some of the major institutional systems and their characteristics are summarised in **Table 4.**

Table – 4: Some Institutional Systems for Cluster Development in India

Institutional System	Broad Features	Focus Area / Penetration
UNIDO Cluster Development Programme	Aims to leverage overall performance and collective efficiency of SMEs Selection of pilot clusters to implement programme Customized methodology to Indian setting	378 clusters across 20 states. Broad area partnering with ministries of textiles, small scale industries, S&T; financial institutions (SBI, SIDBI) etc, ICT, biotechnology, instrumentation, agriculture, new materials
DST Incubators and Entrepreneurship Parks	R&D support to SSI through interaction with research institutes / academia Promotion of innovation based \ enterprises Market survey, Information dissemination, Financing, Legal, IPR support	
NABARD	Concentration on rural artisans Forward integration of National Programme on Rural Industrialization Participatory and intensive models of support	119 clusters (108 participatory; 11 intensive) Agri and allied activities Food processing SME in Rural Areas Traditional arts e.g. handloom, handicrafts
National Innovation Council Cluster Innovation Centres	Platform to enable generation of new products, services, processes and business models Facilitates access of MSMEs to technologies, R&D, finance, skills Model to transform regional clusters to regional ecosystems	Broad focus. 6 pilot clusters in area of food processing, furniture, bamboo etc
CSIR Innovation Complexes	Nurturing challenge driven innovation with focus upon building regional innovation systems Integration of CSIR technologies	Healthcare, energy, infrastructure, manufacturing, agro-products, water
National Innovation Foundation	Nurturing and catalysing grassroots innovation Unique initiative through the Honeybee Network Database of more than 1,60,000 innovative ideas Database of traditional practices Financing options	Broad focus
Foundation of MSME Clusters	Promotion of inclusive cluster initiatives and cluster linkages Cutting edge methodologies, tools and information resources	Broad focus

Source: Compiled by author

Institutional Structures in the Caribbean

Piertobelli and Stevenson (2011) have evaluated the cluster programmes in the Caribbean and its associated institutional mechanisms. The Inter-American Development Bank has significant experience in implementing cluster programmes in Latin America and the Caribbean with particular focus on Guyana and Haiti within CARICOM. Institutional spaces created under such cluster development programmes have been used to negotiate, design and implement projects with shared benefits and with the government assuming leadership in all. The involvement of private sector players has proven to be a determinant of success.

Note

Ministry of MSME is the government's administrative ministry dealing with the affairs of the micro, small and medium enterprises in India (*www.msme.gov.in*)

Ministry of Science and Technology is the government's administrative ministry for S&T affairs. Department of Scientific and Industrial Research (DSIR) and Department of Science & Technology (DST) are departments under the Ministry. Council of Scientific and Industrial Research (CSIR) is an autonomous body headed by the Prime Minister of India and functions under the DSIR. (*www.dst.gov.in, www.dsir.gov.in, www.csir.res.in*)

Khadi Village Industries Commission (KVIC) is a statutory body of the Government of India with a mandate to provide employment, producing saleable articles, and creating self-reliance amongst the poor to build up a strong rural community. (www.kvic.org.in)

National Bank of Agricultural and Rural Development (NABARD) is the apex institution of India that looks after the development of cottage industry, small industry and village industry. It reaches out to allied economies for support and promotion of integrated development. (*www.nabard.org*)

Small Industries Development Bank of India (SIDBI) is an independent financial institution in India established to aid growth and development of micro, small and medium enterprises. It provides direct credit to SMEs and also supports micro-finance institutions for capacity building and lending. (*www.sidbi.com*)

National Innovation Council (NInC) is an autonomous body that works under the aegis of the Office of the Prime Minister of India on Infrastructure and Innovation to promote the national agenda of innovation. (*www.innovationcouncil.gov.in*)

Gramin Development Services is a professional non-governmental development organization in India that works for the development of the poor and disadvantaged sections of the society. (*www.gdsindia.org*)

Discussion
Both India and CARICOM need to search for and leverage on mutual synergies

Cluster initiatives in both India and CARICOM have underscored the need for collaboration in order to drive the innovation process. In India, the national think-tank repository, National Knowledge Commission of India (2007), has highlighted a major cause of failures in cluster processes. It says:

"… Growth and innovation in both large firms and the SMEs are seriously compromised because of lack of collaboration between industry and academia/R&D. Thus the existence of the triple helix in India is seriously compromised…."

In a globalized economy that is focusing on demand-driven innovation, it would be logical to expect that integrating the triple helix of university, industry and government could occur not only at the national level but also in a global context. This would require the involvement of innovation actors from both India and overseas e.g. the CARICOM region.

Interestingly, Article 64 of the Revised Treaty of Chaguaramas, which highlights the growth strategies for CARICOM, observes:

"…to encourage inter-alia, inventions and innovation and acquisition, transfer, assimilation, adaptation and diffusion of technologies in the Community and the promotion and co-operation in research and technological development among the Member States and with Third States and competent international organizations.."

The possibility of India qualifying as a "Third State" in such a collaborative scenario is strong. Except for the sole impediment of geographical separation, India and the Caribbean region share common institutional systems, comparable IPR regimes and synergies in the policy framework. India, with its relatively strong institutions driving innovation, could be crucial in sharpening the cluster processes in the Caribbean. This apart, Indian institutions have an inherent structure that makes them rather well-suited for global integration. India's TRIPS-compliant IPR regime also provides a supportive milieu for such integration. India and the Caribbean are thus well-positioned for leveraging each other through cross-country collaboration.

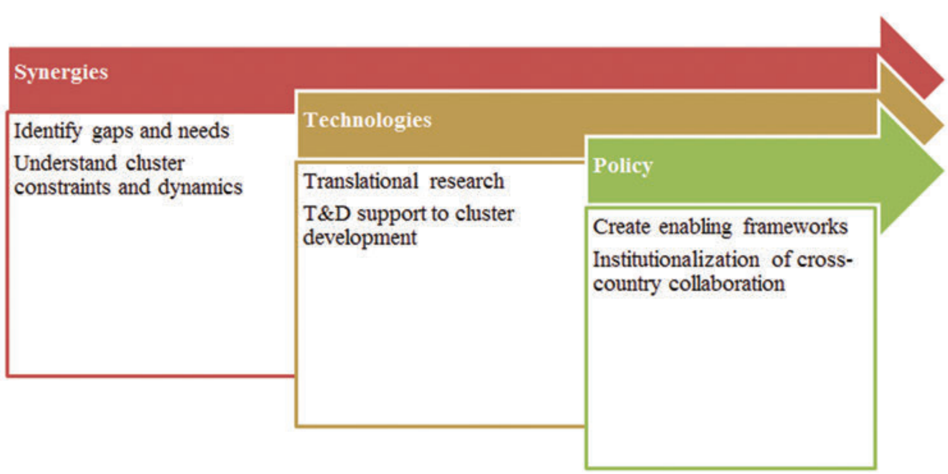
Co-learning as a collaborative tool

Co-learning in the Innovation Clusters can occur along three major determinants, namely:

- Synergies – are there significant synergies between the clusters under consideration?
- Technologies – what are the technologies that are required and are they available?
- Policies – does there exist a supportive policy framework to support cluster co-operation?

The scheme of operation along these three determinants is summarized in **Figure – 4.**

Figure – 4: Co-Learning Scheme in the Innovation Clusters



An analysis of the cluster domains in India and within CARICOM is summarised in Table 5. As evident from the data, synergy in cluster theme exists for agriculture, IT and IT-enabled services, agro-processing, furniture, forest products, manufacturing, fruits and vegetables, garments, textiles and apparel, food processing, tourism, electronics and paper products.

Table – 5: Mapping the Clusters in India and the CARICOM

	Agriculture	Fisheries	IT and ITes	Agro Processing	Furniture	Forest products	Alternative Energy	Manufacturing	Fruits & Vegetable	Garments	Textiles & Apparel	Food processing	Tourism	Electronics	Paper Products
India			√	√	√	√		√	√	√	√	√	√	√	√
Antigua & Barbuda	√	√											√		
Bahamas															
Barbados			√										√		
Belize	√			√	√								√		
Dominica	√		√										√		
Grenada		√											√		
Guyana	√		√			√	√	√					√		
Haiti			√	√				√	√	√			√		
Jamaica	√		√	√									√		
Montserrat															
St Lucia									√		√	√		√	√
St Kitts and Nevis															
St Vincent & Grenadines				√											
Suriname															
Trinidad & Tobago												√	√		

Source: Compiled by author

Some of the synergistic clusters outlined in Table 5 could be chosen for co-learning and thus for co-developing using existing strengths and maximising emerging opportunities.

Energising Clusters for Driving Development

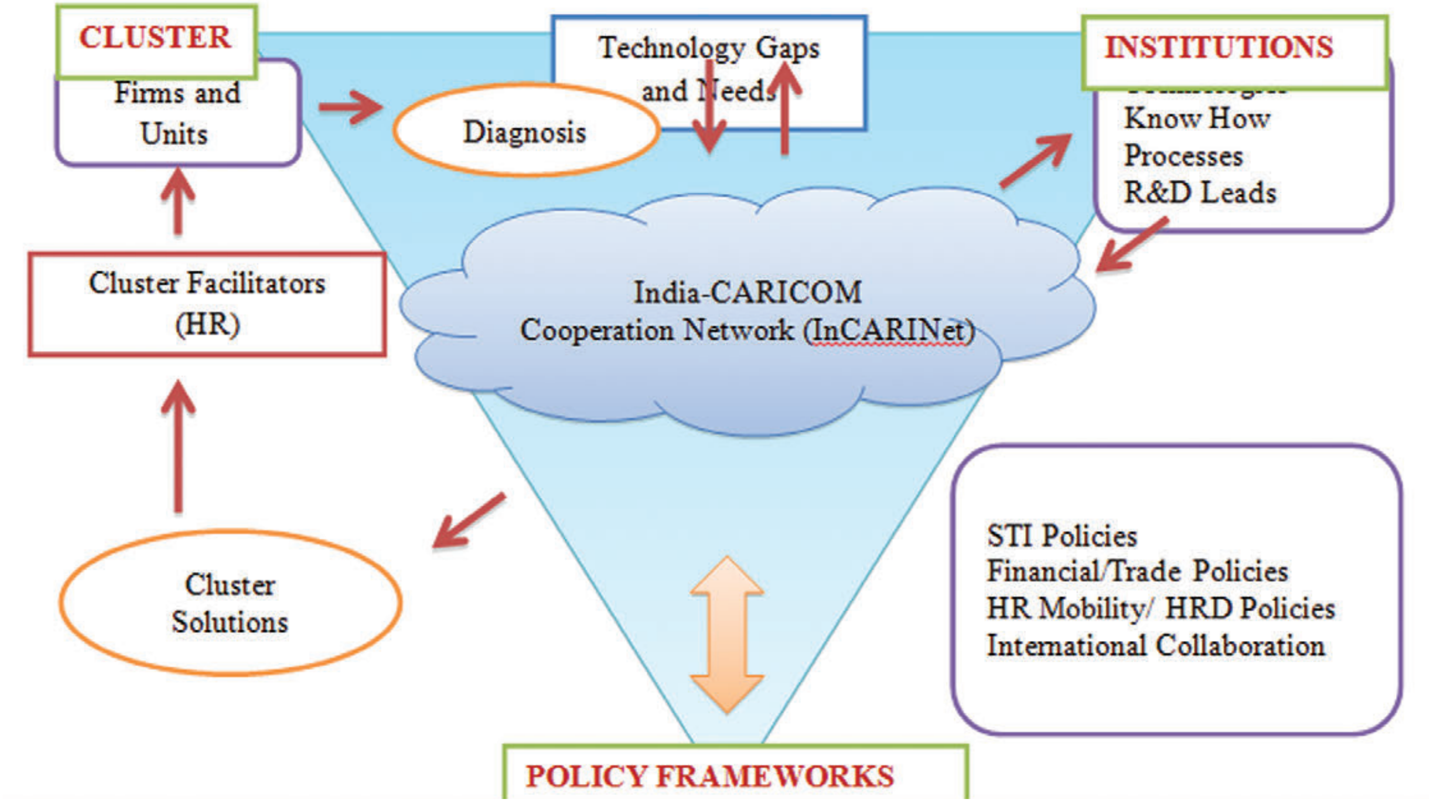
Regions with stronger clusters are also regions with a higher share of employment and industries. In a study on knowledge-intensive sectors in Sweden, Wennberg and Lindquivst (2010) demonstrated that clustered firms created more jobs, yielded higher taxes and paid higher wages.

European cluster policies can be considered to be benchmarks for cluster initiatives in several regions of the world. Europe tends to follow the "horizontal approach" to cluster policy that aims to bring different policies together and using synergies between them. Cluster initiatives in Europe achieved the transformation of the industrial and innovation eco-system by enabling a shift from the traditional concept of incubators to that of the more comprehensive regional innovation systems (*Cooke, 2002*).

Nevertheless, the scheme for energizing cluster development is diverse and subject to large regional variations. Industrial development through clusters essentially tends to focus upon such parameters as the development of common facilities, the establishment of a supply chain and the enabling of human capital development through training programmes (*Mitra, 2013*). Government has played the role of master strategist in cluster development in both India and the Caribbean. Such a government-managed process has often been fraught with a number of inadequacies. This has led the National Innovation Council in India to concentrate on a more unique model that focuses on indigenous cluster processes and institutions with reasonable success (*Mitra, 2013; NInC Report to People, 2012*).

In this discussion, we move a step further to ask whether this NInC approach could be extrapolated beyond the local levels. Could the power of technological networking enable local institutions and processes in the distant Caribbean to be leveraged through institutional inputs from India? Fine-tuning such processes could effectively leverage clusters and accelerate development. A schematic overview of the proposed mechanism is shown in **Figure 5.**

Figure – 5: Proposed Model of Cluster Development through India-CARICOM Cooperation Network



While the interplay between the cluster and institutions is similar to what is proposed for driving cluster innovation in the CSIR, the aspect of policy framework needs to be highlighted. In a local or national setting, both clusters and institutions operate within the same policy frame. In case of global networking, clusters and institutions might exist in different settings thereby requiring externalities arising out of cross-country differences and international laws to be factored in. Thus, STI policies relevant to HR mobility, finances and international collaboration, international trade & IPR, etc need to be expanded substantially beyond the traditional framework.

The present study indicates a strong possibility for synergising the development of India and CARICOM through collaboration, co-learning and co-creation models. For this, it would be important to leverage existing provisions and move beyond that. Such provisions, though minimal, do exist. In 2003, the Government of India and CARICOM established a Joint Commission of Co-operation in which collaboration in science, technology and innovation features prominently. India's Department of Science & Technology has established bilateral linkages with Trinidad & Tobago and CSIR is in the process of streamlining a joint action plan with Trinidad & Tobago for connecting CSIR-NISTADS and NIHERST. It is thus imperative that an India-CARICOM Network (InCARINet) be set up to initiate the proposed cluster collaboration stated herein. The activities could begin by identifying areas for intervention, documenting the cluster data jointly and establishing an institutional structure to implement the action plan on a joint basis. Such an arrangement should result in the development of effective enabling provisions at the macro level, exchange of technologies, HR mobility and accelerated co-development of clusters. At a wider scale, this offers the potential for catalysing economic prosperity through appropriate application of science, technology and innovation.

Acknowledgements

The author thankfully acknowledges Professor Subhashis Mukhopadhyay of the University of Calcutta, Kolkata and Mr Indranil Biswas of the CSIR-CGCRI, Kolkata for their constructive suggestions during the course of the work. Dr. Sukanya Datta of CSIR-CGCRI is thankfully acknowledged for her editorial inputs. Dr. Partha Banerjee, Director of CSIR-NISTADS, is thanked for his critical comments on the initial research data. Director, CSIR-CGCRI, India and President, NIHERST, Trinidad & Tobago are thanked for funding the participation to the conference.

References

1. *Caribbean Regional Policy Framework in Action (2007): Science, Technology and Innovation for Sustainable Development,* CARICOM
2. Cluster Observatory: A compendium of cluster resources for undertaking cluster initiatives: Foundation of MSME Clusters and DST, www.clusterobservatory.in (accessed on 29/07/2013)
3. Cooke, Philip (2001): *From Technopoles to Regional Innovation Systems – The Evolution of Localised Technology Development Policy*, Can. J. Regional Sci., XXIV(1), 21-40
4. Department of Science & Technology: Science & Technology Policy 2003, www.dst.gov.in (accessed on 29/07/2013)
5. Department of Science & Technology: Science Policy Resolution 1958, www.dst.gov.in (accessed on 29/07/2013)
6. Department of Science & Technology: Science, Technology and Innovation Policy 2013, www.dst.gov.in (accessed on 29/07/2013)
7. Department of Science & Technology: Technology Policy Statement 1983, www.dst.gov.in (accessed on 29/07/2013)
8. Etzkowitz, H and Leydesdorff, L (2000): *The dynamics of innovation – from national systems and 'mode 2' to a triple helix of university-industry-government relation*, Res. Policy (29), 109-123
9. Hart, D.A.(2000): *Innovation Clusters – Key concepts*, University of Reading Working Papers, University of Reading, 1-14 (accessed on 29/07/2013)
10. Marshall, A (1925): *Principles of Economics*, Macmillan, London
11. Mitra, Samir (2013): *Innovation Cluster Initiative – Transforming India's Industry Clusters for Inclusive Growth and Global Competition*, Global Innovation Index Report 2013, 107-114
12. Monsoon, C. K. (2011): "Do local clusters matter – the forgotten importance of local cluster strength for individual companies: Evidence from Denmark", Master's Thesis, Copenhagen Business School
13. National Bank of Agricultural and Rural Development, www.nabard.org (accessed on 29/07/2013)
14. National Innovation Council (2012), *Report to the People, 2012*, www.innovationcouncil.gov.in (accessed on 29/07/2013)
15. National Innovation Council (2013): Building the Innovation Ecosystems – Role of NInC and SInC. www.innovationcouncil.gov.in/images/stories/presentations/State_Innovation_Council_Initiative.ppt (accessed on 29/07/2013)
16. National Knowledge Commission (2007): Innovation in India
17. Nurse, Keith (2002): *Science, Technology and Innovation in the Caribbean, Proc. Of Technology Policy and Development in Latin America*, UNECLAC, Santiago, Chile
18. Office of Advisor to the Prime Minister on Public Information, Infrastructure and Innovation (2011): "Towards a more Inclusive and Innovative India Strategy Paper." www.iii.gov.in/images/stories/innovation/Innovation_Strategy.pdf (accessed 29/07/2013)
19. Piertobelli, C and Stevenson, C (2011): "Cluster Development Programmes in Latin America and the Caribbean", Inter-American Development Bank, IADB Discussion Paper IDB-DP-180
20. Planning Commission, Government of India (2012): "Faster, Sustainable and More Inclusive Growth -- An Approach to the Twelfth Five Year Plan", Ch-16 (Innovation), 135-139
21. Sala-i-Martin et al (2009): The Global Competitiveness Index 2009-10 – *Contributing to long term prosperity amid global economic crisis*, The Global Competitiveness Report 2009-2010, 3-47, World Economic Report
22. Schumpeter, J.A.(1934): *The Theory of Economic Development*, Harvard University
23. UNESCO Science Report 2010: United Nations Educational Scientific and Cultural Organization
24. Weber, A (1909): *Uber den Standart der Industrien*, I – Reine Theorie des Standarts, Tubingen
25. Wennberg, K, Lindquivst, G. (2010): *The effect of clusters on the survival and performance of new firms*, Small Business Econ. 34(3), 221-224

Technology and Sustainable Development:

Promoting Technology Transfer in Various Sectors and SMEs

6.

Jamaica's Energy Dilemmas

Prof. Anthony Clayton
University of the West Indies, Mona, Jamaica
anthony.clayton@uwimona.edu.jm

Abstract

Despite high oil prices, Jamaica's energy consumption has consistently grown faster than the economy. As a result, Jamaica now requires 21,152 BTU to produce US$1.00 of output, compared to a global average of 4,600 BTU. This has driven up electricity and transportation costs, which reduces Jamaica's ability to compete on international markets. This highlights three anomalies:

- Most of the technical solutions are known.
- Jamaica has renewable energy resources, including hydropower, wind, solar energy, and bio-fuels, but these remain largely undeveloped.
- There have been many initiatives in the past to develop a better energy system in Jamaica, including the promotion of diversification, the development of renewable energy sources and increased energy efficiency, but these have only delivered a small fraction of the improvements required. An analysis of the factors that have impeded progress highlighted problems with governance, policy conflicts and misguided technology choices, the latter indicating weak educational linkages and technology transfer pathways. Jamaica therefore needs to build stronger linkages between the policy and research communities.

Introduction

Jamaica, in common with some of the other Small Island Developing States (SIDS), faces a number of inter-related challenges with environmental, energy policy and economic dimensions. For example:

- One of the possible effects of climate change is an increase in the incidence of severe hurricanes and cyclones, which are likely to have the greatest impact on poor and middle- income countries with settlements and infrastructure in low-lying coastal regions. This is a particular concern for SIDS as a relatively large per centage of their human capital is potentially vulnerable.
- Climate change is largely driven by the consumption of hydrocarbons, so the problems of climate change have to be considered in conjunction with the need to ensure national energy security. All countries need affordable and reliable supplies of energy. The task now is to find a way to secure energy supplies while minimizing the associated environmental costs.
- Since the cost of producing goods and services is a critical determinant of competitiveness, and energy costs are typically a major component of total production costs, it is essential for SIDS governments to encourage greater energy efficiency and, therefore, productivity. A strategy to increase productivity and enhance energy efficiency that would solve a number of problems simultaneously, should therefore be accorded greater support in the decision-making process. The dimensions of the challenge are outlined in greater detail below.

Demand For Energy

The demand for energy is projected to continue to increase as a result of three drivers of increased demand:

- Some 30% of the world's population still does not have adequate energy services;
- The world's population is currently projected to increase to over 9 billion by 2050; and
- More energy will be needed as more countries industrialize.

Recent projections by the United States Energy Information Administration indicate that world energy consumption will increase by 49 per cent by 2035, from 495 quadrillion BTU (QBTU) to 739 QBTU, while projections by the International Energy Agency (IEA) indicate that demand for oil will increase by almost 40 per cent and coal by almost 75 per cent by 2030, with developing countries generating over 75 per cent of the increase. Without a rapid transition to renewable and low-carbon energy sources, over 85 per cent of global energy consumption in 2030 will still be based on hydrocarbons.

This means that the increase in world energy demand will significantly increase emissions of carbon dioxide, thereby accelerating climate change. Some projections indicate that this could result in an average temperature rise of 2 to 4 degrees by 2100.

The only way to avoid this outcome is to implement significantly more energy-efficient solutions, and to develop low-carbon energy sources to supply the volumes required. It is particularly important to develop solutions that are designed for the new industrial powers and other developing countries, since these countries could otherwise become the primary drivers of accelerated climate change. China is now the world's largest carbon emitter but may eventually be overtaken by India, as projections of differential rates of population growth indicate that India will be the more populous nation by mid-century. These developments will erase all the efficiency gains made in the post-industrial nations causing the world's carbon emissions to continue to rise.

There are also concerns about the continued availability of conventional hydrocarbon energy sources. Recent research by Citigroup and BP suggests that Saudi Arabia could become a net oil importer by 2022, indicating that conventional oil will become increasingly scarce and expensive in the near future. Unless there is a move away from hydrocarbons, demand will have to be met by unconventional hydrocarbon sources such as shale gas and tar sands.

The world is making some progress towards improving efficiency. In 1980, the global energy system operated at an efficiency level of just 34 per cent. Today, the global energy system is 39 per cent efficient, but this still means that over 60 per cent of total latent energy input is still being lost, rather than being converted into useful energy. About half of the "missing" energy is lost in energy generation and transmission with the remainder lost as a result of leaky buildings, inefficient appliances and so on. Current estimates suggest that greater efficiency in energy generation and transmission, and more energy-efficient buildings, appliances, industrial processes and transport systems could increase the efficiency of the global energy system to 50- 60 per cent by 2040. Averting the threat of climate change, however, requires that the rate of energy efficiency be increased to a level higher than the rate of growth in demand.

Energy Costs

Jamaica's economic competitiveness is seriously undermined by the high cost of energy due to a high level of dependency on imported oil and old, inefficient generating plant. Any country that is dependent on imported oil is highly susceptible to periods of oil price volatility, such as those experienced in 1973 and, more recently, from 1999 to 2008, when the price of crude oil on the international market increased fifteen-fold from US$10/barrel to US$147/barrel. The cost of Jamaica's oil imports increased from US$344 million in 1998 to US$2.7 billion by 2008 with serious implications for the balance of payments, inflation, business competitiveness and household poverty.

Energy price volatility is a particular problem for poor and middle-income countries with high levels of oil imports compared to their Gross Domestic Product. This is partly because of their economic dependency on oil (i.e. the GDP/energy ratio), which has not declined to the same extent as in developed nations, as well as their high current account deficits and public debts, and limited access to global capital markets due to the perception of weak governance, economic fragility and exchange rate volatility risk. In such circumstances, a rise in the price of oil usually has multiple impacts: increased energy costs, increased indebtedness, reduced competitiveness and growth, and compounded social problems. A sustained rise in the price of oil could therefore disrupt a number of relatively fragile SIDS economies, resulting in an increase in emigration, an outflow of skills and capital, and an increased rate of illegal activities as legitimate development options are eroded. Rising crime rates and eroding security deter investors, thus delaying recovery and precipitating a further downward spiral.

Future Uncertainties

It is important to note that most current energy, development and environmental policies in Jamaica and other SIDS are based on assumptions (about technology, costs and the availability of resources) that may fail in the near future, given the clear signs that world energy markets could undergo significant changes over the next few years. For example, the advent of cheap shale gas is already affecting oil and gas markets which could have profound implications for both energy costs and geopolitics. It is also important to note that a period of falling oil and gas prices will make the economic case for investing in renewables much weaker. In addition, the financial problems in a number of Caribbean nations make the case for long- term strategic investment in new energy infrastructure much harder, since extremely constrained budgets almost invariably lead to the lowest-cost choices.

No Regrets

The most rational solution for dealing with such significant uncertainties is to adopt a 'no-regrets' strategy to reduce the risk of investing in the wrong technology, for example, then having to write- off the investment and incur significant opportunity costs. This means that it is usually more important to focus on increasing energy efficiency and productivity than it is to develop new renewable energy sources, as current energy efficiency standards in Jamaica and the other Caribbean nations are very low, providing ample scope for improving efficiency and reducing waste at relatively low cost. This option is likely to remain economically attractive even if energy costs become cheaper in the future, whether as a result of cheap shale gas or the development of a disruptive new energy technology.

Even modest, incremental advances in key areas would be very effective over time, and some solutions are readily available, provided that the institutional and market barriers can be overcome. For example, buildings are responsible for some 30 - 40 per cent of global energy demand. This includes the energy required in the mining, manufacturing, transport and assembly of building materials, and the final demolition and recycling of structures. The greatest demand, however, is generated in the use and operation of the building. As a result, buildings are – in most countries – the largest single source of greenhouse gas emissions (GHG). Building-related emissions were estimated at 8.6 billion tons in 2004, and is projected to double by 2030. The residential sector alone (i.e. not including offices, industrial and public buildings) accounts for 25 per cent of total end-use demand and 19 per cent of global GHG emissions. However, currently available technologies could reduce energy consumption in buildings by 30 - 50 per cent without significantly increasing investment costs. Even modest improvements in building efficiency could reduce world end-use demand for energy by 32 QBTU by 2020.

This indicates another possible multi-dimensional solution that would solve several problems at the same time. It is now technically possible to construct buildings with net zero energy demand, using a combination of good design and energy-efficient technologies. The residential sector alone accounts for 25 per cent of total end-use demand (and 19 per cent of global GHG emissions), so even basic improvements in building efficiency would reduce world end-use demand for energy by over 30 quadrillion BTU (QBTU) by 2020. The greatest need for innovative and cost-effective building solutions lies in tropical and sub-tropical regions, as it is more technically difficult to keep the interior of a building cool and dry in a hot, humid climate than to keep it warm in a cold climate. Levels of energy efficiency in most of the buildings in the Caribbean region, for example, are very low, with high cooling loads. However, this means that the building sector in tropical and sub-tropical regions has considerable potential for positive change, to become far more efficient in terms of resource use, less environmentally intensive, and less costly. Countries that introduce the relevant building codes will therefore be able to reduce their dependence on imported energy, retire inefficient generating plant and minimize their environmental impact. In addition, a reduction in household expenditure on energy will increase levels of disposable income.

The integration of policies for energy, planning guidelines and building controls will also help to resolve problems with energy security, climate change adaptation and disaster preparedness. For example, the post-disaster relief efforts in most countries are seriously handicapped by the lack of electricity in the critical disaster and post-disaster periods and the consequent inability to operate lighting, air conditioning and refrigeration, water pumps and communication systems. This problem arises directly from the centralized generation of electricity and the network of distribution systems. These systems, especially distribution poles and lines, are usually damaged during hurricanes and similar disasters; it takes time to bridge the broken sections. Some sites have standby generators, but the majority of the population remains vulnerable. The development of more energy-efficient and self-sufficient buildings, with decentralized sources of energy such as bio-gas and photo-voltaic supplies should therefore also be seen as an essential component of disaster preparedness.

As this example suggests, the integration of policies for energy, planning, housing and development, with associated reforms to planning guidelines and building codes, could be used to achieve multiple outcomes: reduced dependence on imported energy, higher levels of disposable income, reduced environmental impact and greater resilience to disasters.

Adapting to climate change

It is essential for SIDS to implement a wide range of such adaptive strategies, as average surface temperatures will continue to rise for many years to come even if there were to be a radical change in policies and technologies in the near future. The average surface temperature of the planet has risen by about 0.8 degrees Celsius since 1900 and is expected to continue rising for several hundred years by at least another 0.6 degrees C, even if carbon emissions were stabilized at the current level. This is largely because of the thermal inertia of the oceans. Oceans have about 500 times the mass of the atmosphere and therefore take longer to heat.) A significant level of further climate change is therefore now inevitable.

Anticipating impacts

There is less scientific confidence about regional projections of the impact of climate change. In general terms, however, it is thought that the greatest degree of warming will occur over land and high northern latitudes; that the Arctic, Africa, the Asian mega-delta regions and small island nations will be most affected by climate change, with poor developing countries being particularly vulnerable.

There are also likely to be significant disparities between social groups, as people with wealth and skills are, in general, better able to move, adapt and protect their interests than those living in poverty, children and the elderly. With regard to environmental support systems, the sub-systems that are likely to be relatively sensitive to the impact of climate change include water resources, land-use patterns (such as agriculture, which will be affected by elevated levels of CO_2 in the atmosphere, rising temperatures, changing rainfall patterns, increased frequency of severe weather events, and changes in the distribution of weeds, pests and pathogens), coastal zones, reefs and fisheries, while the spread of particular disease vectors (such as malaria-bearing mosquitoes) will affect human health. The economic sectors that are likely to be most immediately affected by climate change include agriculture, forestry and fisheries, water services, energy, construction, insurance and tourism.

Some countries in the northern hemisphere may benefit from some of these changes, as higher temperatures and elevated levels of CO_2 in the atmosphere may result in increased agricultural productivity in countries such as Canada, Russia and the Ukraine. However, tropical and sub-tropical countries are more likely to be affected by water and food shortages. Similarly, countries in temperate zones are likely to have fewer deaths from cold exposure, while tropical and sub-tropical developing countries are more likely to be affected by an increased incidence of malaria, dengue and water contamination-related problems, such as diarrhoea. Young children are likely to be among the most vulnerable.

The level of a country's economic development and the structure of its economy are therefore important components of its general ability to adapt to climate change. The domestic distribution of climate change impacts will also depend on the distribution of wealth and poverty in society, on levels of education, the availability of good public health services, and on the quality of the housing stock, water, transport and communication infrastructure.

The overlapping of these variables makes possible generic predictions about the communities that are likely to be most severely affected. For example, children in poor fishing communities with limited resources, bad schools, basic housing, poor drainage, water contamination, bad roads and limited access to health services, are likely to be among the most vulnerable members of that society.

Protective measures

Many of the measures needed to protect the most vulnerable people overlap with well-managed, focused poverty reduction programmes, since better schools, health services and infrastructure would all help to increase the resilience of these communities.

These supply-side measures, in conjunction with reforms to improve governance, eradicate corruption, build stronger institutions, reduce the cost of government services, and minimize bureaucratic delays would serve to attract investment and retain human capital, thereby increasing economic opportunities and growth rates. Regional risk-pooling insurance could be used to manage the cost of floods and hurricanes.

Planning and regulatory reform are also needed to prevent environmental degradation of important protective eco-resources such as reefs and mangroves, and control depletion rates of key natural resources such as water. One particularly important measure is the establishment of clear planning guidelines and "no-build" zones in order to direct people and infrastructure out of areas that are likely to have an increasing risk of coastal and alluvial flooding in the future. Whatever lead time exists should be used for developing, implementing and enforcing the necessary planning guidelines as soon as possible.

Translating information into action

There are three important points about using and disseminating information:

- All Caribbean governments are aware of climate change, but few have taken the necessary steps to prevent the construction of additional infrastructure and settlements in areas that are likely to become vulnerable in the years ahead. It is clear, therefore, that risk analyses and other relevant information have not yet been translated into planning and regulatory frameworks. It is important to ensure that the necessary information is not just collected, but also utilized.

- It is important that governments develop public support and political awareness of the importance of simultaneously lowering the energy intensity of human activity and expanding low-carbon sources for the production of energy. Jamaica and other SIDS nations, in common with all countries, need consistent and coherent energy, economic and environmental policies that take into account local opportunities and constraints as well as the relatively volatile conditions and serious uncertainties in global energy markets.

- It is important to note that policy integration would allow all of these objectives to be met as efficiently and economically as possible.

The energy situation

Jamaica is a small economy, heavily dependent on imported oil. Imported oil current meets over 90 per cent of Jamaica's total energy requirement. Jamaica is therefore highly vulnerable to any sustained increase in the price of oil. Jamaica is also a small island with a significant amount of critical infrastructure (including two international-grade airports) just above sea level, and is therefore vulnerable to flooding. There have been many initiatives in the past to develop better energy policies in Jamaica, including the promotion of diversification, the development of renewable energy sources and increased energy efficiency, but these have failed to deliver any substantial improvements.

There are a number of factors that have effectively impeded progress, including problems with governance and policy conflicts, misguided technology choices, market failures, and unhelpful institutional structures. Similar problems can be seen in many other developing countries.

Specific problems in Jamaica include an inefficient public electricity system with old generating plant, inefficient use of energy in manufacturing and other productive sectors, inefficient energy use in the public sector including the extensive use of pumps (rather than gravity feed) to deliver the nation's water supply, low public awareness of the importance of energy conservation, and an inadequate policy framework to promote energy conservation and efficiency.

A 2005 report, "The Renewable Energies Potential in Jamaica", identified a number of barriers to the expansion of renewable energy use in Jamaica. These are:

- Time-consuming administrative procedures related to renewable energy project development.
- Lack of economically viable contractual arrangements.
- Inadequate financial and fiscal incentives, e.g. a lack of relevant duty or General ConsumptionTax exemptions or property tax rebates. By contrast, the development of wind turbines in Denmark and solar cells in Germany was encouraged with direct tax offsets.
- Lack of dedicated grants or soft loans for relevant research, development and exploration.
- Public generation and grid system losses, which include both technical losses (conversion inefficiencies) and non-technical losses (theft), which currently exceed the total energy produced by renewable energy providers, effectively raising the price of electricity (from all sources) to paying consumers.
- Lack of penalties for not meeting renewable energy targets in the National Energy Policy.
- Lack of building code enforcement for items such as solar water heaters.
- Lack of uniform net-metering and interconnection standards for small-scale power generation units (e.g. solar photovoltaic systems).

Another barrier includes the All Island Electricity License (2001), which gives the Jamaica Public Service Company Ltd (JPSCo) the exclusive right to transmit, distribute and supply electricity throughout Jamaica, for a 20-year period.

This monopoly has allowed JPSCo to protect its sunk capital investment in old generating plant by paying low rates to new suppliers, thereby inhibiting the development of renewable sources. In addition, the pricing structure is based on the "pass through" whereby increases in the price of oil are passed through directly to the consumer, taking the economic pressure off the company to improve efficiency.

As a result of this combination of factors, Jamaica is unusually inefficient in its use of energy. While many nations have become more energy efficient over the last three decades, Jamaica's Energy Intensity Index (EII) has actually increased steadily over the last two decades. Despite high oil prices (which peaked at US$147/barrel in July 2008) Jamaica's energy consumption has consistently grown faster than the economy. As a result, Jamaica now requires 21,152 BTU to produce US$1.00 of output, compared to a global average of 4,600 BTU. Jamaica's annual oil imports fell slightly from 23.6 million barrels in 1999 to about 22.1 million barrels in 2009, representing an overall average annual decline of 1 per cent per annum, so it is the combination of low growth and recession that has caused Jamaica's EII to rise.

Jamaica's energy mix remains heavily dependent on imported petroleum fuels which account for 91 per cent of the energy mix, with the remainder derived from renewable sources of which 57 per cent is fuel-wood and bagasse. The former means that Jamaica also has a deforestation rate of about 0.5 per cent per annum. These are followed by ethanol, hydro, wind and solar, in that order. Jamaica's extreme dependence on oil means that Jamaica is highly susceptible to periods of oil price volatility, such as those experienced in 1973 and, more recently, from 1999 to 2008, when the price of crude oil on the international market increased fifteen-fold from US$10/barrel to US$147/barrel. Unlike many other countries, however, Jamaica has not taken the necessary steps to reduce its dependence on imported oil, although Jamaica is a price-taker and has suffered significant economic losses as a result of high energy costs. This apparent lack of price sensitivity reflects, in part, the lack of awareness of alternatives.

Even modest improvements in the efficiency of energy production and consumption in Jamaica would contribute markedly to reducing the energy intensity of the economy. However, it is clear that past efforts to increase energy conservation and improve efficiency have not been coherent or sustained. The 2010 National Renewable Energy Policy was designed to overcome the barriers and create an enabling framework for the development of the sector and the deployment of renewable energy technologies. This was intended to provide the context for a range of projects to enable the country to reduce petroleum imports by about 10% by the end of 2011. This target was not met. There was, however, a modest increase in the per centage of renewable sources in the energy mix, which rose from 6 per cent in 2008 to 9 per cent in 2009. This was due primarily to the roll-out of E10, the 10 per cent ethanol-blended gasoline for use in motor vehicles. This was partly intended to reduce Jamaica's dependence on imported oil, but failed to do so.

The current national energy policy, which is a component of the Vision 2030 National Development Plan, sets targets for renewable energy and for the per centage diversification of energy supply. By 2030, 20 per cent of the country's energy mix is to be derived from renewable sources, while LNG is to replace oil as the main energy source. The national Energy Intensity Index (in BTU/US$1 output, measured in constant year US$2,000), is to be reduced from 21,152 BTU to 6,000 BTU per US$1.00 of output. It should be noted that this would still be higher than today's global average of 4,600 BTU, and double the projected global average of 3,000 BTU in 2030.

The high cost of energy has driven up electricity and transportation costs, which significantly reduces Jamaica's ability to compete on international markets. The cost of electricity is the third most significant factor, along with crime and corruption, and dysfunctional government bureaucracy, in reducing business competitiveness. In addition, the disproportionately high consumption of petroleum products due to Jamaica's current level of energy inefficiency results in increased greenhouse gas emissions, thereby increasing Jamaica's contribution to global warming and the concomitant increase in hurricanes, floods and droughts. This combination is a significant deterrent to investment in Jamaica.

In the context of the above, the major issues to be dealt with include:

- The current status of the development and use of Renewable Energy (RE) in Jamaica, including the current status of RE connection (industrial or domestic) to the national grid
- The support/incentives offered by the Government to promote RE
- Government policies on RE
- Current major constraints to the implementation of RE in the country which include:
- Slender technical capacity
- Low rates of investment in R&D
- Very little local technological innovation
- Lock-in around existing technologies
- Sunk capital
- Monopoly grid and dominant supplier
- Institutional and market inertia, sometimes compounded by inappropriate political involvement, rent-seeking behaviour and, in the worst cases, corruption
- Low levels of awareness in the marketplace
- Unsystematic and inadequately researched technological adoption
- Limited awareness of cutting-edge research and future research directions

It is therefore important to consider measures to:

- Encourage innovation in energy technologies
- Improve the process of converting the results of scientific research into industrial and commercial development
- Improve the process of technological adoption to make it better informed

This resolves into a number of specific tasks, including:

- How can the volume, quality and relevance of both pure and applied research be increased?
- How can more productive relationships between researchers, entrepreneurs, industrialists and financiers be established?
- How can the policy, planning, regulatory and macro-economic environment be improved in order to remove market barriers to innovation and the entry of new technologies, including the removal of overt or hidden subsidies to old technologies?

It is important to note that the primary constraint is not lack of access to capital since many funding sources for Jamaica and the Caribbean are often under-utilized. The problems, therefore, are lack of capacity, inertia, and poor organization.

In general, knowledge networks are the key to rapid development, dissemination and uptake of new ideas, business concepts and technologies. At the best exemplars, knowledge networks act as crucial links between the business community, academics and civil servants, and function across a range of industrial sectors. This involves building more flexible, effective and productive links and partnerships between four key groups in order to assemble functional knowledge networks:

- Researchers
- Investors and financiers
- Entrepreneurs and industrialists
- Government agencies and ministries with energy and economic development remits

There must be a high level of communication between the key groups, so that researchers can be better informed about the changing needs of industry, entrepreneurs can be better positioned to identify opportunities, industrialists can keep abreast of developments in science and technology, and Government agencies can remove obstacles and encourage progress. The evidence from successful models of technological innovation, development, dissemination and uptake is that the key to success lies in the creation of these dense networks of researchers, financiers and entrepreneurs.

With regard to the role of government, several studies have found that excessive government direction can actually hinder technological and economic development by diverting the resources needed for research, development and innovation, into technological options that may then fail in the marketplace, and by increasing the financial and other risks of innovation in non-favoured areas. Politicians and civil servants typically have less detailed knowledge of the technological options than scientists, and less understanding of the market than entrepreneurs and industrialists.

This is not the whole picture, however, because other studies have found that regulation can also promote innovation by encouraging research and development, sometimes in new areas, and by creating new markets and new opportunities for making profits. Government should therefore seek to play an enabling role, with pro-innovation incentives and regulation. This includes innovation in both management practices and technological solutions. With regard to pro-innovation regulation, there are three possible strategies for moving new concepts into development, all of which have various strengths and weaknesses.

Technology forcing. This occurs where a firm is obliged, by regulatory or other external pressures, to invest in particular technologies or lines of research, which then helps to open up a range of new market opportunities. This can lead to innovation, but also to conflicts between industry and government.

Strategic niche managing. This is the approach of firms that target their research intelligently with the intention of first developing a good hold on some particular strategic market or technological niche and then of using this to gain a strong position in an emerging market as processes and industries are scaled up to meet expanding demand. This is, essentially, good management, but governments cannot create good managers by fiat.

Development of technological hubs. This occurs with the creation of new alliances across old technological, market, regulatory and other boundaries. If properly managed, this could combine the best elements of the two other strategies, allowing firms that would otherwise be competing to realize common interests and pool relevant aspects of their efforts in technological and market development.

This suggests that the task for government should be an intelligent management of the process of support for innovation, with judicious use of technology forcing measures when appropriate, but with a primary emphasis on the creation of new strategic alliances.

The way forward, therefore, is to construct a network of productive relationships in Jamaica, focused on RE issues and opportunities. Universities, as primary generators of knowledge and skill, are key nodes in knowledge networks, and many universities have now established science, technology or business parks in order to support the development of the related networks.

Research and education

The Energy Outlook 2010 report of the International Energy Agency estimates that an investment of US$36 billion per year will be required to ensure that every citizen in the world has access to electricity and clean cooking facilities by 2030. This is a relatively modest sum, which could be mobilized with sufficient political will. There are three areas where action is required: financial resources, public policies, and technological innovation. The weakness of poor countries in technological innovation underscores the need for Research, Development and Demonstration (RD&D), with particular regard to renewable energy, in order to assure the future progress of the Caribbean region.

Current investment in energy research worldwide is acknowledged to be inadequate for meeting global challenges, but the situation in the Caribbean is worse than in most other regions of the world. Investment in renewable energy projects is low, human capacity is limited, and the educational infrastructure is inadequate.

Science and engineering provide the core guiding principles for sustainable energy development. Science provides the basis for selecting particular technologies and for identifying research priorities. Engineering supplements this scientific knowledge by optimizing the most promising technologies and providing practical solutions. Policy and economic analysis is also necessary for understanding market constraints and signals that determine dissemination and uptake of particular technological solutions. It is important, therefore, to develop undergraduate and graduate programmes to develop a strong and comprehensive set of RD&D programmes related to renewable energy.

Current status of renewable energy education

Tertiary education is currently provided mainly by five universities, about 28 colleges including teachers' colleges and community colleges and 35 vocational training centres in Jamaica. The University of the West Indies is the only higher education institution with a formal curriculum for teaching sustainable energy; the Department of Physics offers a B.Sc. degree with a major in Alternative Energy. There are three relevant courses- solar power, wind and hydro power and integrating alternative energy- which are offered as optional core courses along with two other courses in Part II of the degree programme.

This programme is not, however, adequate since it does not include other important energy policy components. It would have been helpful, for example, if the course had been developed as an inter-departmental programme with the collaboration of the departments of chemistry, geology, computer science and economics.

Many graduate students therefore prefer to go abroad, to the United Kingdom in particular, to pursue postgraduate studies in renewable energy, as the necessary facilities do not currently exist in the Caribbean. The UK is particularly strong in this regard, with about 30 universities offering good quality, comprehensive undergraduate and graduate degree programmes in renewable energy. Some of these universities also offer scholarships, and some offer courses via distance learning.

It is therefore important for Jamaica to develop energy policy course options in the education system. This depends, however, on building the necessary research capacity because teaching at this level cannot be developed in the absence of a strong research base. There is already research activity at UWI with regard to solar and wind energy, but relatively little with regard to bio-fuels, hydrogen storage and the use of hydrogen in fuel cells for generating electricity. Energy efficiency is another key area but in Jamaica, this is more of a social, economic and cultural problem than a technical problem.

Conclusion

Jamaica's economic competitiveness is seriously undermined by the high cost of energy which results from a high level of dependency on imported oil and an old, inefficient power generating plant. Jamaica is also highly exposed to climate change, with much of the infrastructure co-located in areas that are likely to be vulnerable to storm surge. There is therefore a clear case for greater investment in raising energy efficiency and productivity. In spite of this, relatively little progress has been made to date. The main factors that have impeded progress include problems with governance, policy conflicts and misguided technology choices, the latter indicating weak educational linkages and technology transfer pathways. Jamaica therefore needs to build stronger linkages between the policy and research communities.

References

US Energy Information Administration, International Energy Outlook 2010

http://www.guardian.co.uk/environment/2012/nov/15/shale-energy-implications-geopolitics-america

http:/www.guardian.co.uk/environment/2012/nov/15/Gazprom-chill-shale-gas-revolution

D Farrell, S Nyquist and M Rogers. Curbing the Growth of Global Energy Demand. *The McKinsey Quarterly July 2007.*

7.

Skill Development in Greening Economy: The Indian Case

Dr. Kasturi Mandal and Lalita Devi
National Institute of Science Technology and Development Studies, India

kstr.mndl@gmail.com
lalita.negi02@gmail.com

Abstract

The green economy is a system that creates decent employment opportunities in green jobs, and produces green products and services with equitable distribution and sustainable consumption leading to regeneration of the environment. A skilled workforce is necessary if we are fully to realize the opportunities offered by the green economy and support green growth. This paper thus draws the attention of policymakers and social partners in both developed and developing countries to the role of skills development in facilitating the transition to a greener economy and the employment opportunities that the transition entails.

It takes the case of skill development in the solar energy sector in India and looks at how the country has attempted to make the transition to a green economy in the sector. The objective of the paper is to develop a thorough understanding of how an emerging economy like India is slowly making the transition to a green economy and, in the process, creating new employment opportunities.

The paper thus looks at how the country is addressing the human resource development requirements by creating new skill sets, the policies and programmes undertaken in this respect and their effectiveness, the skill gaps that still exist, and how they can be recovered. The purpose of this paper is to identify some of the potential challenges related to skill development and to highlight areas where policy changes can make a successful transition.

Keywords: **solar, green, jobs, skill, sector**

Introduction

The green economy is defined as one in which value and growth is maximized across the whole economy, while natural assets are managed sustainably.[1] Such an economy needs to be supported and enabled by a thriving and low-carbon environmental goods and services sector. The green economy is thereby a system that also creates decent employment opportunities in green jobs and produces green products and services with equitable distribution and sustainable consumption leading to regeneration of the environment.[2] A skilled workforce is necessary if we are fully to realize the opportunities in a green economy and to support green growth.[1] The green economy initiative is pro-growth, pro-jobs and pro-poor. It seeks enhanced economic growth, income opportunities and social inclusion.[3] A green economy is generally considered to be based on six main sectors: renewable energy (RE), green buildings, clean transportation, water management, waste management and land management.

Overview of the green economy

The green economy is, therefore, one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities, as it is based on business opportunities and jobs that help protect and restore the environment, often through reducing resource use or rehabilitating natural resources.[4] The terms "green economy" and "green jobs" are in vogue due to the observation that many renewable energy technologies seem to create more jobs per unit of installed capacity and per unit power generated compared to fossil fuel technologies.

In this context, the role of RE technologies in ensuring energy security and mitigating climate change has been established[5]. Renewable resources include solar energy, wind, falling water, the heat of the earth (geothermal), plant materials (biomass), waves, ocean currents, temperature differences in the oceans and the energy of the tides.

The main renewable energy technologies are wind, solar, geothermal, hydropower and bio energy. Just 12.9 per cent of the global energy supply comes from renewable sources, mostly from traditional combustion of biomass and from the relatively mature modern biomass sector, but more renewable capacity is being deployed rapidly. Almost half of the new electricity-generating capacity deployed globally in 2008 and 2009 was based on RE technologies[6]. Table 1 illustrates how the installed capacity in renewable energy is increasing over the years and also gives an idea of the leaders in the sector.

Thus, deployment of all renewable energy technologies is growing powerfully. Employment in renewable energy (RE) is not just located in the energy-producing sector. The renewable energy value chain encompasses manufacture and distribution of renewable energy equipment, renewable energy project development, construction and installation work associated with the development of renewable energy capacity, operation and maintenance of renewable energy facilities, and a range of cross-cutting activities that contribute to more than one of the other value chain stages[6].

Table 1: Renewable Energy Installed Capacity in Top 5 Countries

Country	Installed capacity in GW	
	2010	2012
China	62	90
United States	52	86
Germany	42	71
Spain	25	31
India	17	24

Source: REN21 Renewable Global Status Report 2010 & 2013

What are green jobs?

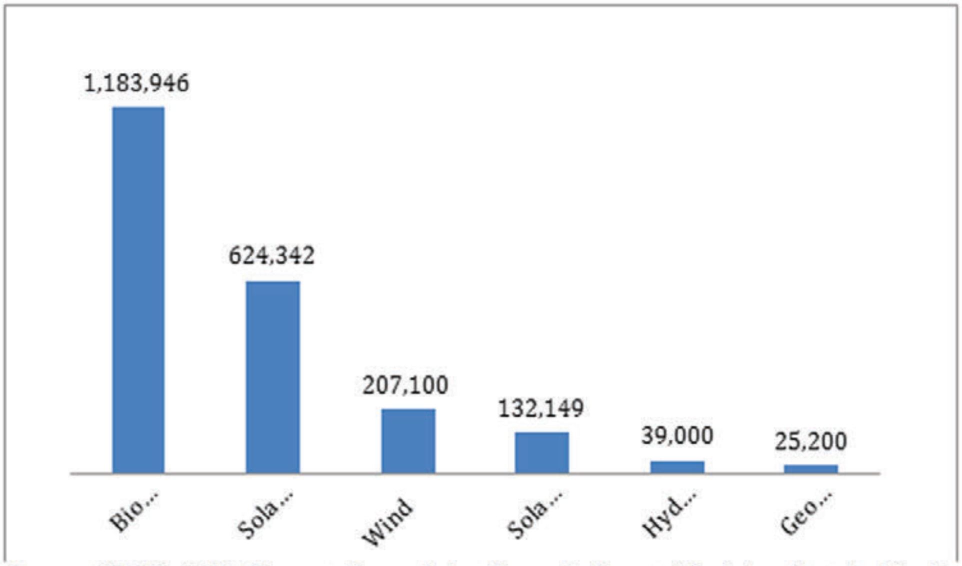
Human resource development is a driving force of economic growth and social development of any country. The economy becomes more productive and competitive through skilled human potential. The composition of employment and growth are the critical indicators of the process of development in an economy. During the last two decades, the process of globalization and technological change has provided growing opportunities for economic expansion and job creation. Therefore, critical factors are the optimum exploitation of emerging employment opportunities by minimizing social costs and dislocation of the level and quality of skills possessed by a nation.

In this context of emerging occupations and employment, green jobs are now often being discussed. "Green jobs" are jobs that reduce the environmental impact of enterprises and economic sectors, ultimately to levels that are sustainable. This definition covers work in agriculture, industry, services and administration that contributes to preserving or restoring the quality of the environment (*UNEP/ILO/IOE/ITUC, 2008*)[7]. Studies across countries have been undertaken and reports published to estimate the quantum of skill development that is required for greening the economy (*Rajvanshi 1995; Heavner and Chiaro 2003; Kammen et 2004; Kalkar 2009; ILO Report 2010; Deshmukh, Sant and Gambhir 2010 and 2011; Lewis, Justice and Biggs 2011; Sharma 2012; Jain and Patwardhan 2013*). The studies have identified various kinds of jobs for different renewable energy sectors and categorized them under direct or indirect, or manufacturing, construction, fuel processing, etc.

1.4 The Employment Opportunities of a Green Economy: Renewable Energy

Employment in the RE sector has grown rapidly since 2009 with than 3 million people worldwide estimated to be working directly in the sector, with additional indirect jobs well beyond this. Figure 1 and Table 2 indicate the estimated employment in the RE industry, by country and by technology. China accounts for the largest number, with more than 1.12 million workers estimated in the renewable energy industry in 2008, with a growth rate of around 100,000 jobs per year[8]. Given the phenomenal growth of RE worldwide, jobs in the sector have rapidly increased over recent years and the sector will witness even higher growth in the future. It is estimated that biomass, solar PV and wind alone will employ 20 million people by the year 2030, which is a 10-fold increase as compared to employment levels in 2006 (Figure 2). The share of employment in biomass would be the largest (59 per cent), followed by solar photovoltaic (31 per cent) and wind (10 per cent)[9]. Table 3 shows that in terms of average employment over life of facility, solar energy leads the way.

Fig. 1 Employment in the Renewable Energy by technology, 2006



Source: UNEP, 2008, (Report: Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World)

Table 2 Employment in the Renewable Energy in selected countries

China	943,200
Brazil	500000
USA	406,600
Germany	230,000
Spain	80,940
Denmark	21,000
Europe	20,000
India	10,000

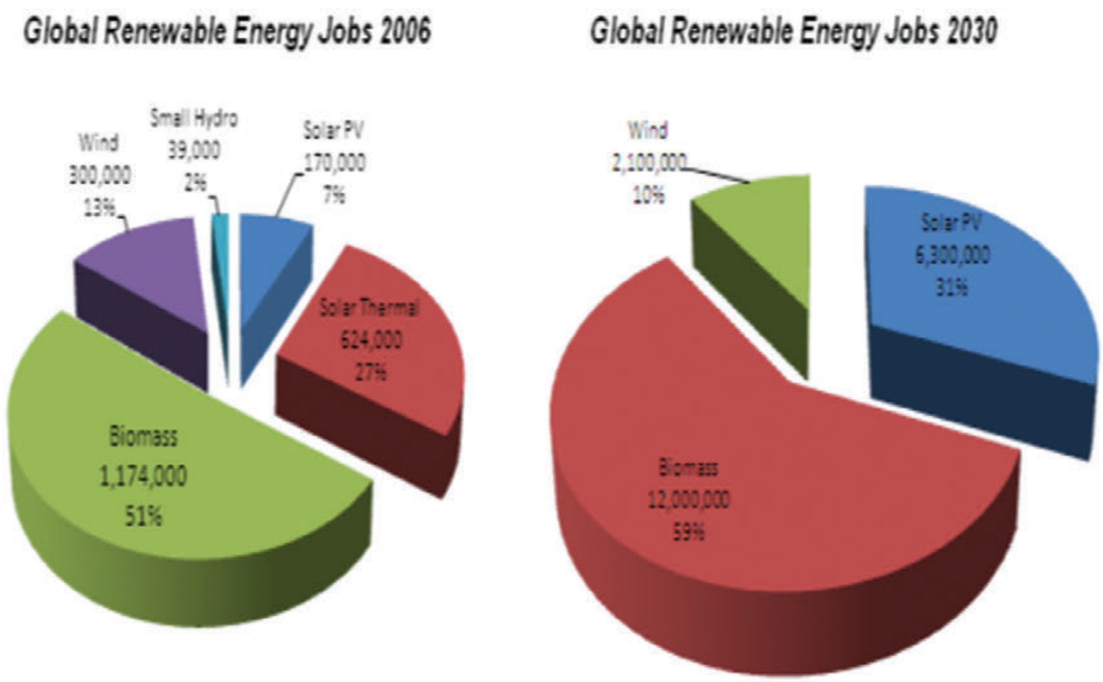
Source: UNEP 2008 (Report: Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World)

Table 3 Employment in Renewable Energy by Jobs, 2006

	Manufacturing, construction, Installation	Operating & maintenance/ fuel processing	Total
Solar Photovoltaic	5.76-6.21	1.20-4.80	6.96-11.01
Wind Power	0.43-2.51	0.27	0.70-2.78
Biomass	0.40	0.38-2.44	0.78-2.84
Coal Fired	0.27	0.74	1.01
Natural Gas Fired	0.25	0.70	0.95

Source: UNEP 2008 (Report: Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World)

Fig.2 Global Renewable Energy Jobs 2006-2030



Source: UNEP, 2008, (Report: Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World)

Why is skill development important to greening the economy?

The widespread adoption of more eco-friendly approaches to economic production and consumption is changing the nature of work, and thus the skills required of many workers. The development of skills for green jobs is crucial for ensuring an efficient transition to a green economy by matching the supply and demand for skills. Promoting skills for green jobs fosters investment in green activities and accelerates the green transformation. A number of factors are driving the transition to greener jobs.

This paper thus draws the attention of policymakers and social partners in both developed and developing countries to the role of skills development in facilitating the transition to a greener economy and the employment opportunities that the transition entails. India is emerging both as an economic powerhouse and a global environmental leader. As India's economy charges ahead, the country needs to produce more energy to provide a better life for its people, many of whom live in rural areas and are very poor. At the same time, India has recognized that tackling climate change is in its own national interest.

The nation is taking concrete measures to constrain its own emissions and to protect its people from climatic disruptions. In 2008, Prime Minister Manmohan Singh released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programmes addressing climate mitigation and adaptation. The plan identifies eight core "national missions" running through 2017 and directs ministries to submit detailed implementation plans to the Prime Minister's Council on Climate Change by December 2008. One of the mission was the National Solar Mission, which aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil-based energy options.

The plan included specific goals for increasing use of solar thermal technologies in urban areas, industry, and commercial establishments; increasing production of photovoltaics to 1000 MW/year; and deploying at least 1000 MW of solar thermal power generation. Other objectives include the establishment of a solar research centre; increased international collaboration on technology development; strengthening of domestic manufacturing capacity; and increased government funding and international support. In order to achieve such goals, India realized that suitably skilled manpower was one of the prerequisites[10].

This paper thus takes the case of skill development in the solar energy sector in India and looks at how the country has attempted to implement the transition to a green economy in the sector. The objective of the paper is to develop a thorough understanding of how an emerging economy like India is slowly undergoing a transition to a green economy and, in the process, creating new employment opportunities.

While generating green jobs, what are the new skill sets that are required? The paper looks at how the country is addressing the human resource development (HRD) requirements for meeting the new skill sets; the policies and programmes undertaken in this aspect and their effectiveness; and the skill gaps that still exist and how they can be recovered.

The purpose of this paper is to identify some of the potential challenges related to skill development and to highlight areas where labour market and social policies can support workers to make a successful transition.

Methodology

The paper is based on a review of the policies and programmes related to solar energy development in India since its initiation, more specifically investigating how the country had planned to meet its manpower requirement in the newly emerging sector. It is a qualitative analysis of how the policies and programmes have changed from time to time as per changing needs of the sector. The paper also looks into the skill development *per se* that had taken place in due course in the form of new courses and new institutions coming up, and then traces the changes that are taking place relating to skills in the context of greening the economy, e.g. the green structural change, the emergence of new occupations etc.

Renewable Energy In India

India is blessed with an abundance of sunlight, water and biomass. Currently, about 8 per cent of the power generation in India comes from the renewable sector. India has the world's largest programmes for renewable energy. The Government of India created the Department of Non-conventional Energy Sources (DNES) in 1976 to develop renewable energy.

Table 4 Grid-Interactive renewable power installed capacity

Renewable Energy Source	Installed Capacity (MW)	India's position in World
Wind	12,010	Fifth
Small Hydro (up to 25 MW)	2,767	Tenth

Source: Ministry of New and Renewable Energy - Human Resource Strategies for Indian Renewable Energy Sector Report, 2010

In 1992, a fully fledged Ministry of Non-conventional Renewable Energy (MNRE) was established and solar energy became the responsibility of the central government at the centre and of power ministries at state level. Thus, India had started its transition to a green economy way ahead. India now ranks as a "wind superpower" with an installed wind power capacity of 1167 MW. Altogether 13 states of India have a net potential of about 45000 MW.1 Table 4 indicates India's prominence as a global player in the sector with regard to its position in the world RE scenario.

In solar energy, solar water heaters have proved the most popular so far, and solar photovoltaics for decentralized power supply are fast becoming popular in rural and remote areas. More than 700,000 PV systems generating 44 MW have been installed all over India. Under the water pumping programme, more than 3,000 systems have been installed so far, and the market for solar lighting and solar pumping is far from saturated. Solar drying is also one area which offers very good prospects in food, agricultural and chemical products drying applications.[11]

Development of Solar Energy in India

India is one of the sun's most favoured nations, blessed with about 5,000 trillion watt hour (TWh) of solar insolation every year.[12] Even if a tenth of this potential is utilized, it could mark the end of India's power problems by using the country's deserts and farmland to construct solar plants. Solar energy also has the potential to re-energize India's economy by creating millions of new jobs, allowing the country to achieve energy independence, reduce its trade deficits and propel it forward as a Green Nation.

Recognizing the importance, the Jawaharlal Nehru National Solar Mission (JNNSM) was launched on the 11th January, 2010 by the Prime Minister, which was one of the goals of the National Action Plan on Climate Change (NAPCC) 2008. The Mission has set the ambitious target of deploying 20,000 MW of grid connected solar power by 2022 and aims to reduce the cost of solar power generation in the country. It is to be noted that under the JNNSM, grid-connected solar PV capacity has increased by 165 per cent in 2011 to reach 427 MW[13]. Table 5 gives an idea of the work in progress.

Table: 5 Capacity Addition and Installed Capacity in SOLAR energy by the end of 2017 and 2022

Target Fixed and Achievements made under JNNSM					
Application Segment	Target for Phase-I* 2010-13	Achievement 2010-11	Achievement 2011-12	Cumulative Target for Phase-II 2013-17	Cumulative Target for Phase-III 2017-22
Grid Solar Power incl. Roof top and Distributed Small Grid Connected Plants	1100 MW	802 MW Allotted	1152 MW Capacity allotted	4000 MW- 10000 MW	20000 MW
Off-Grid Solar Applications	200 MW	40.6 MW Sanctioned	118.071MW Sanctioned	1000 MW	2000 MW
Solar Collectors	7 million Sq. Meters	4.5 million Sq. Meters	5.5 million Sq. Meters	15 million Sq. Meters	20 million Sq. Meters

Source: Ministry of New and Renewable Energy- Jawaharlal Nehru National Solar Mission Phase 11-Policy Document Report, 2012 and http://idsa.in/idsacomments/SolarEnergyinIndia_emukherjee_100213

Structure of skill development in the solar sector

As discussed earlier, the solar energy sector not only sustains India's positive economic growth and combats climate change but also introduces the scope for creating millions of green jobs. As per official statistics, in order to fulfill the installed capacity targets under the JNNSM, the Indian solar energy industry will need an estimated 100,000 people by 2022 across all domains, profiles and levels. Table 7 brings out a comparison between moderate growth and best growth scenarios for the period 2015 and 2020, which exemplify the kind of employment that the sector promises. In this context, it is noteworthy that employment is not just located in the energy-producing sector.

The solar energy value chain encompasses manufacture and distribution of equipment, project development, construction and installation work, R&D associated with the development of solar energy capacity, operation and maintenance of the facilities, marketing of products and a range of cross-cutting activities that contribute to more than one of the other value chain stages. Table 6 gives an indicative list of occupations in selected solar energy sub-sectors by value chain. The manpower requirements for the solar energy sector can be classified based on the nature of jobs that they would perform.

Each of the functional areas would require different skills. For example the installation of solar PV systems may need technicians who have undergone a few weeks of training on solar PV. The different kinds of institutions that can effectively help in skill development at various levels are classified in Figure 4. Figure 5 illustrates the type of institutions that would require skilled personal and thus greener job creation could take place.[14]

Fig. 4: Classification of Training Levels for skills development

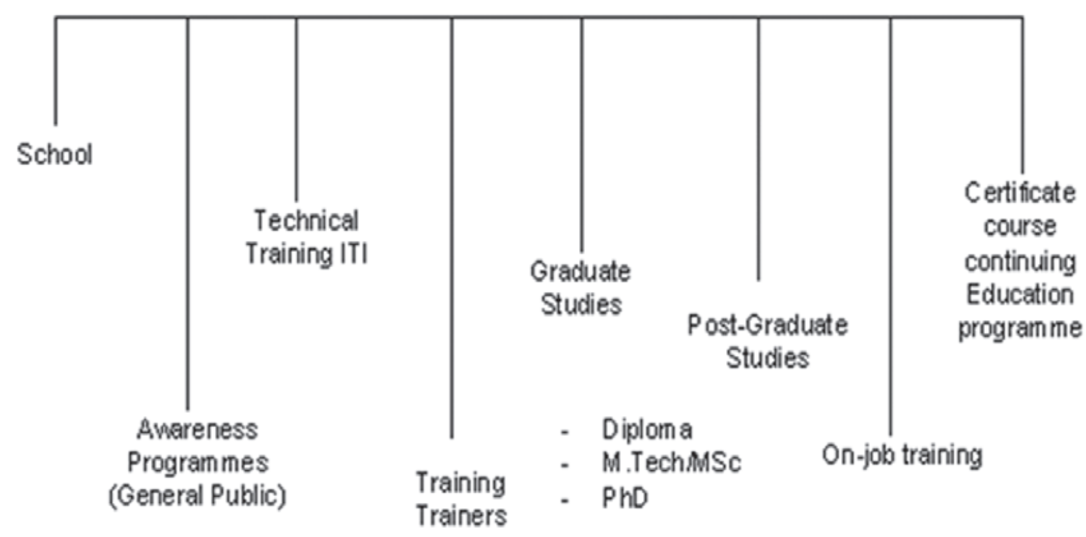


Fig 5 Institutions involved with renewable energy

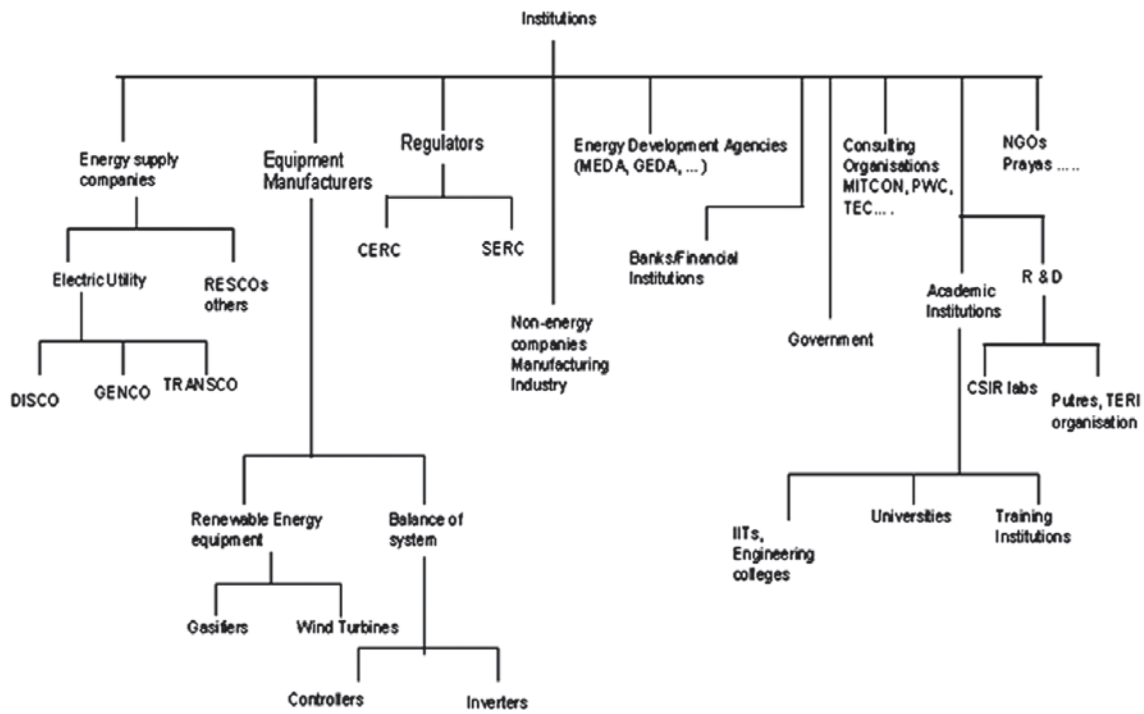


Table 6. Occupations in selected solar energy sub-sectors by value chain
(H = High skill level,M = Medium skill level)

Project Development (Solar Energy)	Project Designers (Engineers) (H)	Land Development Advisor (H)
	Architects (H) (small projects)	Land Use Negotiator (H)
	Atmospheric Scientists and Meteorologists (H)	Lobbyist (H)
	Resource Assessment Specialists and site Evaluators (H)	Mediator (H)
	Environmental Consultant (H)	Environmental and Social NGO Representatives (H,M)
	Lawyers (H)	Public Relations Officer (H)
	Debt Financier Representatives (H)	Procurement Professionals (H,M)
	Developers/Facilitators (H,M)	Resource Assessment Specialists (H)

Source: ILO, 2011 Report, (Skills and Occupational Needs in Renewable Energy)

Table 7: Estimated Current and Future Employment in the solar sector in India

Sector	Estimated Current Employment	Projected Growth %	Estimated Projected Employment (in No.)	
			2015	2020
Solar Pv On-Grid	40,000	50	39,000*	152,000**
Solar PV Off-Grid	72,000	50	140,000*	225,000**
Solar Thermal	41,000	17	123,000*	270,000**

Source: Ministry of New and Renewable Energy Report- Human Resource Development Strategies for Indian Renewable Energy Sector, 2010

Government Initiatives for skill development in solar energy

A systematic manpower development effort in the ministry was started way back in 1999-2000 for project planning, system design, product development, operation, maintenance and repair of deployed systems for the first time, by way of introducing a scheme for renewable energy training and study tours, with provision for organizing short duration training programmes of one to two weeks within and outside the country. Later on, the scheme was revised with enhanced provisions of development of training modules.

The ministry simultaneously empanelled educational and other entities to undertake short-term training courses on a regular basis. While some of these short-term training courses were supported by the ministry as per the provisions of the scheme, institutions were encouraged to undertake self-financing courses on various aspects of solar energy. Skill development initiatives on solar energy gained momentum after the launch of JNNSM. Since then, MNRE has introduced solar courses in a number of institutes, including 100 institutes at graduate level, 100 institutes at diploma level and 1,000 institutes at Industrial Training Institute (ITI) level. Among the courses introduced were: Solar Thermal Systems (One Year Diploma Course for Graduate Engineers); Solar Photovoltaic Systems (One Year Diploma for Engineers); and a post graduate (PG) programme for engineering leading to M. Tech in renewable energy systems with specialization in solar energy.

The Renewable Energy Chair, which has significant focus on solar energy, is being established to act as a focal point for renewable energy education in at least one educational institution every year by providing one-time grant. Such Chairs will be instituted in 15 educational institutions of the country. Educational institutions which have been active in the field of renewable energy education can be considered for an RE Chair. While 12 Chairs will be dedicated to science and technology aspects, three Chairs will be dedicated to the legal, environmental, management and economic aspects of RE in institutions of repute such as the National Law Institutes, India Institute of Management, Institute of Economic Growth, Delhi University, etc. To facilitate sustainability of this concept, a one-time grant of Rs. 1.5 Crore is being provided to the selected institutions, which may be kept in fixed deposits with salaries and research being provided, if desired, through the interest on this fixed deposit.

In order to address the curriculum needs of technical institutions to cover renewable energy, the government also urged the need to develop model curricula for inclusion in the ITIs, diploma and degree course. The curricula and course material so developed will be circulated to all such institutions through State Technical Education Boards and the All India Council for Technical Education (AICTE). In addition, the ministry has taken up the issue of incorporating Solar Lighting and Solar Thermal in the regular syllabus of ITI students in training to be electricians, fitters, turners, welders, and plumbers, etc.[15]

Table 8 List of Institutions

Institutions	Universities
Indian Institute of Science, Bangalore	School of Energy, Jawaharlal Nehru Technology University, Hyderabad
Tata Institute of Fundamental Research, Mumbai	Centre of Energy Studies and Research, Devi Ahilya University, Indore
Indian Association for Cultivation of Science, Kalkata	TERI University, Delhi
Solar Energy Centre, Gwalpahari, Gurgaon	School of Energy Studies, Jadhavpur University
National Physical Laboratory, New Delhi	School of Energy Studies, Anna University, Chennai
Indian Institute of Technology, Delhi	Department of Energy, Tezpur University
National Institute of Technology, Bombay	Department of Physics, Lucknow University
National Institute of Technology, Madras	University of Petroleum 7 Engineering, Dehradun
National Institute of Technology, Kanpur	Energy Research Centre, Punjab University
National Institute of Technology, Kharagpur	CR University of Science & Technology
National Institute of Technology, Roorkee	Guru Govind Singh Indraprastha University, Delhi
National Institute of Technology, Jodhpur	H.N. Bahuguna University, Srinagar, Uttarakhand
National Institute of Technology, Bhopal	Mata Vaishno Devi University, Katra, Jammu
National Institute of Technology, Jaipur2	Birla Institute of Technology and Science, Pilani
National Institute of Technology, Hamirpur	

Source:http://mnre.gov.in/file-manager/support-programme-scheme/national-solar-science-fellowship-programme.pdf

The course material was prepared and passed on to the Directorate General of Employment and Training (DGET) and has been incorporated in the syllabus of trades of ITIs so that about 16-60 hours are devoted to Renewable Energy skill development during the regular two-year ITI course. DGET is also planning to start special programmes of skill development under their Craftsman Training Programme (CTS) and Modular Employment Skill Development Programme (MES), in which special training is provided for 60-960 hours.

This type of training is beneficial especially for the educated unemployed youth. Since most of the current skill development programmes are long-term in nature, poor and less educated persons cannot afford long-term training programmes due to higher entry qualifications, opportunity cost, etc. Therefore, the DGET has developed MES, in consultation with industry, as a new framework for skill development to address the employability issues, with an emphasis on demand-driven, short-term training courses based on modular employable skills.

There is a flexible delivery mechanism (part-time, weekends, full-time), different levels of programmes (from foundation up) to meet the demands of various target groups, optimum utilization of existing infrastructure to make training cost-effective, testing of trainees' skills by an Independent Assessing Body (IAB) which is not involved in conducting training programmes in order to ensure that it is done impartially, and testing and certification of prior learning (skills of persons acquired informally). Under MES, courses have already begun on Solar Heater and Solar Cooker System, Solar Lighting System and Solar Electric System Installer and Service Provider for high school children.

In addition, the government has developed an institutional framework in universities/technical institutions to attract students and professionals in the field of solar energy. This is all part of the plan to meet the manpower requirements for addressing the long-term HRD needs of the solar energy sector. To encourage talented science students to take solar energy as a subject at post-graduate level followed by active research in renewable energy area (both basic as well as applied R&D), the ministry has introduced scholarship schemes. The coverage of renewable energy fellowship scheme was enhanced recently by covering more universities/ institutions and also R&D institutions to conduct training and research on all aspects of renewable energy. The fellowship was increased from 50 to 400 students/researchers and was categorized as shown in Table 9.

Table 9 Provision of Fellowships as instituted by MNRE

Course	Duration	Intake every year	Fellowship 1st Year	2nd Year	3rd Year (stabilized no. for subsequent year)
M.Tech	2 Year	200	200	400	400
M.Sc	2 Year	100	100	200	200
JRF	2 Year	40	40	80	280*
SRF	3 Year	40	40	80	120
RA/PDF	3 Year	20	20	40	60
TOTAL		400	400	800	1060

Source: http://www.cseindia.org/userfiles/Human%20resource%20development%20in%20solar%20energy.pdf

Educational institutions will be given one-time financial assistance to upgrade existing laboratory and library facilities for undertaking renewable energy educational programmes to the value of Rs. 50,00,000/- (Rupees Fifty Lakhs only) per institution. A maximum of five institutions will be provided such grants every year based on a selection process that is conducted either through open advertisements or the selection of five accredited institutions for M.Tech/Integrated M.Sc. fellowships. In addition, Advanced Training Institutes of the Ministry of Labour will be awarded grants for upgrading their training facilities for trainers in renewable energy.

Research, Design and Development: MNRE has identified some of the thrust areas in solar technology under solar photovoltaic and solar thermal technologies. Most of these technologies call for efficiency improvements and material used for design of system. In case of photovoltaic technology, the emphasis is on developing new and efficient materials for manufacturing cells, module efficiency and system design. Thermal technology is identified for improvements in the design of solar collector/concentrator, sterling engine efficiency, obtaining higher temperatures, waste heat recycling etc. MNRE has proposed collaborations with various institutions like universities, research institutions, R&D laboratories, industry, individual or consortia for conducting RD&D projects. The ministry has also set up Centres of Excellence for providing quality education in R&D thrust areas in solar as well as other renewable technologies. Some of the current projects initiated by MNRE in collaboration with other institutions are: Tools for Architectural design and simulation (TADISM) with IIT Bombay; Energy Plantation for production of biomass with National Botanical Research Institute (NBRI) Lucknow; Design, Development and Testing of low temperature Solar Desalination System with The Energy and Resources Institute (TERI); Performance monitoring of SEC greenhouse with TERI; and Solar, Optical and Thermal modeling of energy flow at different nodal points of a 50kW power plant with IIT Delhi[16].

Another opportunity for sparking investment in solar is the United States-India Energy partnership programme called SERIIUS (the Solar Energy Research Institute for India and the United States). This collaboration could lay the foundation for an energy independent future – one in which the Indian government takes advantage of the vast amounts of energy available from the Rajasthan Desert sun (instead of oil from the Arab nations) to power its future energy needs[17].

International co-operation

India has the potential to emerge as a key global player in solar energy. This can be achieved by positioning India's expertise/knowledge and making it available for the developing world. MNRE had initiated a series of international programmes on solar energy. The training primarily focuses on resource assessment, technology development, economics of solar energy, test standards, test procedures, passive architecture, hands-on exposure on various solar energy devices such as SPV lighting, power plant, solar thermal systems and hybrid systems. IIT Bombay's experience with running a two-week course on solar energy for energy professionals indicated an excellent response and the potential benefit of cross-country experiences.

Private sector participation

SEMI India in association with IIT Bombay has launched solar PV technical training programmes from August 2011. It is also planning to launch training courses on grid-connected solar power plants and systems. Solar Energy International conducts training programmes that are designed to explore different applications of renewable energy technologies in developing countries. Participants learn how to successfully accomplish sustainable development projects with renewable energy. Effective technology transfer methods are presented, as well as the establishment of infrastructure and the economics and financing of renewable energy projects. Case studies are presented on solar cooking, rural household electrification, appropriate building technologies, rural health care and micro-enterprises utilizing renewable energy.

Barefoot College of Rajasthan is taking initiatives to train villagers and rural people to develop decentralized solar power systems. Its strategy is to develop a Village Environment Energy

Committee. Its qualified professionals are called Barefoot Solar Engineers. They also conduct Rural Electronic Workshops. The villagers are also paid stipends and BSEs are given an opportunity to earn their livelihood.

Spear Technology Alliance is providing Plant Design Training using CAD/CAE to help power plant developers and EPC contractors. The course contains training in orthographic drawing, isometric drawing, pipe modeling, logistics support, equipment sizing, modeling, project engineering etc. solar technology training module includes cell manufacturing technology, solar radiation statistics, module efficiency, energy principles, PV charge controllers, energy storage, wiring systems and design of stand-alone systems.

Arbutus consultants along with MNRE and Karnataka Power Corporation Limited have come up with the National Centre for Solar Technology Training. Since September 2011, the training has been conducted every month[16].

Discussion

Thus, from all these initiatives we find that India aims to take full advantage of the golden opportunity as the country is blessed with 300 sunny days a year in most regions and which is of particular relevance in remote and rural areas where there are still around 289 million people who do not have access to reliable sources of energy[18].

Solar energy can be the most cost-effective future option for India to reduce energy poverty without having to extend national grid services to provide power for individual homes and buildings. With nations around the world vying for clean energy leadership, India has taken a bold step toward becoming a leader in solar development. In only two years under India's ambitious national solar policies, prices for solar energy in India have dropped dramatically, approaching the price of traditional energy from fossil fuels. While the Indian government has a long way to go to reach its goals of 20 giga watts of solar energy by 2022, India's experience is a strong example of how national and state policies can unleash the potential of clean energy.[18] India's solar energy market is picking up. From 17.8 megawatts (MW) in early 2010, cumulative installed capacity reached 506.9 MW at the end of March 2012. The Jawaharlal Nehru National Solar Mission has catalyzed much of this growth. But India still has miles to go in this sector as creating a new solar energy market in India is no easy task[19].

The Ministry of New and Renewable Energy (MNRE) has estimated that in order to achieve the target of 20 GW by 2022, over 1, 00,000 skilled solar professionals will be required, comprising multiple skill sets. But considering upcoming state policies and private sector investment, it is estimated that around 200,000 such professionals will be needed. This underscores the need for solar technology education across all academic levels.

Despite several efforts at skill development in the solar energy sector at the Government level, certain gaps can be observed. They exist at different levels (Table 10).
There exists a qualitative as well as quantitative mismatch between education and employment. The database of the All India Council for Technical Education (AICTE) shows that there

are currently approximately 1,346 engineering colleges in the country. Of these, only 52 engineering colleges offer courses on energy management at the postgraduate level, in which renewable energy is one of the major electives. It is estimated that every year more than 40,000 students pursue postgraduate studies in courses in various streams. The estimated number of openings that are available in energy management courses is only 910, which amounts to 2.25 per cent of the available postgraduate cadre.

Furthermore, only 60 per cent-80 per cent of the postgraduate openings offered in energy management get filled out of the 910 admissions; within these more than 60 per cent choose the IT sector as their career path with the majority of the rest being employed by industries/ consultancy firms involved in Energy Management[9]. Very few students opt for renewable energy jobs. This shows that the actual number of students opting for renewable energy jobs is much less when compared to the needs of the sector. This is because the salary packages at entry level are not so attractive. Moreover, off-take of students into the RE industry through campus selections is minimal. (E.g. in 2010, only two RE companies conducted campus recruitment). Thus, there is a perception that career prospects in the RE sector are not so attractive when compared to conventional manufacturing industries and the IT sector. This is because awareness regarding the future growth potential of solar is low amongst the students. To understand the key reasons for such low in-take of students in the sector, the Confederation of Indian Industry (CII) interacted with major solar industries. The industry feedback was that the courses and curricula offered by universities do not meet the specific skill requirements of the sector. The curriculum lacks adequate focus on technology and design aspects. Also the institutions do not provide extensive training and exposure on trends and technologies.

Some institutions absorb non-engineering graduates for postgraduate courses who do not have sufficient engineering knowledge to meet the design and process requirements of the industry. Hence, the industry finds it difficult to employ them. But the industry feels there is a shortage of semi-skilled candidates with exposure to the solar sector, e.g solar electricians, fitters, mechanics etc. Here, non-formal institutions are mushrooming. The manpower in this category already knows the experience of servicing and maintenance in the traditional field of energy supply. So generic knowledge remains the same; what they learn from their peers are the specialties of solar energy systems. It is based on the "learning by doing" process since most of it is soft knowledge based on interpersonal interactions.

In the non-formal mode, however, they often suffer from proper quality assurances in training. This indicates a need for expanding vocational training institutes specific to the sector. Often, admission to such institutes requires completion of a minimum number of formal schooling years. Since most of the persons in the above-mentioned categories do not possess this, aptitude-based training courses may be preferable.

Some institutions in the energy sector may need to train employees for dealing with solar energy systems. For example, a state electricity board may need to train its engineers to deal with grid-connected solar PV. Existing energy companies (e.g. traditional manufacturing industry) may need exposure to solar energy systems such that they could exploit the potential.

Table 10 Function-wise Skill Gaps in Solar PV & Solar Thermal systems

Solar (PV & Thermal)		
Solar	R&D	❖ Knowledge and exposure in advanced areas like wafer technology, semi conductor technology. ❖ Design skills in installing BIPV in buildings
	Project Development &Consultancy	❖ Lack of awareness & experience in handling concentrated solar collectors (CSP).
	Manufacturing	❖ Low skills in module assembly ❖ System integration in solar PV
	Construction & Installation	❖ Installation and commissioning of solar thermal systems (SWH). ❖ Third-party installers are not skilled in erection ❖ Grid integration of mega watt scale solar PV power projects
	Operation & Maintenance	❖ Shortage of skills in trouble shooting of circuitry of solar PV lanterns and home lighting systems
	Marketing	❖ After sales service, customer care ❖ Techno-commercial analysis of mega projects in on-grid solar PV

Source: Ministry of New and Renewable Energy Report- Human Resource Development Strategies for Indian Renewable Energy Sector, 2010

The skills required for the development and deployment of solar energy need interdisciplinary approaches, innovative financing and marketing. While MNRE has been restricted to off-grid deployments, it has developed an internal complexity. Precociously early (1982), a set of solar energy centres were given the mandate under the MNRE to develop technology and to act as a link between state, market and "user organizations". Over the course of time, this network has settled into a role of evaluating and establishing standards for new technologies. The National PV Solar Energy Programme initiated in 1980, has a set of highly decentralized "nodal" agencies in each state mandated with hybrid roles of participation and regulation and to effectively protect an infant industry at district level. In controlling local tenders, they are vulnerable to capture by distributors with local monopolies so that the subsidy controlled by these agencies is not necessarily optimized[9].

Recently the Indian Renewable Energy Development Agency (IREDA), which had been established in 1987 but languished, received a financial boost with Rs 17,000 crore under the 11th Five-Year Plan to finance renewable energy technology. Seventy per cent is destined for wind, while the remainder will nurture hydro, solar and biomass technologies. However, loans for technologies where costs are front-loaded (capital costs being up to 90 per cent of total costs), have been actively dis-incentivised by regulation: interest rates exceed those of commercial sources (because the agency is forced to borrow from them) and a 25 per cent deposit is needed to trigger loans. More recently, a special national incentive package scheme has been initiated for semi-conductors and thermal and PV cells but is suffering from similar flaws. Rural banks are reluctant to loan to support solar technology. Investment is not coming from the fossil fuel sector. Under the Integrated Energy Policy of 2006, the Department of Science and Technology created technology incubators with a call for venture capital to invest specifically in renewable energy, energy efficiency and rural energy, but little is forthcoming.

From 1995, a network of 268 "Aditya" solar energy shops have been created in upcountry towns to sell lamps and lanterns, etc., the licences for which have become a source of patronage and modest but widespread rent-seeking by individual retailers, non-governmental organisations (NGOS) and even manufacturers' associations. From 2002, private agents were given authority to disburse state subsidies for, small-scale solar installations (solar water-heating, etc.). So while knowledge of, and demand for these technologies are still limited, the market for off-grid solar technology is now institutionally very rich[18]. Therefore, it is high time that banks and financial institutions acquire an understanding of solar systems with an idea of the different benefits, risks and cash flows associated with them.

Conclusion

Economic growth in India is increasingly supported by robust industrial growth. The Renewable Energy sector is one of the relatively lesser known but significant sectors that support almost all industrial activity. However, notwithstanding its importance and size (INR 4 trillion), it has traditionally not been accorded the attention it deserves as a separate sector in itself. The level of inefficiency in solar energy sector activities in the country has been very high across all modes. The required pace of efficiency and quality improvement will demand rapid development of capabilities of service providers and with the sector being service-oriented, skill development will emerge as a key capability. Moreover, renewable energy development will also help India to reduce its carbon emissions, which is now crucial in the face of climate change as the country aims to decrease its emissions from 1.7 million tons in 2009 to 426 million tons in 2050[20].

Recommendations

As of now, skills development activities for greening the economy exist in India but are not embedded in an overall policy framework. The policies promoting solar in India indicate national adaptation needs and priorities, but fall short of providing concrete procedures and strategies for meeting adaptation needs and mitigation goals. There is a long to-do list for building a robust system for skill development in the sector.

Internationally shared standards; better linkages between formal education, vocational training and stakeholders or industry; uniform educational curricula and skills classification; increased public private investments to finance continual dialogue between stakeholders on skills (type of skills needed); increased private sector programmes of skill development; embedded green employment generation as a major component in all missions and programmes related to greening or otherwise; skill development through on-the-job training with a certification system across several levels for green employees in informal sector are all prerequisites. Financing will be one of the crucial factors in the coming years. The requirement is thus for designing a better mechanism of financing—a Government-Fund devolution mechanism, involving private sector investment by providing fiscal incentives and tax relief, etc.

There is also a need for emphasising skill development in the unorganised sector since more than 23 per cent of the male and 40 per cent of the female population in the unorganised sector are below primary level. The combined figure for numbers below the secondary level, is even more alarming since more than 83.5 per cent of the workers fall into this category. This situation is extremely disturbing as the vocational skill development programmes start after the secondary level suggesting the need for more courses under DGET's MES scheme. There is also the immediate need to restructure the syllabi and curricular of ITIs and polytechnics to meet the requirements of the green economy, since there is currently hardly any course or programme on the subject. Consideration should also be given to identifying emerging training requirements pertaining to occupations in the sector and to improving the effectiveness, efficiency and relevance of training.

Institutions should be strengthened while a few centres of excellence equipped with state-of-the-art research/testing facilities should be established in the field of solar energy. The establishment of new units/department/faculties at higher technical institutions should, preferably, be made compulsory. Setting up of a public sector/joint solar-energy corporation along the lines of the National Thermal Power Corporation/ Nuclear Power Corporation would help in promoting solar energy in the country.

In several sectors of the economy, people have developed informal on-site training initiatives in the absence of formal training programmes. These people now have the knowledge and experience of newly adapted green technologies, which can be very useful to the nation. Formal training programmes with a mechanism for accommodating these personnel should be established. For this, web-based modules can be prepared. A team with industry-academic-government input should identify the requirements for certificate/diploma modules and use the existing institutions of IITs, TERI, NITs as content providers.

There is need for establishing a consortium of renewable energy interests including industry, research and academic institutions and the government to define the research and development needs of the sector and to build targeted R&D programmes. The solar energy sector has to attract the brightest minds. In order to be cost competitive, several breakthroughs are required. This would require the pooling of intellectual (research) resources from the conventional science and engineering disciplines.

In order to attract such researchers, it is essential that the energy industry play a pro-active role in defining R&D directions. R&D expenditure by Indian companies on renewable energy is marginal. The government's spend on renewable energy is also low (Ministry of Non-conventional Energy Source (MNES) spent about Rs. 12.3 crores on R&D in 2000-2001) as compared to other countries ($2.47 billion by Japan (1997), $3.7 billion by USA (1999)). Indian technology development and R&D efforts are often sub-critical[13].

The conclusion, therefore, is that although India had taken the forward step towards skill development in solar energy, the country's effective transition from a fossil fuel-driven energy system to the future solar-based energy system requires that India focus more on building capacity for manpower training, strengthening institutions and building infrastructure. A road map for the next 20 years should be prepared detailing the steps required for implementing the recommendations suggested in this paper. This needs to be discussed and agreed upon by industry, academia and government.

References

1. http://www.greeneconomyindia.com/why_green_economy.htm

2. http://greeneconomycoalition.org/sites/gecnew.iiedlist.org/files/GEC_India 0_1.pdf

3. http://fs-unep-centre.org/sites/default/files/publications/2012-07-26geeneconomypresentationshuford.pdf

4. http://www.baltimoresustainability.org/economy#sthash.JuQQZNrj.dpuf

5 Jain Manish and Patwardhan Anand (2013), "Employment outcomes of Renewable Energy Technologies Implications of Policies in India", *Economics and Political Weekly*, Vol. XLVII, No. 7, Mumbai, Feb. 16, pp. 84-88.

6. International Labour Office, "Skill and Occupational need in Renewable Energy", European Union, Geneva, 2011, p. xix.

7. http://www.ilo.org/wcmsp5/groups/public/@ed_emp/@ifp_skills/documents/publication/wcms_164630.pdf

8. International Labour Office, "Skill and Occupational need in Renewable Energy", European Union, Geneva, 2011, p. 6.

9. India Govt of Human Resource Development Strategies for India Renewable Energy Sector, Final Report Delhi, 2010, pp.17-19.

10. http://www.c2es.org/international/key-country-policies/india/climate-plan-summary

11. k. k. Goyal, *Renewable Energy,* Published by Mahaveer & Sons, 2009.

12. http://www.triplepundit.com/2013/07/renovate-india-renewable-energy-sources/

13. http://libflow.com/d/8uzwyxop/Meeting_India%E2%80%99s_Renewable_Energy_Targets%3A_The_Financing_Challenge

14. http://www.me.iitb.ac.in/~rangan/publications/recent%20papers%20published_homepage/Capacity%20Building.pdf

15. http://mnre.gov.in/file-manager/support-programme-scheme/national-solar-science-fellowship-programme.pdf

16. http://www.eai.in/ref/ae/sol/education_careers.html

17. http://mozlo.com/platinum/news/indias-renewable-energy-potential-remains-untapped/

18. http://www.electricalmirror.com/html/viewdesc.aspx?id=6

19. http://www.nrdc.org/international/india/files/indiasolarmission.pdf

20. http://www.greenbusinessguide.co.za/indian-renewable-energy-sector-to-create-2-4-million-jobs-by-2020/

8.

Inclusive Growth and CARICOM Economies: Key Considerations in Developing a Green Growth Framework

Dr. Debbie A. Mohammed
Institute of International Relations,
University of the West Indies, St. Augustine, Trinidad
debbie.mohammed@sta.uwi.edu

Abstract

CARICOM countries are experiencing slow and uneven recovery from the global crisis of 2008 and must now re-examine the relevance of currently pursued models if economic recovery and growth are to be achieved. Global trends indicate that resource-intensive growth strategies continue to erode natural capital and pose a real risk to sustained, inclusive development. Since CARICOM states rely heavily on resource-intensive activities, green growth (GG) strategies may enable more efficient use of limited resources and provide the means to achieve long-term economic, social and environmental gains and Millennium Development Goals.

Greening sectors like tourism and agriculture will entail developing new businesses and adopting green practices within existing industries. Key drivers will be the ability to leverage new technologies including renewable energy, industry-based standards like eco-labelling and certification and life cycle analysis. This paper examines R&D and human resource implications of pursuing GG sector strategies in CARICOM countries.

Keywords: **CARICOM, green growth, sustainable development, tourism, agriculture, training and innovation**

Introduction

Caribbean Community (CARICOM) countries have been impacted in varying degrees by a general lack of competitiveness that can be attributed to a number of factors. Smallness is often cited as a causal factor for problems associated with economies of scale, undiversified production and limited domestic investment.

Concentration on a few exportables that remain at the low end of the value chain and declining levels of productivity suggest a failure or unwillingness at both public and private sector levels to mobilize research and development (R&D) and innovation as transformative tools, not only in boosting industry competitiveness, but in developing new, high value market activities. Export activities in the region remain heavily concentrated in resource-intensive sectors which are finite in nature and rely on, or are impacted by, environmental and climatic conditions. These bring to the forefront issues of decline/depletion, environmental degradation and implications for long term growth, employment and environmental sustainability.

These export industries are major contributors to economic growth and public sector financing, including financing of social programmes, but have experienced serious challenges relating to declining output and uncompetitive exports, as well as maturing industries and increasing competition for foreign investment. These challenges have been compounded by the impact on the region of the global economic downturn and the continuing Eurozone crisis. CARICOM countries have recognised that diversification is required to place their economies on a more sustainable growth trajectory. However, diversification can no longer mean shifting from one resource-intensive activity to another. It must take account of the loss of natural assets, including biodiversity and increasing climate variability and their potential economic and development impacts.

The focus of this paper is on economic greening as a means of generating more inclusive, sustainable growth, looking specifically at the agriculture and tourism sectors. The paper recognises that replacing these major export industries is neither practical nor feasible for CARICOM states since they do exhibit some comparative advantage and are major generators of revenue, employment and investment for these countries.

Instead, an alternative will be to introduce green practices to these industries using a range of instruments including eco-labelling, environmental standards, certification and accreditation and life cycle analysis, which may provide avenues for CARICOM economies to develop new niche segments, or move products and services further along the value chain to capture a share of a global market poised for growth. Several studies have highlighted the growing demand for green goods and services globally, which provides a basis for re-aligning the tourism and agriculture sectors to capture rents from this potential market segment.

A 2011 study by the Massachusetts Institute of Technology (MIT) noted that companies recognise green practices as vital to their competitiveness and profit generation and sustainability is now a permanent part of 70 per cent of corporate agendas (Earthshare.org). This supports the Boston Consulting Group's (BCG) 2008 survey that consumers "more systematically purchased green products in 2008 than 2007" and were willing to spend more, despite the recession, for such products (bcg.perspectives). This trend is reinforced by a Deloitte study which found that "a significant portion of consumers are now considering social and environmental benefits as part of their calculation of product value and purchasing decisions", which impacts what and how companies produce and market goods and services (*Deloitte, 2009*).

A United States Department of Commerce report 2010 noted the growth potential of the green sector, with shipments/receipts of green products and services valued between US$371 billion to US$516 billion in 2007, and green jobs employing between 1.8 million to 2.4 million (*US Department of Commerce, 2010*). In developing a green growth framework for both the agriculture and tourism sectors, the paper examines the technology, standards and human resource implications for policy makers at the government and firm levels in the Caribbean.

Section 1 provides an overview of the region's current economic position in the post-global recessionary period and its attempts at diversification to address declining competitiveness and revenue. It suggests that for diversification attempts to be more impactful and translate into more sustainable and inclusive socio-economic growth, strategies which will invariably entail ramping up sector activities that make even more demands on natural assets, will have to take account of the potential impacts of such resource-intensive industrial activities on long term economic growth and development.

Section 2 introduces greening as a diversification option for the agriculture and tourism sectors. The concepts of green growth and sustainable development are elaborated as the basis for actionable frameworks for revitalising major industries within CARICOM countries through incorporation of green principles and practices. This section further examines the current pattern of industry activities and details key features of industry-relevant green practices and identifies major elements than can contribute to greening, including eco-labelling, certification and industry standards, and adaptation of technologies drawing from industry best practice and country examples.

Section 3 examines some of the major inputs required to develop agriculture and tourism green growth frameworks and the policy implications for both governments and firms in the region.

Section 4 concludes with specific recommendations that can facilitate the creation of viable, green agriculture and tourism sectors specifically, and a more sustainable green approach generally in the Caribbean.

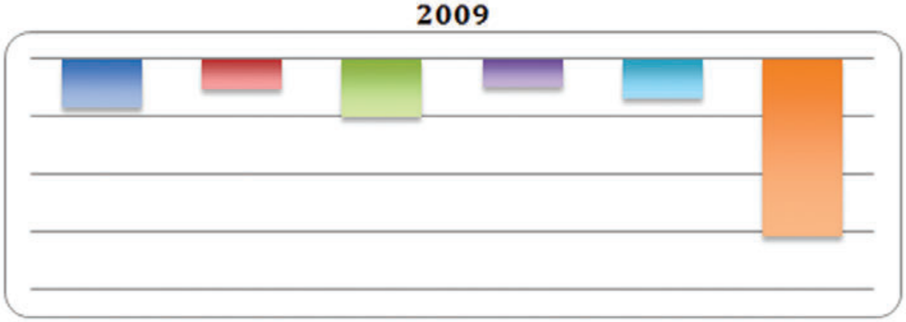
SECTION 1

CARICOM's Economic Performance in the Post-Economic Recession Period

Although the International Monetary Fund (IMF) estimates that real gross domestic product (GDP) growth in the Caribbean is likely to rebound to around 3 per cent over the medium term, after a cumulative flat performance from 2009 to 2012 (*Rambaran, 2013*), much of this anticipated growth and its sustainability will depend on the region's ability to move beyond "business as usual", to understand where in life cycle analysis its exportables reside, and the implications for competitiveness and sustainable, inclusive development, defined in this paper as the ability of countries to increase economic growth across sectors to achieve increased economic well-being, reduction in social inequities and enhanced environmental prudence.

In the post-recession period, several CARICOM countries which rank among the most tourism-dependent in the world (*Fritz-Krockow and Sun, 2009*) experienced revenue shortfalls as a result of a decline in tourism receipts (Figure 1) which forced nine countries, among them Belize, Dominica, Grenada and St Lucia, to seek IMF assistance in 2009. Jamaica negotiated a new IMF loan in February 2013 for $750 million, but this is accompanied by extremely onerous conditionalities and unless there is a marked improvement in tourism receipts, many of its CARICOM neighbours may be faced with the new National Debt Exchange (NDX) index introduced by the IMF.

Figure 1: Decline in Tourism Expenditure –Select CARICOM Countries (%), 2009



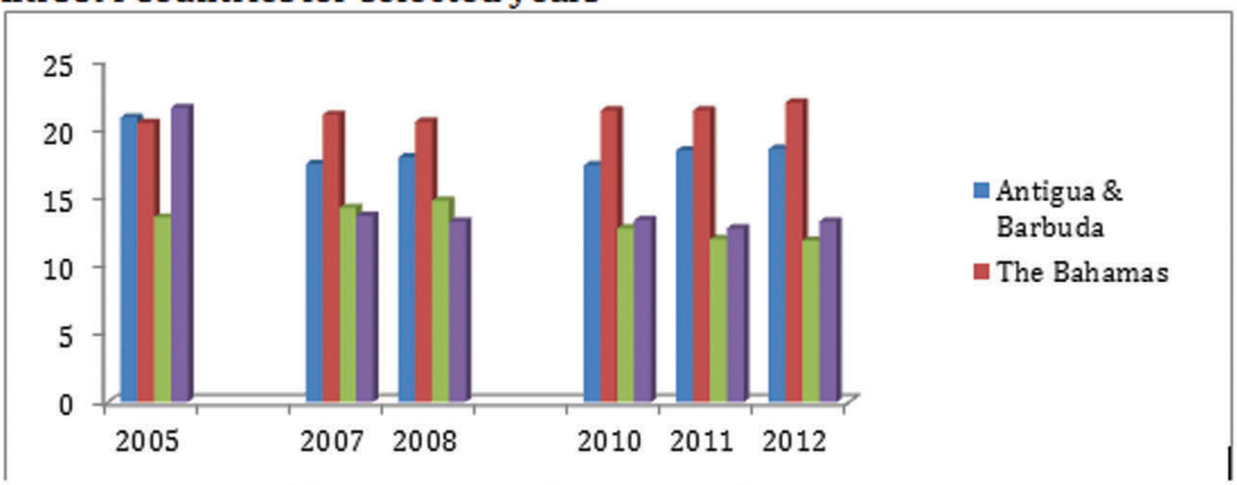
Source: Author's Compilation from Select CARICOM Central Banks' Reports 2009/2010

The direct contribution of tourism and travel to GDP and employment of four of CARICOM's tourism-dependent countries, Antigua & Barbuda, the Bahamas, Barbados and St Lucia, pre and post-recession, is depicted in Figure 2 below.

What is evident is the importance of tourism for GDP and employment in these countries, with Barbados and St Lucia seemingly most negatively impacted in the post-recessionary period in terms of contribution to GDP, the former registering 4.2 per cent in 2007, declining to 12.7 in 2010 and 11.8 per cent in 2012, while the latter experienced a marginal decline from 13.6 per cent in 2007 to 13.3 per cent in 2010, dipping to 12.7 per cent in 2011 (*World Travel and Tourism Council)*.

In terms of employment, Barbados was the most negatively impacted by this industry's performance. Travel and tourism's contribution to employment dropped from 14.5 per cent in 2007 to 12.9 per cent in 2010 and continued this downward trend to 12.0 per cent in both 2011 and 2012 (World Travel and Tourism Council).

Figure 2- Direct Contribution (%) of Travel and Tourism to GDP of Select CARICOM Countries for selected years



Source: World Travel and Tourism Council http://www.wttc.org/research/economic-impact-research/country-reports/

Poor performance of this sector was exacerbated by competition from destinations such as Australia, the Mediterranean and Cuba, as well as other tourism dependent CARICOM countries. Continued instability within the Eurozone and the United States, which constitute the bulk of its tourist market, saw a reduction of 6.2 per cent in long stay arrivals (*Bourse, 2013*). Additionally, the imposition of the UK Air Passenger Duty and a reduced number of flights to Barbados contributed to this sector's contraction by an estimated 3.5 per cent (*Bourse, 2013:1*).

The picture is one of cautious optimism for some of these tourism-dependent countries due to a slight improvement in tourism's contribution to GDP and employment in 2012. However, given the contraction in output in the global economy, sustainable gains from this industry will require policies and strategies at the governmental and firm levels that protect the inputs for this industry, while creating new, differentiated niches to attract different market segments.

For both scenarios, it will be necessary to address supply-side issues, particularly the environmental and natural resource sectors since this industry is a heavy consumer of water and energy which can put severe pressures on the limited resources of these small island nations. Furthermore, its existence is contingent on the use of fragile or finite environmental assets such as seas, coastlines, forests and other ecosystems, all of which are likely to be negatively impacted by global warming and changing climatic conditions.

This is supported by a 2010 report commissioned by the United Nations Development Programme (UNDP), which noted that rising sea levels due to climate change could result in more than “300 premium tourist resorts” being destroyed as a result of sea level rise and rebuilding, which could cost the region US$187 billion by 2080 (*Allaham, 2011*).

With respect to agriculture, the global financial crisis of 2007, and the subsequent global food crisis which resulted in scarcity and high prices, reinforced the need for CARICOM countries to address, as an urgent priority, the issue of food security within the context of poverty reduction and inclusive, sustainable development (*CARDI, Medium Term Plan 2011-2013:9*).

Globally, food prices have continued to trend upward with marked increases in staples such as wheat, maize, sugar and edible oils (CARDI: 11) which have, in turn, precipitated increases in the price of feedstock and final products in this region.

At the same time, there has been no commensurate increase in extra-regional agricultural exports of mainly sugar and bananas for the region, as small size, outdated production methods, high production costs, frequent occurrence of tropical storms and hurricanes, and more rigorous health standards and regulations exacerbate the region’s lack of export competitiveness in the agricultural sector.

Most CARICOM countries, with the exception of Belize and Guyana, have experienced worsening agricultural deficits, which have facilitated a shift in production for the local markets where standards are not as rigorous (*Agritrade, 2012*). Agriculture’s contribution to employment and GDP in the region has fallen over the last decade as shown in Table 1. Its contribution to GDP declined by roughly 50 per cent, from 6.3 per cent in 1997 to 3.2 per cent in 2006 (*FAOSTAT*), due in part to the transformation of the OECS economies from agriculture to service-based.

Table 1 - Agriculture contribution to GDP and Labour Force Composition CARICOM Economies 1960-2009

Country	Agriculture (% of GDP)		Agriculture Employment (% of labour force)	
	1960[iv]	2009[iv]	1981[iv]	2007[iv]
Antigua and Barbuda	11	4	3	3
Dominica	38	20	28	21
Grenada	27	6	20	14
St. Kitts and Nevis	19	3	51	NA
St. Lucia	15	5	23	15
St. Vincent and the Grenadines	18	7	25	15
Bahamas, The	2	1	5	2
Barbados	21	4	9	3
Belize	31	12	24	20
Guyana	26	28	28	21
Jamaica	8	6	27	18
Suriname	11	5	17	8
Trinidad and Tobago	3	1	10	4

Source: Author’s Compilation from World Bank Development Indicators: http://data.worldbank.org/data-catalog/world-development-indicators

In the case of energy-producing Trinidad and Tobago, Dutch Disease has negatively impacted the agricultural sector. This decline has been facilitated by its inability to attract labour because of the high wage competition from energy as well as several social programmes. A recent survey found that the average wage for workers in the petroleum sector in 2009 was "almost 5 times higher than the average wage of persons in the other sectors"… and that workers in domestic agriculture earned the lowest wages in 2000. *(Mahabir et al, 2013: 8,9*)

Despite substantial support to the agricultural sector, there has been a steady decline with the sector accounting for only 0.6 per cent of GDP and under 4 per cent of employment in 2010 (*WTO Trade Policy Review Trinidad and Tobago, 2012*).

This is reflected in the country's food import bill which amounted to 10.06 per cent of total imports in 2010 (*Ministry of Food Production, Land and Marine Affairs: National Food Production Action Plan 2011-2015: 4*). The government has embarked on a National Food Production Action Plan for the period 2011- to 2015 as a means of diversifying the economy and transforming agriculture into a dynamic sector capable of generating sustainable employment and careers, reducing the food import bill and contributing significantly to the country's food and nutrition security.

Most CARICOM countries are now attempting to increase local food production as a means of improving their food security positions and reducing their food import bills. For this reason, a more balanced approach to growth and sustainable development is required, one that can generate revenue and long term employment and contribute to poverty reduction while ensuring the protection and longevity of natural inputs upon which such economic growth is predicated. Despite differing levels of development and resource endowments, both tourism and agriculture continue to be important contributors to GDP, foreign exchange earnings and employment for CARICOM countries.

If they are to contribute meaningfully to growing these economies and placing them on a more secure development footing, both sectors will need to increase output, introduce differentiated and high quality goods and services that can build competitiveness, secure market share, and earn revenue. The challenge for CARICOM countries will be to avoid a "race for resources" as each tries to compete in the same market with the same products.

This paper advances the need for a more harmonised approach to industry expansion and diversification as specified in the Revised Treaty of Chaguaramas, where standards, best practice and protection of natural assets become key drivers. Utilising a Green Growth Framework to guide the process of "dynamising" critical sectors provides a realistic option for smaller economies like those of CARICOM to better address growth and development challenges within the framework of very limited resources in areas such as financial capital, skilled human capacity, natural endowments and investment in innovation and research.

SECTION 2
Green Growth for Sustainable Development of the Tourism and Agriculture Sectors in CARICOM Countries

While many CARICOM countries have attempted to diversify their economies to reduce dependence on one or two resource-intensive or resource-related activities, most remain anchored to these traditional exportables, primarily because they provide a consistent source of revenue. For this reason, applying green principles and practices to the sectors will be critical for maintaining their viability over time.

Green Growth and Sustainable Development

Green growth (GG) is defined as the "pursuit of economic growth and development while preventing costly environmental degradation, climate change, biodiversity loss and unsustainable natural resource use" (*OECD, 2010*). GG utilises mutually supportive economic and environmental policies to ensure economic progress and sustainability over time. A key component of GG strategy is the creation of competitive conditions to address environmental risks that may impede economic and social progress.

This provides the space for investing in the environment which can trigger new sources of economic growth. Since the ultimate goal of green growth is to enhance well-being, GG is concerned not only with the economic viability of countries but approaches development from a holistic standpoint that includes issues such as poverty reduction, sustainable livelihoods and equitable and balanced development in line with Millennium Development Goals (MDGs). It emphasizes economic growth for sustainable, inclusive development based on a more prudent approach to resource and environmental usage. Green growth thus provides a framework for linking economy, environment and social objectives to achieve concrete measurable progress. As such, GG should be viewed as a key component of, rather than distinct from, the concept of sustainable development.

It should be noted that the concept of a green economy in the context of achieving sustainable growth outcomes for developing countries is a somewhat contentious one. While the United Nations Environment Programme (UNEP), the Organisation for Economic Co-Operation and Development (OECD) and various environmental and non-governmental groups support greening as a more viable means for poorer countries to achieve inclusive growth in line with the MDGs, many argue that this is impractical on two fronts.

Firstly, the transformation to a green economy requires a quantum of investment, research, innovation and expertise for the creation of new industries which are beyond the capacity of poor or small developing countries. Since these countries depend on a few areas of economic activity for revenue and employment generation, there is little room for sector replacement. This is simply not an option. Secondly, McAffee (2012) contends that assigning prices to ecosystem services, bio-diversity banking and carbon-offset sales, rather than benefiting the poor, could result in “upward redistribution of wealth from poorer to wealthier classes and from rural regions to distant centres of capital accumulation, mainly in the global North” because these are based upon the logic of neo-classical economics where the market model for profit maximization is the main objective (2012).

Cognizant of these arguments, what is advocated is not the replacement of major revenue earners such as tourism and agriculture but rather the transformation of these into more sustainable sectors capable of increasing contributions to employment and foreign exchange without unduly diminishing natural resources or negatively impacting the environment.

Greening the Tourism and Agriculture Sectors in CARICOM

Tourism

Efforts at diversification or the search for alternative development options have tended to focus on growth initiatives which would significantly transform current models that have either failed or remained stagnant. While GG may sound like a major transformation involving policy changes, technological input, and tax restructuring, in reality, incremental measures involving improvements along the value chain could significantly alter the product in question to allow it to earn the GG label.

Various “tools” can be adopted by countries depending on their resource endowments and technical capacities and the sub sectors in which they operate. These include investment in solar panels and wind generated devices (renewable energy), energy efficiency practices, waste management/recycling, water conservation, eco-tourism, eco- labelling and green certification.

Currently, there are attempts to apply some elements of green practices and principles to the tourism sector of most CARICOM countries, with Barbados emerging as a clear leader in this area. Recognising that tourism is the principal driver of the economy, accounting for 15 per cent of GDP and 13,000 direct jobs, (*Henry, 2011*), major inhibitors to this sector’s growth were identified as high energy and water demands, intensive land use and high energy costs, while waste was a significant output generated by this sector. To address these concerns and spiralling energy costs, Barbados has developed a Tourism Policy Framework which emphasises a sustainable tourism development approach in keeping with its National Strategic Plan 2006-2025 (NSP) to make Barbados a developed country by 2025, along with the broader vision of making the country the most environmentally advanced green economy in Latin America and the Caribbean (*Henry, 2011*).

In December 2010, the Government of Barbados and UNEP entered a formal partnership to develop a resource efficient green economy in Barbados. As part of this project, a Green Economy Scoping Study was launched in March 2011 to analyse linkages between key growth sectors such as tourism, transportation and agriculture and the implications for cross cutting issues such as energy, waste and water.

The NSP recognised the importance of energy security for attaining sustainable development and has set specific targets for increasing the renewable energy (RE) supply on the country's electricity grid and increasing the number of households with solar water heaters by 50 per cent by 2025 (*Henry, 2011*).

However, energy efficiency (EE) and RE have been directed particularly at the tourism industry since it is such a heavy consumer of energy. The hotel industry and wider tourism sector have been encouraged to conserve energy and to adopt other green practices including solar water heaters, green building design in accordance with industry standards and certification such as Leadership in Environmental Engineering and Design (LEED), eco-labelling, recycling, solar vehicles for tourist transport as well as other eco-friendly modes of transport – trams, segways and bicycles, and eco-branding as a means of differentiating the product and attracting a different market segment.

Many of these measures are private–sector driven. The hotel industry in countries such as St. Lucia, Jamaica, Dominica and Guyana have also begun to introduce measures designed primarily for energy and water conservation. Some destinations and attractions have focused on branding their products as eco-intensive and have been successful in acquiring international green certifications and standards such as Earth Check, Green Key and Green Globe. Hotels such as Fond Doux Plantation (St. Lucia), Spice Island Beach Resort (Grenada), Galley Bay Resort (Antigua) and Accra Beach Resort (Barbados) have been able to gain Green Globe certification by adopting one or more of the following green strategies:

- Use solar photovoltaic systems for electricity and heating water
- Use of water from desalinization plants
- Use of rain water harvesting systems
- Incorporation of salt-based pool purification systems instead of chlorine-based ones
- Use of energy-efficient/ smart systems in buildings and energy efficient appliances
- Development of waste management systems
- Conversion of food waste to compost

While there is a concerted attempt to reduce costly fossil fuel and water consumption and adopt practices that reduce harmful impacts on natural environments in these countries, including energy-producing Trinidad and Tobago, there is no discernible attempt to strengthen and sustain backward linkages with the agriculture sector to reduce the food import bill, reduce carbon footprint and grow the local food sector. Although several countries have articulated sustainable development plans, the Barbados "model" is supported by an actionable policy, institutional and legislative framework with clearly identified targets and time-frames and appropriate concessions to drive GG. Notwithstanding differences in resources across the region, the development of similar frameworks to provide the enabling environment will be necessary for successful replication in other CARICOM countries since the problems tend to be similar.

Agriculture

Like tourism, agriculture continues to be a key contributor to employment in the region. Global food scarcity and price fluctuations have re-ignited concerns for CARICOM's food security and its balance of payments position. The Community Agricultural Policy (CAP), as provided under Article 56 of the Revised Treaty of Chaguaramas, and Regional Strategic Plan which emerged from the Jagdeo Initiative, were introduced to address these critical issues and assist member countries in developing national agricultural policies under a harmonised regional agriculture policy that could effect "transformation of the agricultural sector towards market-oriented, internationally competitive and environmentally sound production of agricultural products"; (56 (1) (a)), through "efficient management and sustainable exploitation of the Region's natural resources, including its forests and living resources of the exclusive economic zone." (56: (1) (f))

The Caribbean Agricultural Research and Development Institute (CARDI) as the regional centre for applied research in agriculture has identified three strategic axes: 1) development of sustainable industries; 2) development of strategic linkages and 3) capacity building for driving its Medium Term Plan 2011-13. Heavy emphasis will be placed on the application of technology, research and innovation to develop new, more commercially viable crops and livestock varieties, and to assist national agricultural departments in introducing these. This is particularly important as countries attempt to move up the agriculture value chain in livestock and food crop production by: 1) expanding agro-based industrial activities; 2) increasing the variety of local fruits/vegetables/flowers for the domestic and international markets; and 3) increasing the scope for agricultural exports by extending the life cycle to include niches in organically produced crops and related products.

Key to the development of viable, competitive agricultural sectors will be the application of research and innovations that are internally generated and/or adapted from external sources via strategic partnerships. Adherence to relevant food regulations and standards, as well as increasing food-testing laboratories across the region, will also be major factors in determining the export viability of agricultural and related products. Application of eco labels can also be used as a green growth measure to identify products that were produced sustainably with little to no lasting effects on the environment. This can range from crops to processed foods to fertilizers and pesticides used in plant products and the feeds and living conditions of animal products. Additionally, harmonisation of agricultural policies and standards, increased budgetary allocations for agricultural research and capacity building must be seen as urgent priorities to address intensive land use, unsustainable farming practices and the use of certain pesticides and fertilizers since these impact natural resources, habitats and the environment and thus the sustainability of this sector.

While the perception that such initiatives are technology and investment-intensive may be valid, many of the success stories are due to initiatives undertaken by entrepreneurs, with little tangible support from government. The Tobago Cocoa Estate WI Ltd for example, produces gourmet chocolates from organically grown cocoa for the international market and copped a Gold Star at the UK Great Taste Awards 2011. It is now certified organic and has moved up the value chain by introducing sustainable agri-tourism as part of its line (*Zing, April-June, 2010*). Belmont Estate in Grenada has also followed this sustainable agri-tourism model and is producing award-winning chocolates from certified organic cocoa. Hotel Chocolat in St Lucia plans to build a fully solar powered chocolate factory that will utilise harvested rainwater and locally sourced milk and sugar (*Zing, April-June, 2010*).

These green success stories can also be found in vegetable production. By applying hydroponic techniques, one entrepreneur in Trinidad created Mamas's Green Garden which supplies organic vegetables to local supermarkets and restaurants (*Trinidad Guardian, 2012*). A key strategy in building demand for these products and services has been alliances with international partners, both from a marketing and technical standpoint.

Growing sustainable industries will require more active collaboration on the part of local entrepreneurs and government, in addition to accessing strategic international partnerships to assist in areas such as quality, branding and marketing. It also requires a modification of strategies by trade facilitation and promotion agencies eg. Export-TT, Invest-TT, Trinidad and Tobago Manufacturers Association (TTMA) as well as financial institutions, toward promoting and financing these types of goods and services.

SECTION 3
GG Frameworks for the Tourism and Agriculture Sectors

UNEP's Green Economy and Trade (2013) report identifies sustainable tourism and agriculture as emerging opportunities that can be used by developing countries to engage in sustainable trade (*UNEP, 2013:19*). It should be noted that because these sectors are so interconnected, enabling frameworks will have basic elements with certain aspects tailored to the specific demands of each sector.

In the case of tourism, sustainable tourism represents a potentially lucrative growth subsector for the region, since eco-tourism is now the fastest growing segment of this subsector (*UNEP, 2013: 22*). A Travel Insight report (November 2011) noted that environmental awareness and sustainability issues were growing amongst UK consumers and that future travel trends revolved around issues of sustainability, exploring places off the beaten path, increased ecotourism and social responsibility (*Henry, 2011*).

CARICOM countries have a comparative advantage in eco-tourism because each has distinctive natural environments and rich cultures which can be developed as sustainable, certified tourism products and attract a growing market on the export side while potentially reducing negative environmental and social impacts such as air and water pollution, bio-diversity loss and pressures on utilities and waste management systems. UNEP (2013:22) notes that protected areas in Costa Rica attract over a million visitors annually and generate entrance fee revenues of US$5 million; in Mexico, these attract 14 million visitors and generate over 25,000 jobs.

Sustainable agriculture, too, represents a viable export segment as consumers globally become more conscious of organically certified foods. According to the Organic Trade Association (2013), Canada's organic market grew to Cdn $3.7 billion in 2012, of which certified organic foods amounted to $3 billion. It noted that the value of the Canadian organic food market has tripled since 2006, outpacing other agri-food sectors. It attributes this to public-private partnerships, citing government's role in implementing, at industry's urging, "strict national standards and label requirements in 2009 to uphold consumer confidence in organic claims", and funding by major private sector companies such as supermarket and food giant, Loblaws. Public awareness of, and certification in, agriculture is very limited in CARICOM countries. A few sustainable farms have received international certification e.g. Rainforest Alliance, but adaptation of these techniques across the region remains limited.

Community-based cooperative initiatives modelled on the Integrated Watershed and Coastal Area Management (IWCAM) Cuban demonstration project, which used innovative technologies such as Vermiculture along with soil conservation measures to increase agricultural yield (*Clauzel, 2011*) can be an ideal way of linking the agricultural and tourism sectors in pursuit of GG initiatives in CARICOM.

While sustainable tourism and agriculture present new trade and employment opportunities for this region, certain limitations can act as inhibitors and so must be considered in developing GG frameworks. These include limited financing for green activities, low investment in R&D or in technology adaptation, lack of public "buy-in" to greening, and low incentive structures for shifting to greener activities. Government support should focus on introducing policies and development initiatives that are geared towards educating and informing small farmers of the viability of these initiatives, technical assistance to facilitate adaptation of these new initiatives, low-interest financing, marketing of merchandise and access to markets. Such initiatives will be critical for the development, growth and commercialization of these sectors.

Integrated Approach to Sustainable Development Planning

A key component of GG framework will be to situate sustainable tourism and sustainable agriculture strategies and targets within the broader national development objectives so that there is a clear link between sector strategies, inputs, outputs and national development outcomes. Moreover, success of GG will require more than endorsing policy. It requires effective co-ordination of decision-making and monitoring and accountability systems to ensure that GG policies are implemented to produce intended outcomes within specified time-frames. These procedures will facilitate more effective allocation of limited financial and technical resources and avoid costly duplication, while building confidence in the GG process.

Targeted Government Investment & Strategic Partnerships –Capacity Building & R&D

The development of sustainable sectors like tourism and agriculture requires greater emphasis on land, water, energy and waste efficiency while introducing new products/services with market appeal. Targeted incentives for infrastructure, such as CNG to reduce fossil fuel consumption in Trinidad and Tobago and solar energy initiatives in Barbados and Trinidad and Tobago, are necessary to encourage private sector interest in these areas.

The development of strategic partnerships with industry leaders –locally, regionally and globally—is also important for building capacity, standards and benchmarks and for acquiring technology. Investment in public awareness programmes and education and skills training programmes are key inputs to support the development and commercialisation of green activities along the tourism and agriculture value chains. A major inhibitor is low levels of expenditure on R&D at both the national and private sector levels. As depicted in Table 2, expenditure on R&D in Trinidad and Tobago, which has the highest R&D expenditure amongst CARICOM countries, is still very low.

Table 2: Trinidad &Tobago- Expenditure on Research and Development % GDP 2005-2011

Year	2005	2006	2007	2008	2009	2010	2011
Percentage	0.09	0.06	0.05	0.03	0.05	0.05	0.04

Source: NIHERST –Expenditure on R&D as a Percentage of GDP 2005-2010 & 2006-2011

This is in stark contrast (Table 3) to the richest countries who spend some 30 per cent of their budgets for R&D and derive over 50 per cent of their GDP from science, technology and innovation, while CARICOM spends less than 0.13 per cent of its GDP on and receives less than one per cent of its GDP as returns from science, technology and innovation (*Gleaner, July, 2012*).

Table 3: R&D Expenditure of OECD Countries

	Budgetary Expenditure on R & D (private& public sector) (%)	Returns from R&D to GDP (%)
OECD Countries	30	> 50
CARICOM Countries	0.13	<1

Source: Gleaner, 27 July, 2012

R&D expenditure remains woefully low in all CARICOM countries. This is compounded by a general lack of investment in R&D within companies, due in part to small size, segmented markets and high operating costs arising from high energy and other imported inputs. Given pressing constraints on revenue generation in this region and challenges for financing even basic government operations, there is urgent need for increasing strategic alliances and partnerships at the bilateral and multilateral levels including research and teaching institutions, to better access technology and skills sharing, adaptation and upgrade to facilitate greening and commercialisation opportunities.

Further, intensifying regional collaborations with research centres such as IICA, CARDI, CARIRI, CROSQ, UWI and UTT for targeted projects can augment capacity and technology adaptation required to drive more sustainable industries.

The Caribbean Development Bank's (CDB) Climate Resilience Strategy 2012-2017, "seeks to finance investments and strengthen capacity to utilise financing, design and implement policies and strategies to address resilience and deliver on sustainable development objectives" (*CDB Annual Report, 2012: 18*).

There is also dire need for more effective and efficient utilisation of resources, particularly highly trained human capital. This approach requires not only targeted investment for training and certification in specific industry-related programmes, but ensuring these skilled resources can get employment in their chosen specialisations. Misallocation of human capital continues to be a major impediment to real growth in this region.

Harmonisation of Policies/Standards and Regulations

Several CARICOM countries have developed, or are in the process of developing some variant of a sustainable development action plan. Whether targeting agriculture or tourism, meeting international certification, standards and regulations, and producing green goods and services may be beyond the capacity of governments and private sectors in the region. It is for this reason that the Revised Treaty of Chaguaramas called for harmonisation of sector policies and enabling legislation across CARICOM.

Additionally, it safeguards against possible environmental impacts as countries 1) compete to attract investment into the tourism sector, and 2) intensify agricultural activity. To date, however, CARICOM has made little progress beyond recommending the establishment of guidelines and standards. To be effective and meaningful, CARICOM must set enforceable monitoring and accountability standards to ensure that standards set are being met and sustained.

Such a plan may also help the region in developing its own Caribbean green standards, linked to leading global standards for agricultural practices and outputs and for hotel and destination experiences. If implemented regionally, certification bodies could distribute costs and help brand the region as environmentally progressive. Guidelines should be established for different industries to enable firms to find the simplest ways to "green" their production processes. Regional tertiary education bodies such as The University of the West Indies can be used to conduct the research needed to establish green growth measures suited to the region. These institutes would also train the human resource needed to carry out the certification process and ensure compliance.

Incentives & Private Sector Initiatives

Although commercialisation of tourism and agricultural activities is primarily private sector-driven, entrepreneurship building in these areas will require an incentives framework, including subsidies and tax relief, that can attract large firms, but should also aim to encourage smaller entrepreneurs. For instance, both Barbados and Trinidad and Tobago offer incentives to encourage solar water heaters. A Green Fund levy of 0.1 per cent on gross income was introduced for all companies operating in Trinidad and Tobago as a means of balancing the impacts of growth on the environment. Incentives for organic products and sustainable farming can be tied to industry certification to stimulate growth of such products.

For the private sector, understanding the growth potential of the sustainable goods and services market and how these could be replicated in, or developed for the domestic market will be key to commercialisation of new products. The Cariloha brand of apparel is a good example of innovation and commercialisation. Products are made from 100 per cent recycled bamboo and the line has been expanded to include bedding, accessories and fitness wear. By 2014, Cariloha had over 40 full, stand-alone stores and is the only multi-store retailer in the world to provide an entire store experience completely merchandised with products made of bamboo (cariloha.com). Cariloha has successfully branded itself not only as a green brand to capture this growing market, but as a leisure brand to appeal to an even wider market.

Good Governance

The successful operation of GG frameworks is predicated on good governance since the introduction of new industries and activities will require significant investments that should be carefully managed. Linked to this is the need for transparency in decision-making to build confidence in the system and ensure potential gains are shared by all, while risks associated with such investments are not only minimised, but do not negatively impact certain groups, particularly the poor and vulnerable. Additionally, the private sector and NGOs must be active participants. The former provides initiative and leadership to drive GG, particularly in the area of corporate social responsibility, whether voluntary or based on industry standards, and sets the tone for government adopting similar attitudes to sustainable growth and decision-making. The latter monitors both private and public sectors to ensure performance, adherence to standards and accountability.

Conclusion

Sustainability is a concept that will require new ideas and fresh thinking. As CARICOM countries devise strategies to grow their economies and position themselves more firmly along a sustainable development path, this will also require commitment and buy-in by all stakeholders. It will also require more efficient utilisation of limited resources, particularly human capital, and reinforce the case for greater regional cooperation for accessing technology, training and financing, as well as for developing or adopting internationally recognised industry standards and certifications. While governments will remain the principal drivers of the economy for the foreseeable future, greening sectors such as tourism and agriculture present new and dynamic opportunities for entrepreneurs. Targeted support from government must be accompanied by clear private sector strategies to turn green activities into commercially viable industries and translate into more sustainable livelihoods.

References

Agritrade (2013). Opportunities and Challenges Arising from Increased Eco-labelling. 11 March http://agritrade.cta.int/en/layout/set/print/Agriculture/Topics/Product-differentiation/Opportunities-and-challenges-arising-from-increased-eco-labelling

Agritrade (2012). Executive Brief Update 2012: Caribbean: Agricultural trade policy debates and developments. 5 November. http://agritrade.cta.int/Agriculture/Topics/Other/Executive-Brief-Update-2012-Caribbean-Agricultural-trade-policy-debates-and-developments

Barbados Advocate (undated). Barbados Food & Nutrition Security and Action plan. http://www.barbadosadvocate.com/newsitem.asp?more=local&NewsID=24535

Bourse Securities Limited (2013). Regional Review- Barbados Time to Diversify! 31 January. http://www.bourseinvestment.com/content/wp-content/uploads/2013/02/Bourse-Securities-Review-Regional-Review-Barbados-Time-to-Diversify.pdf

Caribbean Agricultural Research and Development Institute (CARDI). Medium Term Plan 2011-2013. CARDI. http://www.cardi.org/wp-content/uploads/2011/01/Medium-Term-Plan-2011-2013.pdf

Caribbean Community (CARICOM) (2001). The Revised Treaty of Chaguaramas http://www.caricom.org/jsp/community/revised_treaty-text.pdf

Cariloha products- http://www.cariloha.com/

Central Bank of Belize (2010) Annual Report 2009 Central Bank of Belize. http://www.centralbank.org.bz/docs/rsh_4.2.4_annual-reports/central-bank-annual-report-2009---full-document.pdf?sfvrsn=2

Central Bank of Trinidad and Tobago (2013). Monetary Policy Report 2013. Central Bank http://www.central-bank.org.tt/sites/default/files/Monetary%20Policy%20Report%20Governor's%20Powerpoint%20Presentation.pdf

Central Bank of Trinidad and Tobago (2013). Governor Rambarran's Remarks - 5th International Business, Banking and Finance Conference - May 2. http://www.central-bank.org.tt/sites/default/files/5th%20Business%20Banking%20and%20Finance%20Conference%20UWI%20-%20May%202%20-%203%202013.pdf

Central Bank of Trinidad and Tobago (2011). Annual Report 2011. December. http://www.central-bank.org.tt/sites/default/files/Central%20Bank%20Annual%20Report%202011_1.pdf

Clauzel, Sylvester (2011). "A model for Integrated Watershed and Coastal Area Management - the Case of Cienfuegos Bay, Cuba." The Global Environment Facility-funded Integrated Watershed and Coastal Areas Management Project. http://iwcam.org/demonstration-activities-1/cuba-demonstration-project/cuba-project-document-final/view

Deloitte.org (2009). "Finding the green in today's shoppers: Sustainability Trends and New Shopper Insights." https://www.deloitte.com/assets/Dcom- Lebanon/Local%20Assets/Documents/Consumer%20Business/DeloitteGreenShopperStudy_2009.pdf\

Dominica Agricultural, Industrial and Development Bank (2009) Annual Report 2009. September 30. http://www.aidbank.com/downloads/AID-Bank-Annual-Report-2008-2009.pdf

Earthshare.org. http://www.earthshare.org/greening-business.html#valuegreen

Eastern Caribbean Central Bank (2010). Economic and Financial Review Volume 30 Number 2, June. http://www.eccb-centralbank.org/PDF/efrjune2010.pdf

Fond Doux (2010). "Eco Friendly Tourism in St Lucia." http://fonddouxestate.com/2010/05/eco-friendly-tourism-in-st-lucia/

Fritz-Krockow, Bernhard and Yan Sun (2009). "Six CARICOM Countries Seek IMF Support". Abeng News Magazine. 6 May. http://www.abengnews.com/2009/05/06/five-caricom-countries-seek-imf-support/

Henry, Gail (2011). "Tourism and Energy in Barbados; Opportunities and Challenges". Presented at Greening Tobago Why and How? Conference. 10 November, Coco Reef Hotel, Tobago.
http://www.caribsave.org/assets/files/Tourism%20and%20energy%20in%20Barbados%20-%20CTO.pdf

Inter-America Institute for Cooperation in Agriculture (IICA). Caribbean Agricultural Development Strategy 2010-2014. http://www.iica.int/Eng/regiones/caribe/guyana/IICA%20Office%20Documents/country_strategy/IICA%20Caribbean%20Regional%20Strategy%202010-2014.pdf

Jamaica Gleaner (2012). "Invest more in research and development – Scientists." Jamaica Gleaner.Friday 27 July http://jamaica-gleaner.com/gleaner/20120727/news/news6.htm

John-Lall, Raphael (2012) "Trade Minister: Region needs to deepen global trade ties". Business Guardian. September 27. http://www.guardian.co.tt/business-guardian/2012-09-27/trade-minister-region-needs-deepen-global-trade-ties

Kaieteur News (2012). "CARICOM Food Security."
http://www.kaieteurnewsonline.com/2012/07/06/caricom-and-food-security/

La Rose, Miranda (2012). "Bharath: $2 billion food bill by 2015." Business Newsday, 13 March.
http://newsday.co.tt/business/0,156799.html

Mahabir, Reshma , Vishana Jagessar, Crystal Neptune and Delvin Cox (2013). "Understanding Wages in a Small Open Economy: The Case of Trinidad and Tobago." Central Bank of Trinidad and Tobago Working Paper WP 11/2013 February. http://www.central-bank.org.tt/sites/default/files/Understanding%20Wages%20in%20a%20Small%20Open%20Economy%20The%20Case%20of%20Trinidad%20and%20Tobago%20Mahabir%20Jagessar%20Neptune%20Cox%20-%20Feb%202013.pdf

McAfee, Kathleen (2012) "The Contradictory Logic of Global Ecosystem-Services Markets". Development and Change. Volume 43, Issue 1, January, pp 105-134.

Merrick, Andrews (2012) "$350m Annual Food Import Bill; Agri Minister Calls for Action" St Lucia News Online. http://www.stlucianewsonline.com/350m-annual-food-import-bill-agri-minister-calls-for-action/

National Institute for Higher Education, Research, Science and Technology (NIHERST). Science, Technology and Innovation (STI) Indicators. Research and Development. http://www.niherst.gov.tt/st-statistics/sti-indicators/index.html

NationNews.com (2012). "700M Food Bill." Barbados Nation Newspaper. Thursday 24 May.
http://www.nationnews.com/articles/view/700m-food-bill/

Natureisland.com.Dominica- EcoTourism Island. http://www.natureisland.com/eco-tourism.html
Organic Trade Association (2013). "Canada's organic market now worth $3.7 billion - Growth driven by broad-scale support of organic food." Organic Trade Association Canada- Press Release. www.organicnewsroom.com/2013/04/canadas_organic_market_now_wor.html

Organisation for Economic Co-operation and Development (OECD) (2010). The Green Growth Strategy: How can we get to a greener economy? November, http://www.oecd.org/greengrowth/46141709.pdf

Sanders, Ronald (2013). "Will other Caribbean states follow Jamaica to IMF?" Trinidad Express, February 26. http://www.trinidadexpress.com/commentaries/Will-other-Caribbean-states-follow-Jamaica-to-IMF-193424611.html

Stabroek News (2012). ""Regional Food Import Bill Still a Major Concern." Stabroek News.
http://www.stabroeknews.com/2012/business/08/03/regional-food-import-bill-still-a-major-concern/

The World Bank. 'World Development Indicators". The World Bank http://data.worldbank.org/data-catalog/world-development-indicators

Trinidad Guardian (2012). "Hydroponics-Mama's Green Garden." Trinidad Guardian 20 August. http://www.guardian.co.tt/lifestyle/2012-08-20/changing-agriculture-through-hydroponics

Trinidad and Tobago Ministry of Food Production, Land and Marine Affairs. The National Food Production Action Plan 2012-2015 http://www.agriculture.gov.tt/pdf/National%20Food%20Production%20Action%20Plan%202012-2015.pdf

Trinidad and Tobago Ministry of Planning, Housing and the Environment (2012) Working for Sustainable Development In Trinidad and Tobago . (Sustainable Development Report), June. http://www.uncsd2012.org/index.php?page=view&type=400&nr=496&menu=45

United Nations Economic Commission for Latin America and the Caribbean (UNECLAC) (2005). "Caribbean Tourism and Agriculture: Linking to Enhance Development and Competitiveness." UNECLAC. http://www.eclac.org/publicaciones/xml/0/29020/L.076.pdf

World Trade Organisation (WTO) (2012). 'Trade Policy Review: Trinidad and Tobago', Report by the Secretariat, WTO, Geneva WT/TPR/G/260, 7 and 9 March.
http://www.wto.org/english/tratop_e/tpr_e/tp360_e.htm

World Travel and Tourism Council (2013). Travel and Tourism Economic Impact 2013: Caribbean http://www.wttc.org/site_media/uploads/downloads/caribbean2013_1.pdf

9.

Domestic Solar Energy: A Viable Alternative in Trinidad and Tobago? Case Study: HDC Housing – The Economic Analysis

Kiron C. Neale
University of the West Indies, St. Augustine, Trinidad and Tobago
kironneale@gmail.com

Abstract

Using solar energy as an alternative subjects it to the laws of economics and ultimately competition with Trinidad and Tobago's energy subsidy. The economics of such energy diversification highlights the subsequent capacity for a potential domestic photovoltaic market. Static direct valuation analyzed the costs of photovoltaic systems and conventional electricity rates for an HDC home inclusive of CO_2 abatement and stock market value. This was expanded to photovoltaic and natural gas import scenarios for national HDC schemes.

The photovoltaic systems yielded initial payback periods of roughly five years with the potential to abate 350 Mg of CO_2 per home. The importation scenarios for extra-regional natural gas revealed projected losses of TT$306 million, favouring the solar alternative.

The solar economic environment is increasing in its viability but such investments are vulnerable to market domination by foreign transnationals, stifling any potential manufacture, marketing and distribution by local firms.

Keywords: **Solar energy, Solar water heating, Trinidad and Tobago's Housing Development Corporation, Alternative energy scheme, CO_2 abatement, Climate change**

1.0 Introduction
1.1 Trinidad and Tobago: A hydrocarbon economy

As early as the 1800s, fossil fuels pervaded Trinidad and Tobago's economy and are still the driving resources. The early years of hydrocarbon extraction was dominated by crude oil production. Such production then transitioned to natural gas in the 1980s with the advent of the petrochemical sector as well as the production of liquefied natural gas in the 1990s (*Bahaw and Furlonge, 2008*). Martin (2009: 153) views the past 63 years as most prominent in the energy sector due to the Trinidad and Tobago Electricity Commission's (T&TEC) natural gas-based electricity generation. T&TEC is the sole authority for electricity technicalities, holding responsibilities for energy resale and fuel sourcing (*Business News Americas, 2010*) and is an entirely state-owned enterprise (*Ministry of Energy and Energy Affairs, 2009*).

Based on the premise of resource security, the Government has implemented an energy subsidy as part of a revenue-generating venture, an economic incentive for transnationals. Lucie-Smith, (2011) quoted the 2010 subsidy bill at TT$2.3 billion, and 2009 at $1.9 billion (*The Guardian Media Limiteda, 2011*). *The Guardian Media Limiteda (2011)* continues, quoting an $11.8 billion subsidy for the last decade. Reports have also been made of a $4 billion subsidy for the last fiscal year. Such operations perpetuate the opinion that sizeable reserves await discovery and that the prospects for carbon sequestration presents a hope for future hydrocarbon longevity (*Persad, 2009*). Such a hydrocarbon-based, economic climate has been subject to criticisms that reserves are dwindling given that production has increased relative to reservoir discoveries.

1.2 The HDC: A Renewable plan

The Ministry of Housing, Land and Marine Affairs has been considering the feasibility of solar water heating on five existing Housing Development Corporation (HDC) homes. The pilot project entitled, "HDC Green- Prototype: Energy Efficient Housing (PEEH) Solar Water Heating Project" is placed under the administration of the Government, Ministry of Energy and Energy Affairs as well as the Renewable Energy Committee. Kowlessar (2011) adds that constructing such "green" units would stimulate capacity building in technology engineering and management, contract procurement, work schedule "greening" and "green" engineering.

1.3 Research Intent and Purpose

The research expands the potential for alternative energy in the context of the solar home using solar arrays as the mechanism for electricity generation. This paper addresses its economic feasibility having considered the natural potential in Part 1 of the study. As such, CO_2 emissions were monetized in the context of the cost of the panels as well as that of national expenditure for a proposed Phase 1 and 2 housing scheme, so adopted to assign monetary values to energy consumption scenarios using a static direct economic valuation method. Given T&TEC's sovereignty over electricity, the financial prospects of the green technology would be compared to that of the domestic residential rates. Relevant comparisons to international energy markets were also included thereby identifying the effect of Trinidad and Tobago's energy subsidy.

The purpose of this study is to assess the economic potential for domestic solar energy utilization in Trinidad and Tobago in the context of the nation's present economy and future prospects.

1.3.1 Objectives

- Investigating the costs of investing in a grid-connected solar system and that associated with conventional electricity generation as well as illustrating the subsidy effect on energy prices

- Incorporating solar energy into Trinidad and Tobago's present economy and assessing its potential for future development as a competitive alternative by creating a large-scale idea of the country's energy generation and assessing how limited reservoirs of natural gas serve to affect energy security

- Establishing some quantitative and monetary prospects for carbon trading and marketing through solar abatement

- Creating a platform through which further analysis and research on the dynamism of Trinidad and Tobago's economic climate and solar energy can be done

2.0 Methodology

2.1 Solar Panel Economics: The Value of the Dollar

The costs associated with conventional electricity consumption and that of the solar system were done for the HDC home (1691kWh), a conservative home (450kWh), an arbitrary average Trinbagonian home (4500kWh) as well as a 6000, 5000, 4000, 3000, 2000 and 1000 kWh consumptive homes. The energy consumption for the HDC and the conservative home were determined by the formula:

$$[\{(2)(C)\}(\sum R)](6) \qquad (1.0)$$

where the 2 was included to cater for the bi-monthly billing regime for the T&TEC system. R represents the rates for that bill statement, \$0.26 for 1-400 kWh, \$0.32 for 401-1000 kWh and \$0.37 for >1000 kWh, where the various ratings would be added for the bi-monthly energy consumption. This would produce the electricity bill for that bi-monthly statement i.e. $[(2)(C)(\sum R)]$, which in turn was multiplied by 6 to assess the billing per year. The costing for the T&TEC billing was tabulated as an annual cumulative account of costs over the 25-year lifetime of the solar panels where the initial costs of inspections and connections were also included. Next, the cost of the solar system was done by first assessing the total power output (PO) of the panel under consideration via:

$$(1.2m2)(149W/m2) = PO \qquad (1.1)$$

where 1.2m2 was the area of the panel under consideration and 149W/m2 the per m2 output. In which case, the formula was modified at the 5th, 12th, 18th and 25th year of the panel lifetime such that it accommodated for losses in panel efficiencies of 5%, 10%, 15% and 20% respectively and where the panels would now show lost efficiency operations (EL) of 95%, 90%, 85% and 80% respectively as well:

$$(1.2m2)(149W/m2)(EL) = POd \qquad (1.2)$$

This would have allowed the costing to factor in any additional panels needed to make up for the energy deficit in this decline in performance over time hence yielding degraded panel performance (POd). The total number of panels for the respective homes was then determined by considering the additional panels needed to buffer the performance decline but using the generic formula:

$$C/PO = \text{Number of panels per home} \qquad (1.3)$$

The cost per panel was used as £100 giving a 973 TTD per panel at a rate of 1£ to 9.73TTD to calculate the total cost of the necessary number of panels for the home using:

$$(\text{Number of panels per home})(\text{Cost per panel}) = \text{Total Panel Cost} \qquad (1.4)$$

As done in the T&TEC billing regime, the costs of installation, maintenance (1 per cent total system cost per annum) and the appropriate inverter for the solar system was added at the respective times along the panel's 25-year lifetime to yield a cumulative account of costs. The above steps yielded a comparative table that displayed costs per year over the panel's lifetime where profits and losses were determined by:

$$\text{Annual T\&TEC cost} - \text{Annual Solar Panel cost} = \text{Loss or Profit} \qquad (1.5)$$

With the costing for both systems determined, the payback periods for making the solar investments for the 6000 kWh to conservative kWh home was determined via:

$$Y + (A/B) = \text{Payback period} \qquad (1.6)$$

Equation 1.6 resulted in the payback periods for the investments where Y was the number of years before payback, A being the total to be paid back to bring the cost to 0, and B as the total sum of money paid back in that year. These values were read off from the tabulation's profit and loss graphs and input into the formula.

The C for each home was used to calculate the CO_2 emissions given that for every 1 kWh used, 0.18 kilograms (Kg) of CO_2 is released. So, too, the market value of the carbon dioxide was also calculated where the rate of US$20 converted to TT$127 (1USD to 6.35TTD) per 1000 kg of CO_2 as given by:

$$C(0.18)(12) = CO_2 \text{ emission per year (Kg)} \quad (1.7)$$

whilst

$$[C(0.18)/1000](127)(12) = CO_2 \text{ market value per year (TTD)} \quad (1.8)$$

The cumulative CO_2 emissions and market value were likewise determined over the 25-year panel lifetime.

2.2 Solar Water Heaters: The Subsidy Effect Identified

The rationale behind the water heating was done on the basis of the formula

$$C = M(Q)(\Delta T) \quad (1.9)$$

where 'C' is again, the energy consumed, but for solely water heating in this context. 'M' is the mass of water given as the 80-gallon tank, 'Q', the specific heat capacity of water (4.186 J/goC) and room temperature as 220 C for 'T'. The 80 gallons was converted to grams where 1gallon = 3780g and ΔT = 29-22 with 29 chosen as an arbitrary temperature to heat the water to. The values were input into equation 1.9 and the resultant joule value was converted to kWh using the rate 1 J = 2.77X10-7kWh. C was multiplied by the number of days in each month to give an energy demand per month (Cm) and then analysed annually as in equation 2.0.

$$\sum Cm = \text{energy consumption per year} \quad (2.0)$$

Using the costing structure in subsection 2.1, the Trinidad and Tobago; Grenada; Alberta, Canada and the United States' cost of heating water by conventional electricity over the solar water heater's 20-year lifetime was determined. The local billing system was used as in the previous subsection with the electricity rating for Grenada; Alberta, Canada and USA quoted as EC$0.4146 per kWh, CAN$0.12903 per kWh and US$0.118 per kWh respectively amongst each region's auxiliary charges (Grenada- 1EC = 3.35TTD; Alberta- 1CAN = 6.47TTD; USA- 1USD = $6.35TTD). The Grenadian and T&TEC rates were then tabulated so that an inter-island cost comparison could be derived as well as to identify the effect of the Trinbagonian energy subsidy on an annual basis. The costs associated with a suitable solar water heater such as system costs and maintenance regime costs were then included at the respective time-frames within the system's lifetime. The CO2 formulae 1.7 and 1.8 were also adapted here to quantify emissions.

2.3 National Economics: Prospects for Trinidad and Tobago

2.3.1 Solar Panels: Import and Shipping

Three methods were used to investigate the shipping costs for the solar panels at the national level. The first was that of UPS shipping and followed the equation:

$$\textit{Total number of panels needed} = (\textit{Number of panels per home})(\textit{Number of homes}) \qquad (2.1)$$

where the number of panels per home was determined by equation 1.3 and the number of homes were identified as 2,300 for Phase 1 and 11,700 for Phase 2.

$$\textit{Total shipment weight} = (\textit{Total number of panels needed})(\textit{Weight of 1 panel}) \qquad (2.2)$$

where the weight of the panel was given on its datasheet as 34.1 lbs. In which case:

$$\textit{Total shipment cost} = (\textit{Total Shipment weight})(\textit{Price per lb}) \qquad (2.3)$$

The price per pound (lb) was given at US$10.14 and converted to TTD using the earlier mentioned exchange rate of US$1 to TT$6.35. The next method was that of the RLV (Recommended Load Volume). This was so done for 20 and 40-foot containers where each had a cost of US$3800 and $5000 per container respectively and again converted using the aforementioned exchange rate. Using:

$$\textit{RLV} / \textit{Volume of 1 panel} = \textit{Number of panels per container} \qquad (2.4)$$

yielded the container capacity where the volume of a panel was found based on its dimensions (1.6m X 0.8m X 0.04m) in the product datasheet. The results were then applied to Phases 1 and 2. Next:

$$\textit{Number of containers required} = \textit{Total number of panels needed} / \textit{Number of panels per container} \qquad (2.5)$$

ultimately leading to:

$$\textit{Total Shipment Cost} = (\textit{Number of containers required})(\textit{Cost per container}) \qquad (2.6)$$

The final method for shipping was using a Volumetric pallet packing. The procedure began using:

$$(\textit{Number of panels per pallet})(\textit{Number of pallets}) = \textit{Number of panels per container} \qquad (2.7)$$

where the 20 and 40-foot containers each had a pallet capacity of 12 and 28 respectively with each pallet holding 26 panels. The remaining procedure for the volumetric packing process followed equations 2.5 and 2.6 for the housing Phases.

2.3.2 Natural Gas: Purchasing and Importation

The 'C' from the HDC home was used as the means to assess the natural gas requirements for the Phases by calculating the volume of natural gas that would be required to power a single home then extrapolating it to the respective Phases. This was likewise done for the CO_2 in the raw natural gas to be used as well as CO_2 actually emitted from use and its associated market values. This was done to assess a one-year period as well as time-frames defined by the lifetime of the reserves under a business as usual scenario (L_b) and a conservative consumption (L_c) scenario. The lifetime of the nation's reserves was first determined using the following equations under two scenarios, a business as usual context:

$$L_b = \text{Volume of natural gas reservoir} / (\text{Volume of domestic consumption} + \text{Volume of exports}) \quad (2.8)$$

and a conservative context:

$$L_c = \text{Volume of natural gas reservoir} / \text{Volume of domestic consumption} \quad (2.9)$$

Here, the size of the reservoir represents proven reserves. The next steps look at the purchasing of extra-regional natural gas from the United States. The U.S. was used to assess this purchase given its potential role as a supplier and given its proximity to the Caribbean region as a world economic giant. Purchasing the gas followed the following procedure:

$$E_{ng} = 1\,ft_3 \text{ natural gas} = 1.1X10_6\,J \text{ (converted to kWh where } 1\,J = 2.77X10_{-7}kWh) \quad (3.0)$$

which yielded the energy in natural gas (E_{ng}) and applied to:

$$V_{ng} = C / E_{ng} \quad \text{(result converted to } m_3 \text{ using } 1ft_3 = .028m_3) \quad (3.1)$$

to yield the volume of natural gas needed to power a single HDC home per month (V_{ng}). Next:

$$[(V_{ng})/1000](\$1034.01TTD) = \text{Cost of Natural Gas Purchase} \quad (3.2)$$

where V_{ng} was divided by 1000 given that the TT$1034.01 was the cost per 1000m_3. V_{ng} was then converted to the mass of natural gas (Mng) using:

$$M_{ng} = V_{ng}\,(1000) \quad \text{(where } 1m_3 = 1000Kg) \quad (3.3)$$

The mass of CO_2 in raw natural gas was then determined via:

$$(M_{ng})(0.02) = \text{Mass of } CO_2 \quad (3.4)$$

where CO_2 was noted to make up 2% of raw natural gas. Whilst the stock market value was determined via:

$$[(\text{Mass of } CO_2)/1000](\$127TTD) = \text{Market value of } CO_2 \quad (3.5)$$

where the division by 1000 was done given that the TT$127 factor was per 1000Kg of CO_2. This CO_2 in raw natural gas was then compared to emission from its usage as found in the single home context in subsection 2.1 but now using the total number of houses in each Phase. For the housing Phases 1 (2,300) homes and 2 (11,700 homes), the energy cost per year was determined by:

$$\textit{Total energy cost per year} = (\textit{Cost of Natural gas Purchase})(\textit{Number of homes})(12) \quad (3.6)$$

This equation included 12, given that the previous single home context in equations 3.0 to 3.6 was done using C, the monthly energy consumption. Whilst:

$$(M_{ng})(\textit{Number of homes})(12) = \textit{Total } M_{ng} \textit{ per year} \quad (3.7)$$

resulted in the weight of natural gas used for the HDC schemes and:

$$(\textit{Market value of } CO_2)(\textit{Number of homes})(12) = \textit{Total } CO_2 \textit{ market value per year} \quad (3.8)$$

gave the market value of the total weight of CO_2 for the respective housing Phases.

The next series of steps assesses the importation costs associated with the purchasing of the necessary volumes of natural gas for the Phases. The price of importation (I_r) was rated at US$5.58 per MMBtu. For the purposes of calculation, the MMBtu was converted to ft_3 then to m_3 and then Kg, where 1MMBtu = $1000ft_3$ = $28.32m_3$ = 28,320kg. It followed:

$$[((\textit{Number of homes})(M_{ng})/(I_r))](12) = \textit{Cost of Importation per year} \quad (3.9)$$

$$(\textit{Cost of Importation per year})(S_L - L) = \textit{Total Importation Cost} \quad (4.0)$$

The (S_L–L) segment of equation 4.0 is defined by the solar panel lifetime (S_L) and natural gas lifetime (L) which gave rise to business as usual scenario as follows:

$$S_L\text{-}L_b = \textit{Number of years that gas would have to be imported in the lifetime panel} \quad (4.1)$$

and the conservative scenario:

$$S_L\text{-}L_c = \textit{Number of years that gas would have to be imported in the lifetime panel} \quad (4.2)$$

in which case each of the scenarios above were applied such that (S_L-L_b) and (S_L-L_c) were factored in. Having derived these time-frames, the costs per year of importing and purchasing were incorporated to yield an overall monetary sum for such an economic venture. CO_2 stock market value and its weight in raw natural gas and emissions were also assessed along these time-frames.

2.4 Solar Panel manufacture, electricity generation and Grid Feedback

The electricity generation capability of the panels was assessed considering the expected reduction in efficiency of output over time by using equation 1.2, where the degradation over time showed that after 5 years it would operate at 95%, 12 years at 90%, 18 years at 85% and 25 years at 80% operability. The total power outputs of the panels at the various intervals were then found using:

$$(PO_d)(\text{Number of panels for HDC home}) = \text{Total degraded output} \quad (4.3)$$

and

$$\text{Total output} / 1000 = \text{Power (kW)} \quad (4.4)$$

where 1 kW = 1000 W. The respective panel output values were then plotted against time to yield a stepped line graph and linear trend line having the equation:

$$y = -0.023x + 3.1152 \quad (4.5)$$

The 'x' variable was substituted by the numerical year to yield a sloping plot as opposed to the original step-like graph, giving a more realistic decline in panel performance over time. By comparing the various output graphs to the HDC home's energy consumption, the potential for excess energy to be fed back to the grid was assessed. Essentially the feedback would be represented by the area underneath the panel output graphs and bounded by the monthly energy consumption line of the home. Next, the carbon dioxide emissions associated with solar panel manufacture was then determined using:

$$C(0.37)(\text{number of homes in HDC Phase}) = \text{Total manufacture } CO_2 \text{ emission} \quad (4.6)$$

where the CO_2 production from solar panel manufacture was at a rate of 0.37 grams per 1 kWh. The number of homes in the respective HDC phases yielded a national emissions scenario which was compared to the CO_2 emissions of the T&TEC regime determined in subsection 2.1 and natural gas importation in subsection 2.3.2.

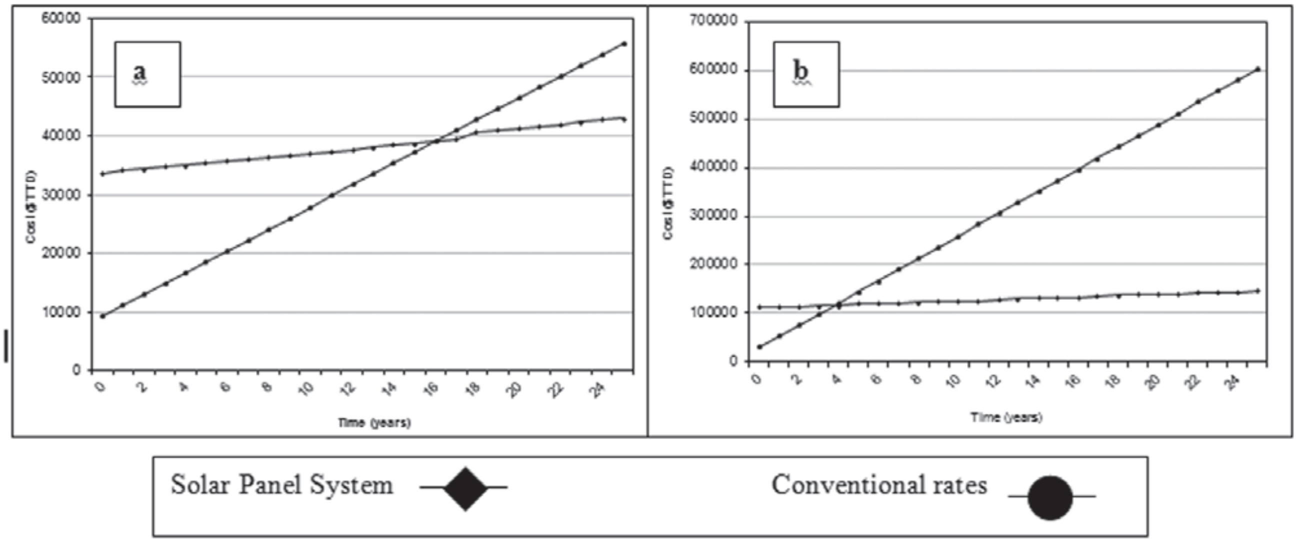
3.0 Results and Analysis
3.1 Solar Economics: The Value of the dollar

3.1.1 Comparative Expenses: Solar versus Conventional Electricity generation

In Figure 3.0, the solar on each graph initially cost more than its competitor as seen from its position. Both parameters show a linear increase over time with conventional electricity having a steeper gradient. The higher solar system initial expense and steeper gradient of the conventional created the intersection on each of the plots.

The range of homes analysed showed these intersections within the first seven years; however the trend was broken by the 450kWh home's intersection occurring in the 16th year. This means that there is some degree of economic viability in solar investments where their cost is seen to be below that of the conventional grid rates as time progresses and payback (near intersection) occurs.

Figure 3.0 Solar Panel costs versus Conventional costs for a conservative (a) and average (b) energy consumptive home



Source: Compiled by Author

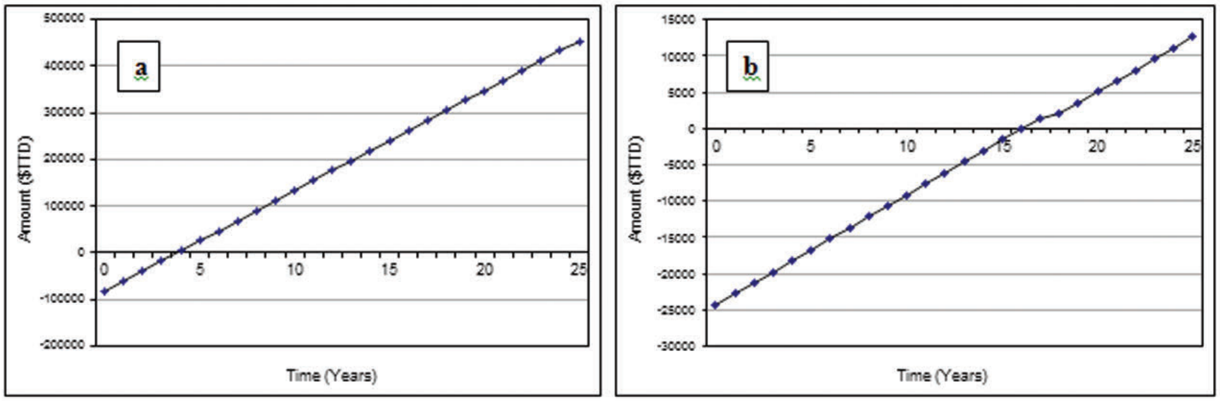
3.1.2 Profits, Losses and Payback periods

Figure 3.1 shows the loss, payback and profit scheme associated with two panel investments. All the graphs derived during analysis show linear trends that are characteristic of a profit-loss graph where regions below the "x" axis represent losses and above the "y" axis, profits. When comparing the expenses (TTD) of the solar panels and conventional bill, it can be seen that, as energy consumption increases, the initial losses associated with solar panels increase from just around $25,000 to $100,000. The graphs however, were dominated by accrued profits during the panel lifetime showing increased savings (TTD) from $80,000 to $600,000, excluding the 450kWh home which showed substantially less profits.

This margin between profits and losses seen as an intersection of the x-axis and linear plot, is the payback period. At this point, the solar panel investments made would have repaid the expenses associated with this initial investment and beyond this, profits are made. Figure 3.2 shows these payback periods as derived from equation 1.6, inferring that as the energy consumption increases, the payback period decreases which means that the investment in solar energy becomes more attractive.

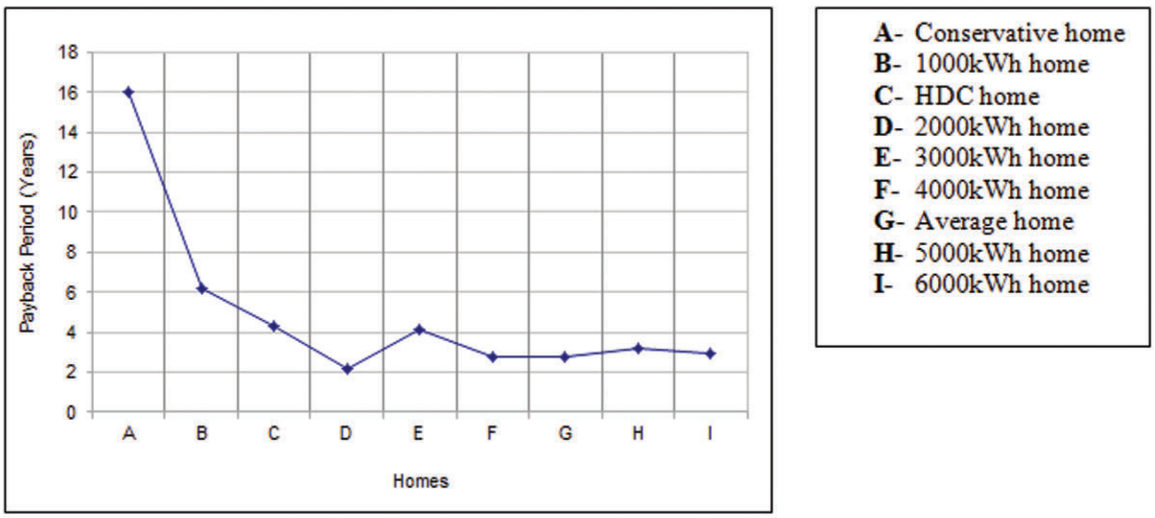
This energy-payback relationship is not, however, a strictly proportional one as can be seen by the kink at E in Figure 3.2.

Figure 3.1 Profits and Losses of investing in solar energy for an average (a) and conservative energy (b) consumptive home



Source: Compiled by Author

Figure 3.2 Payback periods for the range of domestic energy consumptions analysed



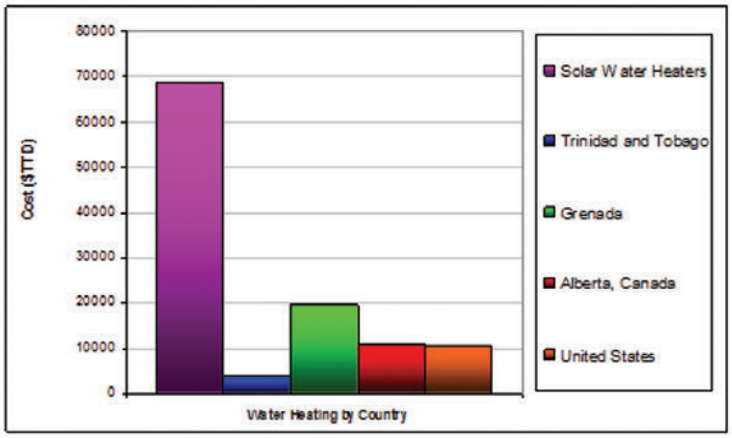
Source: Compiled by Author

3.1.3 Effect of the Subsidy and Domestic energy pricing

Figure 3.3 compares electricity rates between countries and identifies the subsidy through water heating costs versus solar water heating. The investment cost (TTD) for solar water heating of an estimated $70,000 dwarfs that of the grid rates. The flat electricity rate was used to illustrate the subsidy effect and as can be seen in the graph, Trinidad and Tobago's electricity rate and ultimately water heating costs would be significantly cheaper than that of the other territories. Though these figures are defined by equation 1.9, the heating costs would vary especially in the USA and Canada as heated water demands would increase during the winter months.

This subsidy effect was then tested for the full solar array scenario that followed the same methodology as used in the earlier subsection. The resultant costs incurred by an HDC resident to consume electricity from the Trinidadian and Grenadian grid yielded similar graphs to those in Figures 3.0 and 3.1. Implementing solar panels in Grenada seems advantageous as grid electricity rates are higher, but its payback lies between the 20th to 21st year of the investment while in Trinidad and Tobago, payback occurs within the 4th year.

Figure 3.3 Costs of Solar Water Heating, Conventional water heating in Trinidad and Tobago, Grenada, Alberta, Canada and the United States

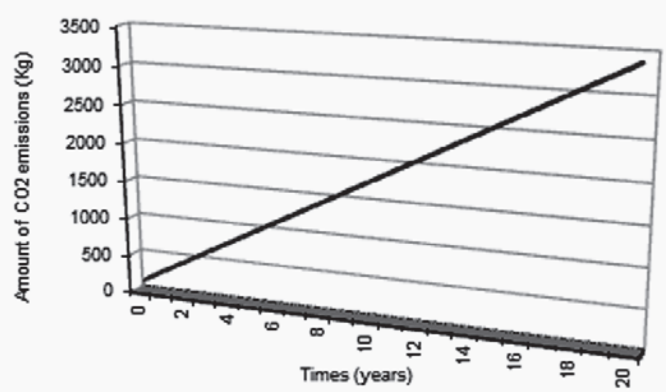


Source: Compiled by Author

3.2 Implications for Global Change: A look at Carbon Dioxide
3.2.1 Solar water Heating and CO2 emissions

Figure 3.4 shows the CO2 emissions that are associated with conventional water heating as defined by subsection 2.3's parameters. The linear trend means that the home would produce such emissions provided that the home users heat the same volume of water to the same temperature over the 20-year lifetime. The CO2 emission abatement is a delicate aspect of solar technology since it is a factor that is dependent on lifestyle; consuming more energy, as in this case, more water or more heat applied to the water would increase emissions.

Figure 3.4 CO_2 emissions associated with the energy consumption for solar water heating



Source: Compiled by Author

3.2.2 Solar Panels and CO_2 emissions

Given that solar panels have been seen as a "green" alternative, one aspect that enforces its branding as clean energy is CO_2 abatement. Given the range of energy consumption scenarios that were presented in the methods, the similar CO_2 quantification methods applied to the solar water heating were applied for the various energy consumptive homes' scenarios. As inferred from the previous subsection, energy consumption slows proportionality to CO_2 production, in which case, the 6000kWh emitted 337,000Kg and the conservative home, 26,000Kg. Likewise, the same trend in the stock market cost of the carbon dioxide was noted whereby the 6,000kWh home incurred a carbon value (TTD) of just under $45,000 and the conservative home, near $5000. Note that such proportionality is a property of the mathematical formulae used and would vary based on such factors as fluctuations in energy usage as a result of lifestyle changes and habits.

3.2.3 CO_2 and the National Economy

The last subsection hinted at carbon trading, but needed a national context; the Phase 1 HDC scheme of 2,300 homes was noted to require 352 million Kg of natural gas to meet the energy needs with the Phase 2, 11,700 homes needing 1790 million Kg (Table 1.0). The energy requirements as shown in subsection 3.3.1, infers a potential strain on present gas reserves given the estimated lifetime of the proven reservoirs. This quantity of natural gas for one year of usage in turn has weighted proportions of 7 and 36 million Kg of CO_2 respectively for the Phases.

However, these quantities represent the amount of carbon dioxide present in raw natural gas, not emissions into the environment. Adapting equations 1.7 and 1.8 to the number of homes under consideration, Phase 1 has the potential to emit near 8 million Kg of the oxide and Phase 2, 43 million Kg in a given year. These derivatives markedly dwarf the CO_2 content of the natural gas which can be attributed to the inefficiencies in electricity generation as well as from the chemistry of natural gas purification and combustion.

Table 1.0 Phase 1 (A) and Phase 2 (B) of the housing scheme's natural gas requirements and CO_2 parameters

A	1 YEAR	15 YEARS	7 YEARS
Natural Gas (mil Kg)	352.0	5419	2287
CO2 in raw natural gas (mil Kg)	7.000	108.0	46.00
Value CO2 in raw natural gas (mil TTD)	0.900	13.90	6.000
CO2 emitted from HDC homes (mil Kg)	8.400	129.4	54.60
Value of CO2 emitted from HDC homes (mil TTD)	1.060	16.40	6.930
B	**1 YEAR**	**15 YEARS**	**7 YEARS**
Natural Gas (mil Kg)	1790.0	27563	11634
CO_2 in raw natural gas(mil Kg)	36.000	551.00	233.00
Value CO_2 in raw natural gas (mil TTD)	5.0000	71.000	30.000
CO_2 emitted from HDC homes (mil Kg)	42.700	658.00	277.00
Value of CO_2 emitted from HDC homes (mil TTD)	5.4300	83.600	35.200

Source: Compiled by Author

Note the 15-year and 7-year periods represent the number of years natural gas would be imported as defined by equations 2.8 and 2.9 and the lifetime of the panel (i.e. panel lifetime- reservoir lifetime)

3.2.4 Manufacturing Solar Panels: CO_2 production

In the energy arena, solar has been hailed as "clean" technology given its CO_2 abating potential. However, whilst it may seem to be a zero carbon form of electricity generation, its manufacture is not. From Table 1.1 manufacturing the 40,000 and 200,000 panels for the Phase 1 and 2 schemes emits estimates of 1.4 million Kg and 7.4 million Kg. This is starkly contrasted with the conventional's emissions over the 25-year panel lifetime producing 218 million and 1,111 million Kg.

After comparing both energy types' emissions, it can be seen that solar energy indeed has the environmental edge since emissions come only from its manufacture whilst that of T&TEC results from energy usage not to mention the extraction and processing methods for the natural gas (not covered in the scope of analysis). This means that such a solar scheme would represent a significant mitigation option should the nation invest in this solar alternative.

Table 1.1 Solar Panel CO_2 emissions from manufacture and emissions from conventional HDC electricity use

	HDC Phase 1	HDC Phase 2
CO_2 emitted from Solar Panel Manufacture (mil Kg)	1.44	7.35
Value of CO_2 emitted from solar panel manufacture (mil TTD)	0.18	0.93
CO_2 emitted from HDC home conventional electricity use (mil Kg)	218	1,111
Value of CO_2 emitted from HDC home conventional electricity use (mil TTD)	27.7	141.1

Source: Compiled by Author

Note that the HDC home CO_2 valuation was done based on the cumulative emissions over the 25-year lifetime of the panels.

3.3 National Economics: Prospects for Trinidad and Tobago
3.3.1 Natural Gas: Importation, Production and Consumption

From Figure 3.5, a common observation can be seen on both graphs; the actual cost of purchasing natural gas from the U.S. market should Trinidad and Tobago be put in the various sub-scenarios, would be the bulk cost of the importation. The three scenarios presented represent importation scenarios for the country in the context of satisfying HDC energy demands.

The first scenario assesses a one-year period for the homes: the second, a roughly 15-year period and the third, an estimated 7-year period. In referring to Table 1.2 and the lines after Table 1.0, the lifetime of the natural gas reserves were seen to be 9.6 years and 18.5 years. The periods mentioned are as a response to the costs of import and domestic consumption of the hydrocarbon after the 9.6-year "business as usual" lifespan (sub-scenario 2) and after the 18.5-year period (sub-scenario 3), based on the import and consumption after the attenuation of natural gas usage such that only domestic consumption exists. These were so done in the context of the 25-year solar panel lifetime.

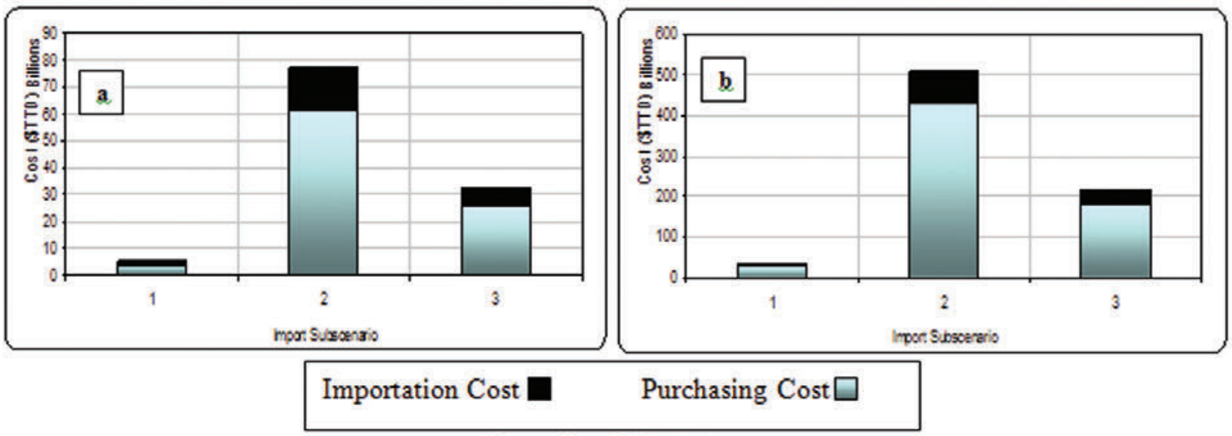
Table 1.2 Trinidad and Tobago's natural gas logistics and estimated reservoir lifetimes

Proven Reserves (bil m^3)	Import (bil m^3)	Export (bil m^3)	Consumption (bil m^3)	Production (bil m^3)	L_b	L_c
408.2	0.000	20.41	21.97	42.38	9.6	18.6

Source: Compiled by Author and Extracted from Indexmundi.com

Note that the Production equals the Export plus Consumption, Lb represents the business as usual and Lc conservative scenarios outlined in the subsection 2.3.2

Figure 3.5 Natural Gas Import scenario for HDC Phase 1 (a) and 2 (b) using the long term Louisiana HUB terminal gas market price



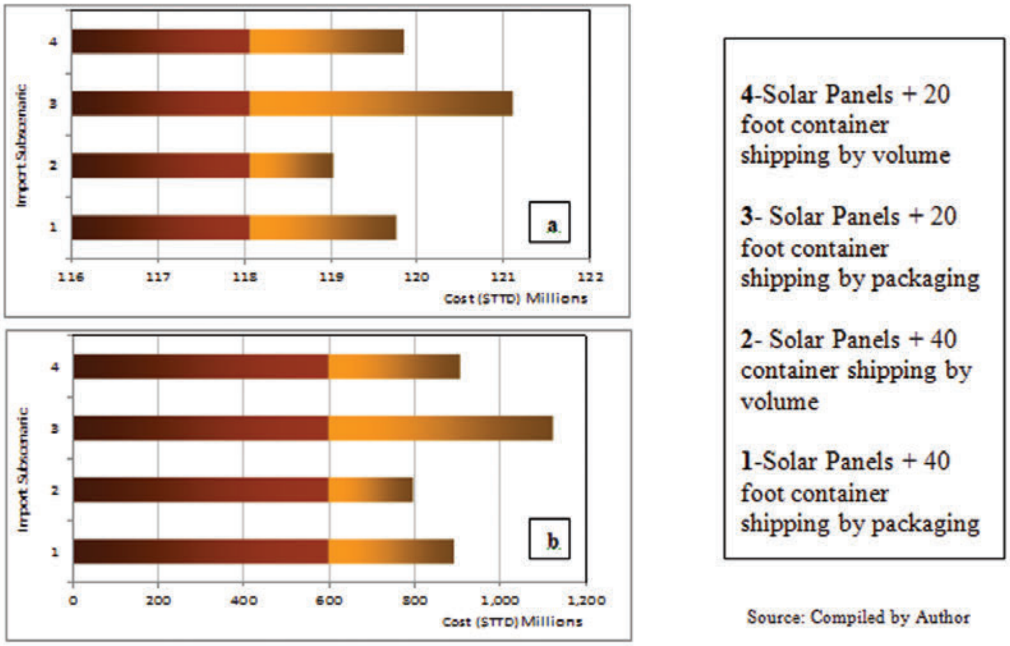
Source: Compiled by Author

3.3.2 Solar Panel: Imports and Shipping

The various scenarios shown in Figure 3.6 are for the Chinese brand, SunTech, where the costs represent the shipping from the eastern territory to Trinbagonian waters. One noticeable aspect of the two graphs is that the bulk cost of importation is attributable to the panels themselves. Phase 1 of the scheme incurred importation costs (TTD) from $119 million to just eclipsing $121 million and Phase 2, just over $800 million to $1 billion.

Both phases have been quoted for the scenarios in subsection 2.3.1. Though not included in the figures below, the UPS importation estimated near 3 to 560 billion for the respective housing phases. As such, the 40-foot containers showed all indications of being the most economically viable option for imports.

Figure 3.6 Solar Panel Import scenarios for HDC Phase 1 (a) and Phase 2 (b)



Source: Compiled by Author

3.3.3 Solar Electricity Generation and Grid Feedback

Graphically, the energy needed to power the HDC home yields a horizontal linear trend, a constant electrical power of 2.35 kW. This horizontal form is only a representative benchmark to which energy generation could be compared. It does not represent a realistic consumption of energy since such patterns would fluctuate with the consumer's lifestyle. The solar panels' plotted power output however shows a stepped trend. From a peak of 3 kW in the first five years, the solar panels then produces 2.8 kW power output for the next seven years continuing to 2.7 kW from year 13 to 18 and finally 2.5 kW for the remaining time period until year 24, just exceeding the 2.35 kW (from equation 1.2). The conversion of this stepped trend into a linear one via extrapolation, illustrates a more realistic decrease in performance over time as a gradual depreciation (from equation 4.5). Essentially, the area underneath the solar panel output line bounded by the HDC power requirement plot represents the potential energy to be sent back to the national grid from a single HDC home.

4.0 Discussion

Energy is one of, if not the most important aspect of society's functionality (*Abdulkarim, 2009*). Such is its significance that economic activity has usually been viewed as having three main inputs in the form of land, labour and capital. However, a fourth, energy, has also been identified as crucial to the progression of society (*Imran and Siddiqui, 2010; Erbaykal, 2008*). There has also been a strong correlation between electricity consumption and economic development (*Erbaykal, 2008; Yee et al., 2008*). The UNFCCC (2007; 7) has noted that as economic development increases, so too does the demand for energy and, as a result, emissions of greenhouse gases also increase. As such, diversifying an economy's energy base not only decreases its vulnerability to shortages but offers avenues for revenue generation and energy sale.

Whilst the natural prospects for solar energy show marked degrees of promise, the economic aspect of such investments would be the influential, if not the determining factor in its true potential for implementation. Table 1.2 notes that the nation's gas reserve life-time is quite limited, in which case the payback periods for many of the panels are within the reserve's lifetime and places solar as a viable prospect. The HDC home falls within the rough 5-year payback period. It has been deduced that the lower energy consumptive homes are favoured to be billed under T&TEC's scheme whilst the high to moderate demanding units are more economical using the solar system. This introduces atmospheres of lifestyle change and cultural perceptions of energy conservation attitudes adopted to practise low consumerism. But should it be that conservation in itself be promoted and by its supposed success continue hydrocarbon usage ("hydrocarbon conservationism")? Or should alternative energy be seen as the way forward and, with it, continue the prevalent mass consumerism ("renewable consumerism") that exists today?

Adopting a "hydrocarbon conservationist" attitude would indeed reduce oil and gas consumption but it does not take away the culture of dependence. It would extend the longevity of the proven reserves but energy generation would still be based upon a finite resource. This also presents the environmental considerations that make up part of the discovery and extraction phases of hydrocarbon extraction. Whilst household consumption becomes more resource-conscious in this case, the potential for oil spills, gas releases, equipment processes and material waste disposal are continuing issues to be addressed in the oil and gas industry. For example, in looking at the broader issues of the environment, would the energy and resources saved from a conservative home warrant the deforestation and drilling to tap an oil/gas reserve in a forest to satisfy the dependency on the resource? This is a trade-off where the positives of energy conservation translate into environmental costs in another part of our natural capital.

However, should the 'renewable consumerism' perspective be adopted, it may hold implications for other aspects of environmental issues that are not facilitated by the infinite resource under consideration. Whilst this solar energy concept addresses the household energy use, hence ultimately reducing the carbon footprint of the household, by keeping the same consumerist lifestyle, the same daily routines may be followed, such as using gasoline vehicles which continue the emissions of CO_2, or even the type of items purchased, where products with a greater carbon footprint and more resource-intensive manufacture and distribution process would still be bought.

Essentially what would occur is an informal transfer of abated emissions from using the household solar scheme to the manufacturing industries. This is a similar concept to the more formal global carbon-trading scheme except that here, there is no framework where costs or penalties are attached to this inferred transfer of emissions. As consumption increases, manufacturing of these processed and highly packaged goods/services would increase and, with it, the emissions from the manufacturing sector. It seems that there needs to be an integration of both technology and culture, whereby attitudes to generic consumption and environmentally assertive resource technology are adopted so as to have a reduced ecological footprint.

Timely implementation is key to this transition where, given the 10-year period of gas under present consumption conditions, and the longest relevant panel payback of seven years, gives the nation will have a 3-year window of planning and implementation, a window not being opened but rather closed as consumption increases. The UNFCCC (2005; 8) has noted that the Caribbean as a region only generates two per cent of its energy via renewable sources. By 2015, the UNFCCC (2005; 8) projects an increase to five per cent with the potential to abate 680,000 tons of CO_2. Consider this time-line in the context of the supposed 3-year window outlined earlier. Note that should the nation invest in such a solar scheme, 28,000 and 141, 300 tons of CO_2 can be abated from Phases 1 and 2 respectively.

Even though the panels initially emit more CO_2 during manufacture, using solar panels abates more CO_2 over their lifetime. A framework for carbon credit schemes allows continued emissions but places a price tag on emissions. A quoted number of credits can be purchased from another source that has reduced its emissions (earning credits) and worth a resale per ton of CO_2 (*Carbon Investments, 2011*). A cap is also introduced on emissions, idealising the cap and trade initiative where an imposed limit on industrial emissions involves the use of the credits for trading (*Ecomii, 2012*). Apart from the positives being the carbon abatement, Ecomii (2012) has identified a negative: consumer-borne costs associated with the cap on industries.

Since energy production is an inelastic good (*Ecomii, 2012*), any change in the price of energy does not instigate a drastic change in energy demand. This effect is more so pronounced where Trinidad and Tobago is concerned, given that the present subsidy buffers the energy costs that are borne by the individual consumer. Such an effect rears up the purchasing parity for solar energy as a stronger economic contender with oil and gas. McDermott (2011) has expected that by 2015 solar energy will become cheaper than oil and gas-derived electricity obeying the supply and demand laws; hydrocarbons would become limited and thus would demand a higher price. Interestingly, the 3-year transition window identified earlier takes the nation into McDermott's 2015 scenario in a context of timing, warranting some governmental discourse. Such a move involves capacity building and energy independence, where Griffin and Karolyi, (1998) have postulated that the renewables' rise can be attributed to the access and utilisation of local sources of energy. However, this use of local resources also accounts for Trinidad and Tobago's heavy reliance on natural gas, since the data also revealed that the country does not import any gas (*Index Mundi, 2011*).

The notion of lifestyle relates energy consumption to the household expenditure per capita in which case, as the standard of living increases so, too, does the energy consumption (*Mazur, undated*). Moske (undated) exemplifies this relationship as Americanized consumption. Hubacek et al (2012) identifies this increase in affluence as a main factor in China's CO_2 emissions surge. He identifies a rural-urban lifestyle differentiation; urbanism is becoming westernized and he stresses the need for a change in consumption patterns. Given Trinidad and Tobago's even closer geographic location to the North American continent than the Chinese mainland, the nation's population is all the more influenced by the lifestyle and media branding of western consumerism as is becoming increasingly evident in today's society. This once again highlights the consideration of the "hydrocarbon conservationist" and "renewable consumerism" lifestyles. Vale and Vale (2010) also adds that implementation of energy efficient systems also paved the way for increased energy consumption, with this advancement in performance so done from economic standpoints and not environmental sustainability. Hubacek et al (2012) adds that advancements were not able to reduce greenhouse gas emissions since consumption rates were too high. The I=PAT formula illustrates the lifestyle-energy-consumption interaction where "I" is the impact on the environment, "P", population size (1.3 million in Trinidad and Tobago (*BBC, 2012*)), "A", the affluence as discussed and "T", the technology inferring the efficiency implications outlined (*Primack, 2006:176; Hubacek et al., 2012)*. In saying that energy efficiency has led to increases in consumption, the "renewable consumerism" attitude may be realised, provided that there is a virtually inexhaustible source of energy, in this case the sun, coupled with the continuous advancements in the efficiency of solar technology.

In light of the energy environment's background, it can be noted that even in the wake of several ideas and concepts put forward to address consumption and the associated environmental ethics, there has been a perpetuation of the "business as usual" attitude in today's society, such that where consumerism and energy coalesce, this trend is expected to increase for the next 20 years (*The Future Policy.org, undated*). This attitude is fuelled by the oil and gas economy with promises of future reserve discoveries allowing the consumer, the man on the ground, to be comfortable with his energy use. This continues despite warnings that the oil economy can falter, reserves are low and the prices are high (*The Guardian Media Limitedb, 2011*). When this theme of energy security is addressed, it seems that society puts its faith in this economic "luck" of hydrocarbon discovery, as opposed to the certainty of renewable consistency.

5.0 Conclusion

This static direct valuation used in the study sets the stage for which another study is to be done to capture the effects of the economy's dynamism. This would factor in interest and inflation rates, in which case the subsidy effect identified here can be explored in the context of the global decrease in solar panel prices, given the repercussions of the global Chinese solar panel trade imbalance. Despite this outstanding analysis, this present study shows that the moderate to high energy demanding homes are seemingly more economical than conservative homes. Solar panel importation costs are also showing indications of being more cost effective than that of natural gas. Though the U.S. was used as the theoretical supplier of natural gas in the depletion scenarios, it is expected that as importation distance increases, so should the price. This relationship would of course be skewed when political/multilateral international agreements involving energy trade and sales are introduced. Ultimately, Part 1 gives substantial support for solar energy's implementation as a function of natural availability, but this Part 2 of the study reveals that the hydrocarbon energy subsidy is the economic giant that stands to thwart renewable energy's diversification prospects in the context of the socio-cultural attitudes towards energy consumption.

6.0 Acknowledgements

I thank God for the guidance and ambition to pursue such national research. Thanks are offered to Alana Green, the HDC home owner, having been given free access to her electricity records and allowed a site visit to her home. Special thanks are offered to my mother, Fermada Mohammed, for allowing the use of our electricity records in the study as well as always believing in my efforts as a parent and friend. I also thank Dr. Matthew Wilson and Dr. Reynold Stone for their supervision and guidance during the research's phase as an undergraduate final year project. Thanks to Mr. James Husbands and Solar Dynamics Limited for their input with respect to the solar water heating. I also offer thanks to the contributing organisations, websites and online interfaces/resources.

7.0 References

Abdulkarim T. (2009). Techno-Economic Analysis of Solar Energy for Electric Power Generation in Nigeria. AU Journal [online]. 8(4): pp. 215-221, Available from: http://www.journal.au.edu/au_techno/2005/apr05/vol8no4_abstract09.pdf (accessed 15/03/2011)

Bahaw E. and H. Furlonge. (2008). A Review of the Dynamics between the Energy sector and the Economy of Trinidad and Tobago. University of Trinidad and Tobago. Presented at 3rd Tobago Gas Technology Conference, Lowlands Tobago, October 7th to 10th, 2008. Available from: http://u.tt/ngia/papers/tgtc_2008_dynamics_energy_economy.pdf (accessed 4/12/2012)

BBC. (2012). Trinidad and Tobago. Sport Olympics. Available from: http://www.bbc.co.uk/sport/olympics/2012/countries/trinidad-and-tobago (accessed 3/10/2012)

Business News Americas. (2012). Trinidad and Tobago Electricity Commission: Description. Available from: http://www.bnamericas.com/company-profile/en/Trinidad_and_Tobago_Electricity_Commission-T*TEC (accessed 21/02/2012)

Carbon Investments. (2011). What are carbon credits? Available from: http://www.carbon-investments.co.uk/ (accessed 7/03/2012)

Ecomii.com. (2012). Cap and Trade. Available from: http://www.ecomii.com/ecopedia/cap-and-trade (accessed 7/03/2012)

Erbaykal E. (2008) Disaggregate Energy Consumption and Economic Growth: Evidence from Turkey. International Research Journal of finance and Economics. 20: pp. 172-179

Griffin M. and G. Karolyi. (1998). Another look at the role of the industrial structure of markets for international diversification strategies. Journal of Financial Economics. 50: pp. 351-373

Hubacek K., et al. (2012). Changing lifestyles towards a Low carbon Economy: An IPAT analysis for China. Energies, 5: pp. 22-31
Imran K. and M. Siddiqui. (2010). Energy Consumption and Economic Growth: A Case Study of Three SAARC Countries. European Journal of Social Sciences. 16(2), 2: pp. 06-213

Index Mundi.com. (2011). Trinidad and Tobago Economy Profile 2012. CIA World Fact Book. Available from: http://www.indexmundi.com/trinidad_and_tobago/economy_profile.html (accessed 19/02/2012)

Kowlessar G. (2011). John reads riot act. The Guardian Media Limited. Available from: http://www.guardian.co.tt/news/2011/01/30/john-reads-riot-act (accessed 15/01/2012)

Lucie-Smith W. (2011). Fuel subsidies and the budget deficit. The Trinidad Express. Available from: http://www.trinidadexpress.com/commentaries/Fuel-subsidies-and-the-budget-deficit-117219578.html (accessed 11/01/2012)

Martin L. (2009). Power to the People: electricity, oil and gas in Trinidad and Tobago. Trinidad and Tobago: Celebrating a century of Commercial oil production. Government of Trinidad and Tobago. pp. 153-156 Available from: http://www.energy.gov.tt/content/Centenery_Pub_Leo_Martin.pdf (accessed 13/01/2012)

Mazur A. (undated). Energy Consumption, electricity and Lifestyle in Industrialised Nations. Center for Environmental Policy and Administration, Syracase University. Available from: http://cepa.maxwell.syr.edu/papers/107/Mazur-2010-07b.pdf (accessed 19/02/2012)

McDermott M. (2011). Solar Prices Falling Quickly, Cheaper than the Grid by 2015 in Places. TreeHugger. Available from: http://www.treehugger.com/renewable-energy/solar-power-prices-falling-cheaper-than-grid-2015.html (accessed 27/03/2012)

Ministry of Energy and Energy Affairs. (2009). Electric Power. Government of Trinidad and Tobago. Available from: http://www.energy.gov.tt/energy_resources.php?mid=9 (accessed 13/01/2012)

Moske S. (undated). How many Energy servants are supporting your Lifestyle? Natural Life Magazine.com. pp. 22-25. Available from: http://ehis.ebscohost.com.login.ezproxy.library.ualberta.ca/eds/pdfviewer/pdfviewer?sid=b74984a2-1f46-463d-ac62-0222d7814e6e%40sessionmgr10&vid=1&hid=2 (accessed 19/02/2012)

Persad K. (2009). The Petroleum Geology and Prospects of Trinidad and Tobago. Trinidad and Tobago: Celebrating a century of Commercial oil production. pp 179-186. Available from: http://www.energy.gov.tt/content/Centenery_Pub_Krishna_Persad.pdf (accessed 23/02/2012)

Primack R. (2006). Essentials of Conservation Biology 4th Edition. Sinauer Associates Incorporated, Sunderland, MA.

The Future Policy.org. (2007). .How much Energy do we consume? World Future Council and Climate Parliament. Available from: http://www.futurepolicy.org/2737.html (accessed 7/03/2012)

The Guardian Media Limiteda. (2011). Subsidies/transfers: $23 billion of budget. Available from http://www.guardian.co.tt/business-guardian/2011/12/08/subsidiestransfers-23b-2012-budget (accessed 15/01/2012)

The Guardian Media Limitedb. (2011). Future of Oil on the Block. Available from http://www.guardian.co.tt/editorial/2011/02/22/future-oil-block (accessed 15/01/2012)

UNFCCC. (2005). Climate Change: small island developing states. UNFCCC Climate Change Secretariat.

UNFCCC. (2007). Uniting on Climate Change: A guide to the Climate Change Convention and the Kyoto Protocol. UNFCCC Climate Change Secretariat

Vale B. and Robert Vale. (2010). Domestic energy use, lifestyle and POE: past lessons for current problems. Building Research and Information. 38(5): pp 578-588

Yee T., et al. (2008). Solar Energy Potentials and Applications in Myanmar. World Academy of Science, Engineering and Technology. 42(74): pp 397-400

10.

Development of Biotechnology in India Role of Public Policies

Kavita Mehra, Priti Chopra and Sunil Chopra

National Institute of Science Technology and Development Studies India

kavitamehra@yahoo.com
priti4env@gmail.com
chopra.biotech786@gmail.com

Abstract

Biotechnology is globally recognized as a rapidly emerging and far-reaching technology. India made an early beginning in 1982 by establishing the National Biotechnology Board (NBTB) under the aegis of the Department of Science and Technology and subsequently, in 1986, as an independent Department of Biotechnology (DBT) under the Ministry of Science and Technology. The focus was on human resource development, R&D capabilities, and infrastructure development.

In 2007, the National Biotechnology Development Strategy (NBDS) was released, which re-defined three general goals aimed at strengthening biotechnology in India—the development of human resources, the strengthening of infrastructure, and the promotion of trade and industry. In line with the NBDS, DBT announced that 30 per cent of its budget would go towards public private partnership programmes (PPP) to accelerate bio-industrial growth. This paper describes the government's efforts and the status of these goals.

In financial year 2011-12, India's biotech industry registered 15.08 per cent growth with revenues of more than INR 200,000 million. Biopharma was the lead sector with a revenue share of 62% of the biotech industry. Of the 350-plus companies operating in this sector, the top revenue earner of 2011-12 was Serum Institute of India with INR 10, 041 million.

Keywords: **India Biotechnology policy, Biotech industry, Institutional Framework, Human resource, Infrastructure, Pharmaceutical sector**

1. Introduction

Biotechnology is defined by the OECD (2005) as "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services." In other words, biotechnology is derived from biological knowledge and is associated with the evolution of biological science.

Biotechnology has touched every corner of the world and made a significant impact on applications to the environment, drugs, vaccines including a range of biopharmaceuticals, diagnostics, transgenic crops, tool improvement for upgrading animal reproduction and quality, useful microbes and food ingredients. As an amalgamation of biology and technology, the term "biotechnology" draws on such disciplines as molecular modeling, genomics, bio-informatics, bio-simulation, clinical information and many others.

Significant opportunities exist for the growth of biotechnology in the region, particularly in the agriculture and healthcare sectors, due to large and expanding markets for food products and pharmaceuticals for the growing population. (*Kumar and Srivastava, 2011*)

Biotechnology is globally recognized as a rapidly emerging and far-reaching technology. In its draft for the National Biotechnology Developmental Strategy (*DBT, 2007*), the Department of Biotechnology describes biotechnology as the "technology of hope" for India due to its potential as a powerful enabling technology for revolutionizing agriculture, healthcare, industrial processing and environmental sustainability. Its output includes a large number of therapeutic biotech drugs and vaccines which account for a market of US$40 billion, and which benefit more than a hundred million people worldwide. India has been ranked among the top 12 biotech destinations worldwide and the third largest in the Asia-Pacific region (*IBEF, 2013*)

2. Early Government Initiatives

India's era of biotechnology began in the 1980s with the establishment of the National Biotechnology Board (NBTB) under the aegis of the Department of Science and Technology. It was set up as an inter-departmental body in 1982, with the objective of promoting large-scale use of biotechnology products and processes. In the 1983 Long Term Plan in Biotechnology, the NBTB identified a set of national objectives including self-sufficiency in food, housing and clothing, as well as a balance in international trade. To promote the development of innovation-based products and processes in the various fields of biotechnology, the Indian government established an independent Department of Biotechnology (DBT) in the Ministry of Science and Technology as early as 1986, long before "biotechnology" became a buzzword (*Singh, 2011*).

This was the platform for the development of biotechnology which occurred through five distinct phases: initial foundation phase, capacity building, research and development, institution building and promotion of innovation and excellence in India (*DBT, 2011*).

Several central government ministries are involved in biotechnology development either through providing education (graduate, post-graduate, doctoral and post-doctoral), faculty training, industrial training, fund allocation, fellowships for R&D and infrastructure development etc. The ministries involved are:

- Ministry of Human Resources and Development (MHRD
- Ministry of Science and Technology (MST)
- Ministry of Health and Family Welfare (MHFW)
- Ministry of Agriculture (MoA)

(*Joshi et al. 2013*)

Six separate agencies under these ministries are responsible for financing and supporting research in the diversified field of biotechnology. (Figure 1).

- Department of Science and Technology (DST)
- Department of Biotechnology (DBT)
- Council of Scientific and Industrial Research (CSIR)
- Indian Council of Medical Research (ICMR)
- Indian Council of Agriculture Research (ICAR) and University Grants Commission (UGC)
- Department of Scientific and Industrial Research (DSIR)

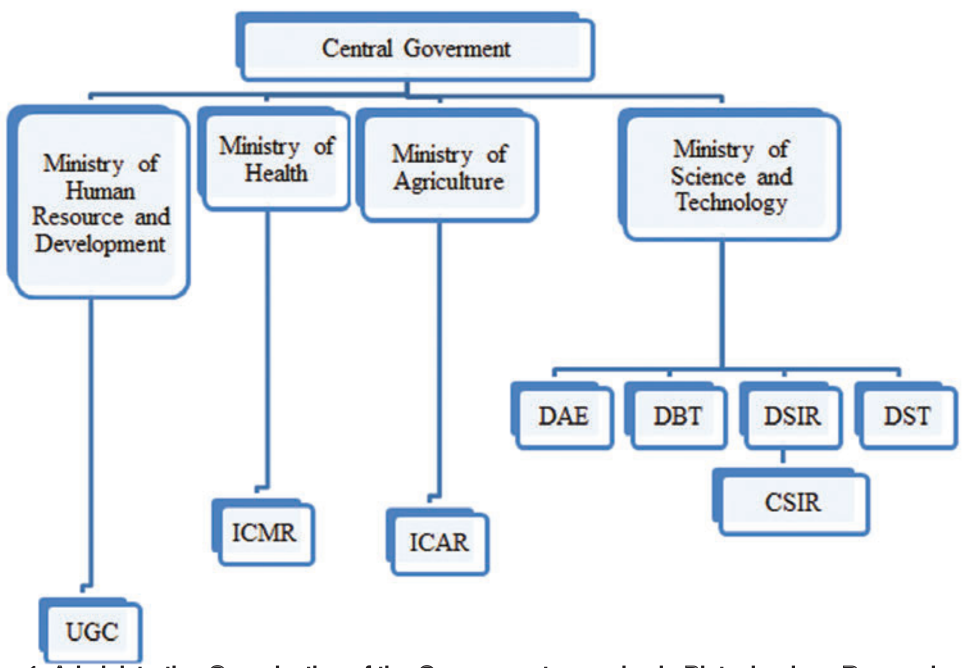


Fig. 1: Administrative Organisation of the Government agencies in Biotechnology Research and Development (RIS, 2002)

DST, DBT and DSIR are part of the Ministry of Science and Technology, ICMR is with the Ministry of Health, ICAR with the Ministry of Agriculture and UGC with the Ministry of Human Resource and Development. DSIR is the funding agency for CSIR and both of them independently fund biotechnology-related research programmes. Out of this, DBT is the only agency completely devoted to R&D in biotechnology (*RIS, 2002*).

A) Budget allocation

In the Seventh Five Year Plan (1985-90), NBTB's biotechnology plan was given considerable importance. Emphasis was on manpower development and the launch of a few multidisciplinary and multi-institutional programmes in biotechnology. Government funding for the Department of Biotechnology (DBT) has increased by almost 37.5 per cent over the period from the 8th to 12th Five Year Plans (Figure 2).

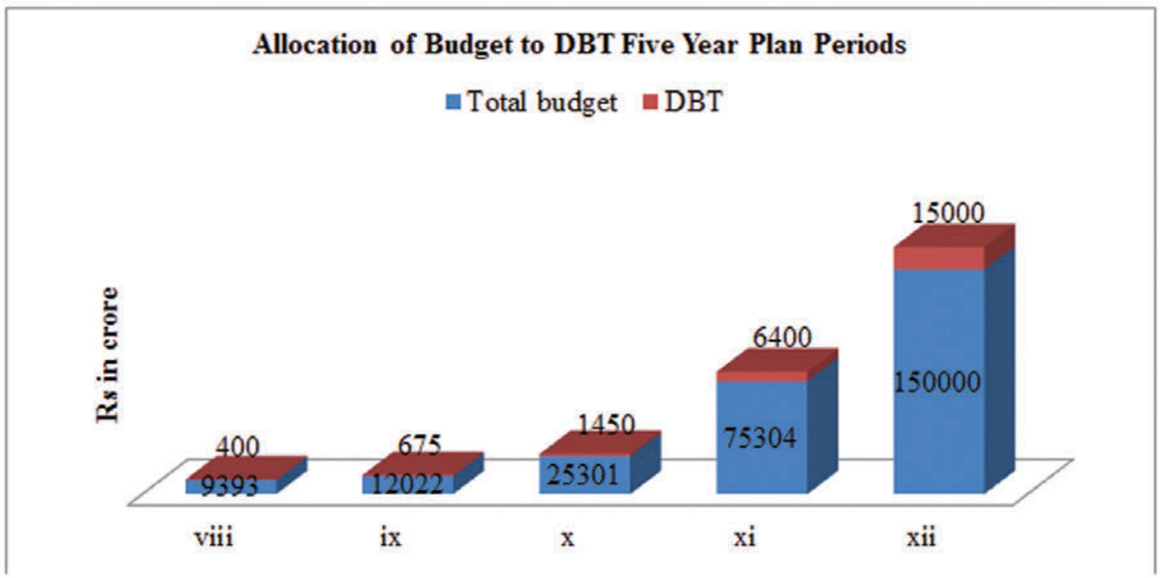


Fig 2:- Allocation of budget of DBT five year plan period (IBEF 2013)

The 11th Plan proposals of the Department were based on the National Biotech Development Strategy (NBDS), which was formulated through wide-ranging consultations involving many stakeholders. Its overall vision was to "create tools and technologies that address the problems of the largest section of the society, to provide products and services at affordable prices and make India globally competitive in the emerging bio-economy".

Under the 12th Plan, the DBT dedicated one-third of its budget to public-private partnership programmes. It also placed a focus on strengthening India's capacity for global competitiveness by focusing on human resource development, R&D infrastructure and boosting collaboration and partnership with public sector institutions, universities and the private sector (*DBT, 2011*).

DBT and other organizations have proactively engaged a number of initiatives in human resource training, established institutional infrastructure (e.g. microbial culture collections, cell and tissue lines, gene banks laboratory animals, facilities for oligonucleotide synthesis, etc.) and built a strong research base in areas relating to agriculture and forestry, human health, animal productivity, environmental safety and industrial production.

B) Human resource development

India has many assets including a strong pool of scientists and engineers, a vast institutional network and cost effective manufacturing. The Government of India has emphasised the building of world class human capital for the growth of science, technology and innovation in BT sectors. Close to 400 universities and 100 research institutes have been established in India to develop skilled human resources. Five new institutions—Indian Institutes of Science, Education and Research – have been established broadly along the lines of the Indian Institute of Sciences (IISc) in Bangalore and are devoted to science education and research. Fifteen new federal universities have also been established in science research. Similarly, existing university departments have been re-engineered to provide quality education and research in basic sciences (*Bhan, 2013*). One million fellowships have also been awarded through the INSPIRE programme to attract talented young people to the study of science at an early age and thus build the required critical human resource pool for strengthening and expanding the country's science and technology and R&D base. The Government of India has introduced several schemes and programmes for strengthening human resources through scientific education and capacity building for innovative technology development.

Biotechnology depends heavily on qualified technicians. In this regard, DBT has made a major thrust in the area of biotech education in order to provide an impetus for the development of biology and biotechnology. Given the multidisciplinary nature of biotechnology education, programmes have been developed to meet the growing demand for trained manpower for any meaningful biotechnology activity in the country. To ensure that students are exposed to recent developments in genetic engineering and biotechnology as well as their use in industry, agriculture and medicine, the programmes have been developed at various levels:

a) School level: Innovation in Science Pursuit for Inspired Research (INSPIRE) by DST under which financial assistance is provided to students under the Scheme for Early Attraction of Talent for Science (SEATS), Scholarship for Higher Education (SHE) and Assured Opportunity for Research Careers (AORC).

b) Undergraduate level: Star College Scheme (by DBT) for improving the teaching of the biotechnology component in existing courses, Centers with Potential for Excellence by UGC, post metric scholarship for SC/ST, Metric Cum Means (MCM) scholarships and National Talent Scholarships (NTS) by ICAR. Star College Scheme has two components viz. the strengthening of support for undergraduate education and the award of Star College status. So far, 86 colleges have been supported under the "strengthening of support" component, under which one-time non-recurring grants of Rs. 5.00 lakhs per department and recurring grants of Rs. 2.00 lakhs per year per department are provided. Twelve colleges in Tamil Nadu followed by eleven in Maharashtra benefited under the Scheme. During 2012-13, 31 new colleges were supported, of which nine were from the North Eastern Region.

An analysis of the impact of the Star Scheme programme reveals that the infrastructure strengthening has resulted in better libraries, increased membership to e-journals etc., enhanced opportunities for interaction by students and faculty with leading experts, faculty improvement programmes for UG teachers through various modes, and more training programmes for laboratory staff and lab technicians.

c) Postgraduate Programme:

There are 72 universities conducting biotech courses. DBT initiated a Masters in Biotechnology programme during 1985-90, which was followed by a large number of masters courses in the period 2002-07. Postgraduate courses in various fields of Biotechnology are offered in 70 universities in India with the support of the University Grants Commission. These courses range from general biotechnology to specialized fields such as medical, agricultural, marine, veterinary and industrial biotechnology among others. (Figure 3)

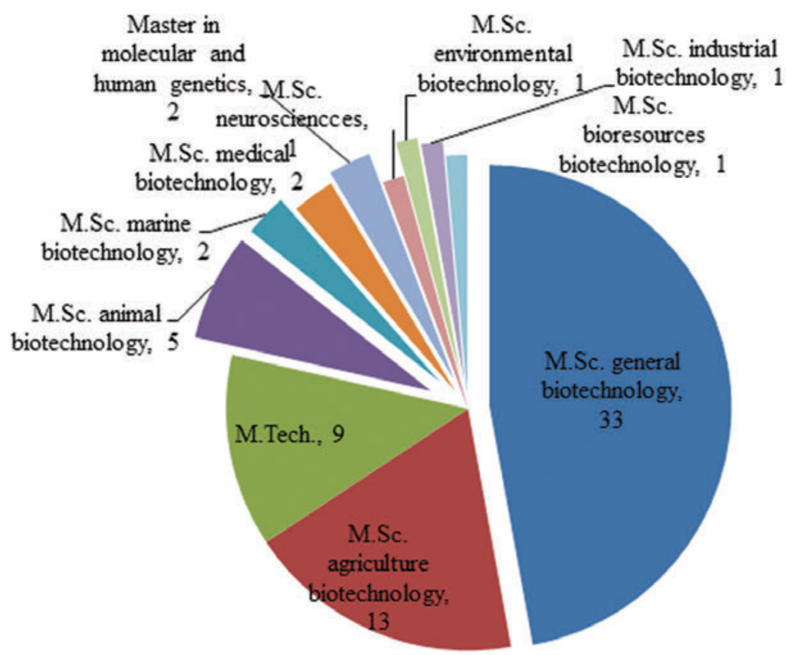


Fig. 3 Area-wise no. of universities conducting postgraduate courses in Biotechnology (Source: DBT Annual Report 2012-13)

d) Fellowship Programme:

DBT Junior Research Fellowship (DBT-JRF) Programme:
DBT initiated the JRF programme during the Xth Five-year Plan in 2004. This programme focuses on providing fellowships to candidates on a competitive basis for pursuing doctoral research at universities and/or research institutions within India.

e) DBT Research Associateship:

The Research Associateship Programme was launched in 2001 and has been implemented by the Indian Institute of Science in Bangalore. Under this programme, selected fellows can opt to work in universities and R&D institutions of their choice. There has been a gradual increase in the number of candidates applying for research associateships.

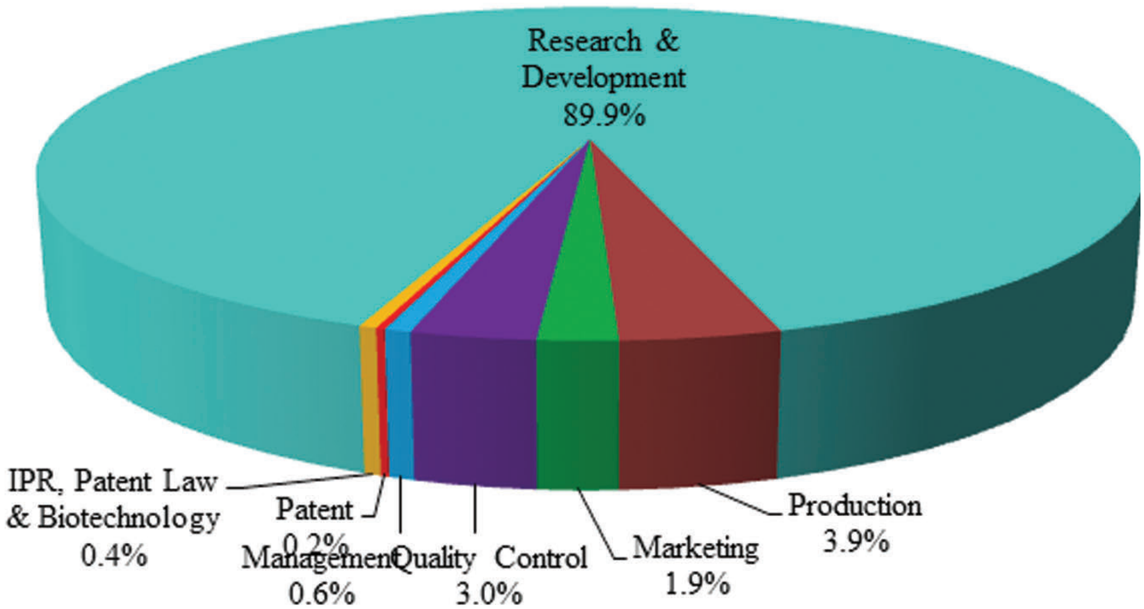


Fig. 4: Training Activity profile of biotech Industrial trainees (Source: DBT, 2012)

f) Other Fellowships:

The Biotechnology Overseas Associateship programme is designed to train scientists in research in frontier areas of biotechnology at leading research institutions in India and abroad. Several schemes have been initiated by the government to encourage researchers and scientists working abroad to find work opportunities in India for pursuing their research interests. These include: Welcome-DBT India Alliance (DBT-Welcome Trust Fellowship, Early intermediate and senior secondary post-docs), Ramalingaswamy Re-enter Fellowship: Young Investigator Meet (YIM, DBT), Biotechnology Postdoctoral Niche Associateship programme (DBT), Tata Innovation Fellowship (DBT), R&D Fellowship for Industry (DBT), Innovation Young Biotechnologist Award (DBT), DBT- Standford Biodesign programme (DBT), DBT-BBSRC (Biotechnology and Biological Sciences Research Council), Biotechnology Yes Programme (DBT), Biotechnology Entrepreneurship Student Team (BEST, DBT), DBT-University of Wisconsin Khorana Fellowship Programme (DBT), Ramanujan Fellowships (DST), Single Window Information and Placement Facilitation in Life Science-related area (Centre for DNA Fingerprinting and diagnostic, CDFD) and MIT Health Science and Technology programme (Translational Health Science and Technology Institute; THSTI, Harvard-MIT Division of Health Science and Technology; HM-HST).

g) Training Programme
Biotech Industrial Training Program (BITP):

BITP was initiated in 1985 to train M.Sc/M.Tech students in industries for a period of six months in order to bridge the knowledge gap between students produced by universities and those required by industries. BITP is similar to the Industry Research Apprenticeship Program (IRAP) implemented by the National Research Council of Canada (NRC). In 2007-08, DBT introduced a bench fee of Rs. 50,000 per student for industry training. The programme is mutually beneficial to students and industry. A profile of industrial activities for training is shown in Figure 4. The majority of students receive 90 per cent of their industrial training in biotechnology R&D, with the remaining 10 per cent dedicated to all other industrial activities such as production, marketing, quality control, IPR, management etc.

C) Research & Development

The major areas identified for R&D include genomics, RNA biology, proteomics, metabolomics, computational biology, systems biology, synthetic biology, regenerative medicine and tissue engineering in stem cell biology, novel animal models, nano-biology and medicine. Priority areas that have been identified include biotherapeutics, vaccines and adjuvant, both for human and animals, diagnostics, biomarkers, biosensors, bioengineering, bioenergy, bioequipments, bioimplants and medical devices, biosimilor manufacturing, nano-biotechnology, novel protein therapeutics, transgenic crops and marker-assisted breeding, nutraceuticals and functional foods.

A number of agencies in India have been supporting R&D in biotechnology including the Department of Science and Technology (DST), Council of Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), Indian Council of Agricultural Research (ICAR), Defense Research and Development Organization (DRDO) and so on. However, DBT serves as the agency nodal point for all international bilateral and multilateral R&D collaborations and agreements in the area of biotechnology and as the nodal point for all technology transfer in the area of biotechnology. (*www.asiabiotech.com*)

During 2012-13, DBT approved 1,939 R&D projects for funding in the areas of core competence of R&D in biotechnology, including: bioprocess engineering, gene manipulation of microbes and animal cells, downstream processing and isolation methods, extraction and isolation of plant and animal products, recombinant DNA technology of plants and animals, stem cell biology, bioinformatics, proteomics and genomics, traditional and molecular marker-assisted breeding of plants and animals, fabrication of bio-reactors and processing equipment, human and animal health products, agriculture biotechnology, industrial and other biotechnology products.

D) Infrastructure Development

The strength of R&D in biotechnology depends upon the quality of institutional and organizational infrastructure. The establishment of a separate Department of Biotechnology must be followed by a focus on manpower development and the creation and strengthening of infrastructural facilities, among other things.

DBT has created 15 autonomous institutions in the areas of plant, animal human sciences and industrial biotechnology. The Government of India has established Centres of Excellence to strengthen institutional research capacity and to promote excellence in interdisciplinary sciences and innovation in selected areas of biotechnology. As at 2011, 15 Centres of Excellence had been set up across the country in different areas: agriculture (3), medicine (8), bio-informatics (1), basic biology (2) and sericulture (1). Biotechnology Information System (BTISnet-BioGrid India) was established in 1986–87 to create the infrastructure for harnessing biotechnology through the application of bioinformatics. Today, more than 150 centres have been established across India to provide training in bioinformatics. A national facility for silicon drug development has been established at IIT, Delhi. Over 150 subject-specific databases and software packages are also now available in India to carry out biomolecular research and development in the biotech sector.

At present, scientists, industries and students have access to about 35 facilities for biological materials and high-end sophisticated equipment, all available at nominal cost. Testing facilities for GMOs and LMOs, DNA sequencing, cell banking and repositories for micro-organism facilities are available at the centres of excellence for research and development. Microbial culture collection facilities (MCC) for agriculture, healthcare and industry have been established at National Centre for Cell Sciences. Since April 9, 2011 the MCC has been recognized as an International Depository Authority (IDA). To ensure worker safety in the laboratory environment, microbiological and biomedical laboratories have been outfitted with the required level of biosafety systems. Molecular and chemical libraries have also been established to support research in different fields of biotechnology.

Biotechnology parks, developed either through public-private alliances or public-private sponsorships are essential to the growth of the biotechnology industry. They provide a useful mechanism for licensing new technologies of emerging biotech companies with start-up ventures and for adding early value to the technology with minimum financial inputs. In India, there are currently 200 laboratories in institutions, all equipped with state of-the-art facilities for promoting innovation and cutting edge research. Both Central and State governments are involved in setting up biotech parks and incubators and conducting pilot projects to promote and encourage entrepreneurial ventures in biotech while providing a template for promoting start-up companies. DBT has established ten biotech/incubator parks in Uttar Pradesh, Hyderabad, Kerala, Himachal Pradesh and the urban centre. India currently has about 150 Incubators and Science & Technology Parks which facilitate lab-to-land technology transfer and serve as an impetus for entrepreneurship through partnerships among innovators from universities, R&D institutions and industry.

E) Entrepreneurship Promotion Programme

During the 1980s, the Small Scale Industrial Sector emerged as a dynamic and vibrant sector of the Indian economy. Small Medium Enterprises (SMEs), which constitute more than 80 per cent of the total number of industrial enterprises and form the backbone of industrial development, are however still lagging in terms of scientific and technology advancement due to

sub-optimal scales of operations and technological obsolescence.
To enable SMEs to mitigate these problems and enhance their access to new technologies to increase their competitiveness in the international market, it is imperative that a conducive environment be created to encourage a seamless technology flow from knowledge centres to them. Biotech ventures need access to top class technology on a continuous basis since the rate of technology obsolescence is very high. In this regard, government agencies and a few private companies such as Biotech Consortium India Limited (BCIL) are trying to make technology available to biotech enterprises that need it.

Biotech Consortium India Limited (BCIL) Initiatives:

BCIL is a public limited company promoted by the DBT with a mandate to provide the requisite linkages among research institutions, industry, government and funding institutions to accelerate the commercialization of biotechnology.

Any technology submitted to BCIL is evaluated for its commercial potential and validated for confirmation of its salient features. Once the technology appears more or less viable it is converted into a package for entrepreneurs and financial institutions to access its commercial viability. Identifying the most suitable entrepreneur is one of the key critical steps and involves a rigorous selection process, following which a licence agreement is executed.

A determination on the price of the technology is made on the basis of several factors including market demand, growth potential, innovativeness of the technology etc. To translate the technology into a commercial venture, BCIL extends all support to the licensee in the form of continuous monitoring and consultancy services. Technologies developed at various research institutes are listed in Table 1 and were transferred by BCIL for commercialization.

Table. 1:- Technologies Transferred through BCIL

Technology	Developed at	Transfered to
Biopesticides	TNAU, Coimabtore	Crop Health Products Ltd., Ghaziabad
Biopesticides	-	Hoechst Schering AgrEvo Ltd., Mumbai
Biopesticides	-	Hoechst Schering AgrEvo Ltd., Mumbai
Western Blot based HIV 1+2 Diagnostics	ACTREC, Navi Mumbai	J. Mitra & Co. Ltd., New Delhi
HIV 1 and 2 diagnostics (ELISA)	NII, Delhi	Ace Diagnostics & Biotech Ltd., New Delhi
Dengue, JE and West Nile diagnostics	NIV, Pune	Zydus Pathline Ltd., Ahmedabad
Alphafetoprotein diagnostics	IICB, Kolkata	Shantha Biotechnics Ltd., Hyderabad
Hepatitis A diagnostics	NIV, Pune	Bharat Biotech International Ltd., Hyderabad
Reproductive hormones diagnostics	NIRRH, Mumbai	Zydus Pathline Ltd., Ahmedabad
Recombinant anthrax vaccine	JNU, New Delhi	Panacea Biotec Ltd., New Delhi
BODSEED	IGIB, Delhi	Indo Bioactive Labs (P) Ltd, Pune
Tricoderma Viride	RRL, Jammu	Haryana Biotech Pvt. Ltd., Gurgaon
Recombinant typhoid vaccine	AIIMS, New Delhi	USV Ltd, Mumbai

Source: (https://www.bcil.nic.in)

F) Institutional Framework

a) Incentives: The Indian government has been proactive and supportive in driving the growth of the biotechnology sector by offering grants and tax incentives, and implementing investment-friendly regulations. Foreign direct investment (FDI) up to 100 per cent is permitted through the automatic route for the manufacture of drugs and pharmaceuticals. Fiscal incentives include tax deductions on R&D, lending to biotech companies, rebates, tax relief for promoting R&D and joint R&D collaboration. This is supported by a trade regulation package that includes exemption of import duties on R&D, removal of the customs duty on raw materials and the rationalization of export and import of biological material for indigenous development of research and enterprises (*NBDS, 2007*). Several State Governments (e.g. Andhra Pradesh, Karnataka, Maharashtra, Himachal Pradesh, Uttar Pradesh, Kerala and Gujarat) have introduced added financial (e.g. tax concessions) and policy incentives (biotech parks, incubators) of their own to spur investment in biotechnology.
(*http://www.investindia.gov.in/?q=biotechnology-sector***)**

b) Legal policy: When assessing the Indian legal framework for biotechnology, attention must be paid both to international compromises and internal norms. India is party to several international treaties that directly impact biotechnology regulation and management. These treaties pertain to several public international law regimes, such as international trade law, international environmental law, intellectual property law and international human rights law. On the other hand, the national normative framework is the outcome of a relatively unsystematic evolution, which has its origin in the 1986 Environment (Protection) Act. The norms of the Environment (Protection) Act provide the legal background to the Rules for Manufacturing, Use, Import, Export and Storage of Hazardous Micro-organisms and Genetically Engineered Organisms or Cells, which are the other key pieces of legislation.

The majority of the agencies that enact rules and control activities in the biotechnology field pertain to four ministries of the Central government:

- Ministry of Science and Technology controls the Department of Science and Technology; the Department of Scientific & Industrial Research and the Department of Biotechnology;
- Ministry of Health governs the Indian Council of Medical Research;
- Ministry of Agriculture controls the Indian Council of Agriculture Research; and
- Ministry of Human Resource and Development controls the University Grants Commission.

It should be noted that the Department of Scientific & Industrial Research funds the Council of Scientific and Industrial Research, both of which provide direct funding of biotechnology.

India has developed a multi-tiered regulatory framework to ensure the biosafety of genetically engineered organisms. This framework came out of the work of a series of committees including the Review Committee on Genetic Manipulation (RCGM), the Genetic Engineering Approval Committee, the Recombinant DNA Advisory Committee, the Institutional Biosafety Committee, the State Biotechnology Coordination Committee and the District Level Committees. In the biopharmaceuticals domain, these bodies work with the Central Drugs Standard Control Organization and the Drugs Controller General of India, which have a broader mandate to cover all pharmaceuticals. (*Seuba and Correa, 2010*)

Review Committee on Genetic Manipulation (RCGM)

The RCGM operates under the aegis of the DBT and is comprised of representatives of DBT, Indian Council for Medical Research, Indian Council for Agricultural Research, Council for Scientific and Industrial Research, and other experts in their individual capacity.

The function of this committee is to frame the regulations for the institutions involved in rDNA research activities, review on-going research involving hazardous micro-organisms, visit experimental sites and ensure that trials are being carried out in accordance with established guidelines and advise customs authorities on the importation of micro-organisms and Genetically Modified products. Before conducting research in rDNA work involving risks categorized as Category III and above, the Principal Investigator (PI)/Applicant is required to obtain the permission of RCGM following approval from the Institutional Bio-Safety Committee (IBSC). After reviewing the application, the RCGM may recommend the application to the Monitoring cum Evaluation Committee (MEC) of the DBT for assessing its agronomic benefits and evaluation.

After detailed deliberations, the MEC may recommend the modified application back to RCGM. In conducting its evaluation and arriving at its recommendations, the MEC may visit trial sites, analyze data, inspect facilities and conduct environmental risk assessment. Applicants also require the permission of the RCGM for conducting greenhouse trials and small-scale field trials in order to generate data for assessing the safety of Genetically Modified (GM)/transgenic crops that are intended to be released into open fields. The safety assessment process includes environmental safety studies (pollen flow, emergence of volunteers, persistence, etc.), food safety studies (toxicity, allergenicity, pathogen drug resistance, alteration of nutritional value, etc.), and the assessment of agronomic advantage over non-transgenic crops. Large-scale field trials also require the approval of the Genetic Engineering Approval Committee (GEAC).

Recombinant DNA Advisory Committee (RDAC)

The main function of this committee is to review developments in Biotechnology at the national and international levels and to recommend appropriate safety regulations for India in rDNA research work. It functions under the DBT.

Institutional Bio-Safety Committee (IBSC)

IBSC is the nodal point of interaction within a commercial organisation/applicant company involved in rDNA research for the implementation of rDNA guidelines. In the first instance, an applicant company intending to carry out research activities involving genetic manipulation of micro-organisms should constitute an IBSC comprised of the head of the applicant company, scientists involved in DNA work, a medical expert and a nominee of the DBT. Institutions conducting such genetic engineering activity should adhere strictly to the guidelines and may be subjected to inspection by the competent authority.

Genetic Engineering Approval Committee (GEAC)

In the cases of large-scale field trials, deregulation and commercialization, the permission of GEAC as constituted under the Ministry of Environment and Forests (MoEF) is required in addition to the DBT approval process. Precisely, GEAC approval is required from the environmental angle on:

i. Import, export, transport, manufacture, process and selling of any micro-organisms or genetically engineered substances or cells including foodstuff and additives that contain products derived by gene therapy;

ii. Discharge into the environment of genetically engineered/classified organisms/cells from laboratories, hospitals and related areas;

iii. Large-scale use of genetically-engineered organisms/classified micro-organisms in industrial production and applications. Production can commence only after such approval is granted; and

iv. Deliberate release of genetically-engineered organisms.

All approvals of GEAC are for a specified period not exceeding four years in the first instance and renewable thereafter for a period of two years at a time. Experiments beyond a capacity of 20 litres for research as well as for industrial purposes are included in the category of large-scale experiments/operations and therefore require the prior approval of the GEAC (*Dubey, 2004)*.

State Biotechnology Co-Ordination Committee (SBCC)

SBCC inspects, investigates and takes punitive action in cases of violations of statutory provisions through the State Pollution Control Board or the Directorate of Health. It also periodically reviews safety and control measures in institutions that handle GMOs. The SBCC also acts as a nodal agency at State level to assess damage, if any, due to the release of GMOs and to take on-site control measures. (DBT)

Intellectual Property Protection

Indian patent law has undergone significant changes over the last 15 years. The main impetus of these changes has been the need to adapt Indian law to the TRIPS Agreement. The Patents (Amendment) Act, 2002 introduced significant changes with regard to the patentability of biotechnological inventions. By specifically allowing for the patentability of micro-organisms, the

law complies with the requirement of article 27.3(b) of the TRIPS Agreement. The exclusion of inventions which represent the "discovery of any living thing or non-living substance occurring in nature", consists of "traditional knowledge" or of "known properties of traditionally known components" would lead to the exclusion from patentability of some biotechnology-based inventions. One of the key issues is whether a merely isolated (unmodified) biological material may be deemed as not "occurring in nature". Indian law seems to indicate that only materials, including micro-organisms and genes, that are the result of human intervention are patentable.
The Patents (Amendment) Ordinance, 2004, which was later replaced by the Patents (Amendment) Act, 2005 (Act 15 of 2005), was introduced as the third set of amendments to the 1970 Patent Act. The key modification was the introduction of product patents for fields of technology previously excluded from protection. This Amendment introduced a new provision (Section 3(d)) aimed at preventing the grant of patents on "minor" or "frivolous" inventions, although the main objective of Section 3(d) has been the avoidance of what have become common "evergreening" practices in the pharmaceutical industry. (*Seuba and Correa, 2010*)

Biosafety

The Government of India has established "Rules for the Manufacture/ Use/ Import/ Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells" through Notification No. G.S.R.1037 (E), dated 5th December, 1989 under the provisions of Environment (Protection) Act, 1986 through the Ministry of Environment & Forests (MoEF). These rules are commonly referred as "Rules 1989". The two main agencies identified for implementation of Rules 1989 are the Ministry of Environment & Forests and DBT, and the Ministry of Science and Technology. Rules 1989 also define Competent Authorities and the composition of such Authorities for the handling of various aspects of biosafety.

In implementing Rules 1989, DBT has published Guidelines from time to time. In 1990, the guidelines under the title "Recombinant DNA Safety Guidelines" were published. These Guidelines provide researchers with information on the Rules, implementation of the provisions of the Rules, approval mechanisms, risk groups, handling of GMOs, import of GMOs, etc. In 1998, DBT published guidelines under the title "Revised Guidelines for Research in Transgenic Plants and Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts". These Guidelines provide information on the level of approvals for conducting research in transgenic plants, category of experiments and testing procedures for toxicity and allergenicity etc. In 1999, DBT also brought out Guidelines for "Generating pre-clinical and clinical data for r-DNA based Vaccines, Diagnostics and other biologicals".
(http://dbtindia.nic.in/uniquepage.asp?id_pk=65)

Drug approval

Demonstration of the safety and efficacy of the drug product for use in humans is essential before it can be approved for import or manufacturing and marketing within the country. However, the requirements for approval of clinical trials and new drugs may vary depending on the nature of the drugs. Guidance documents specify the general requirements for approval of clinical trials and different categories of new drugs viz. Investigational new drugs, new drugs substances, additional strength, additional indication, modified release form etc. Such comprehensive and rational details help the Central Drugs Standard Control Organization (CDSCO) to better review and take the necessary actions while easing the preparation of electronic submissions, which will soon be possible at CDSCO (*CDSCO, 2011*).

c) Ethical Policy

The National Bioethics Committee was constituted with the approval of the Minister of Science & Technology, Government of India in November 1999. This Committee deliberated on various issues concerning the human genome. Its policies have been formulated in harmony with the Ethical Guidelines for Biomedical Research on Human Subjects developed by the Indian Council of Medical Research in 2000. Stem cell research and bioethics guidelines widen the scope for molecular research. (*http://dbtindia.nic.in/uniquepage.asp?id_pk=113*)

d) Biotechnology Regulatory Authority of India

The Government of India has proposed the establishment of this authority in the Biotechnology Regulatory Authority of India Bill, 2011. This authority is designed to be an independent body and legal committee for controlling the production, research, transport, import, and use of organisms and products of modern biotechnology.

e) Clinical Establishments Bill

The Clinical Establishments Bill was passed in 2010 with the aim of standardizing procedures for various clinical trial-related tasks. The bill aims to make registration of clinical trials, as well as clinical research organizations, mandatory throughout India.

G) Biotechnology Policy Document-National Biotechnology Development Strategy

Following national and international consultations with scientists, industry, regulators and civil society, DBT prepared the "National Biotechnology Development Strategy" (*NBDS, 2007*) to promote innovation and encourage the biotech industry.

The Policy clearly outlines the direction for strengthening India's academic and industrial biotech research capabilities; promoting collaboration with business, government and academia to move biotechnology from research to commercialization; fostering India's industrial development; educating the public about science and its applications, benefits and issues of biotechnology; enhancing the teaching and workforce training capabilities and establishing India as a pre-eminent international location for biotechnology.

The NBDS defined three general goals: development of human resource, strengthening of the infrastructure, and promotion of trade and industry. As in the case of NBDS, DBT announced that 30 per cent of its budget would go towards public private partnership programmes (PPP) to accelerate bio-industrial growth. The Biotechnology Industry Research Assistance Council (BIRAC) - a Section 25 company—has been established as an interface agency to nurture industry R&D, academia-industry collaboration, international linkages and techno entrepreneurship. BIRAC plays a pro-active role in ensuring a smooth information flow from the public sector to industry. The following schemes have been employed to boost public private partnerships.

a) Small Business Innovation Research Initiative (SIBRI):

The first PPP initiative created by DBT for domestic early-stage technology development and commercialization, launched in 2005, was the Small Business Innovation Research Initiative. It was modelled on the United States SBIR (Small Business Innovation Research) programme. Among its stated objectives are to:

- Encourage a greater number of SMEs to accelerate innovation by engaging in peer-reviewed quality research
- Encourage innovation in the private sector
- Create an eco-system for translating innovations into commercially viable products/ processes by the private sector

In response to 20 calls for proposals over the period 2005-2012, more than 1,000 proposals were received and nearly 600 laboratories/institutes in 26 states across India responded to requests for submission of proposals under SIBRI. The Apex committee approved approximately 200 projects. About 50 per cent of the approved projects have since been completed in different sectors such as agriculture, healthcare, industry services and instrumentation among others. Projects sanctioned in different sectors of biotechnology are shown in Table 2.

Table 2: Sector wise Project sanctioned in SBIRI scheme

Health care and related area	67
Agriculture	32
Industrial Product process	21
Instrumentation devices	9
Bioinformatics	2

Source: www.birac.org

b) Biotechnology Industry Partnership Programme(BIPP):

This programme was launched in 2008 under the BIRAC scheme with the aim of providing financial assistance to small, medium and large enterprises for advanced innovative technology and product development. A unique feature of this scheme is its support for "breakthrough research" which enables product and process development and is patentable, with Intellectual Property ownership rights residing with industry.

In response to 21 calls for proposals by DBT, nearly 550 proposals were received in the period 2008-2012, of which 95 were approved. Of these, 51 were startups/SMEs. As can be seen in Fig. 5, the largest number of proposals came from the health care sector (36 per cent), followed by agriculture (19 per cent), clinical trial & field trial (15 per cent), Ind. Product & Process (10 per cent), implant and devices (8 per cent), infrastructure (7 per cent) and bioenegry (5 per cent).

In terms of funding, 60 per cent of the proposals from health care was supported, followed by agriculture.

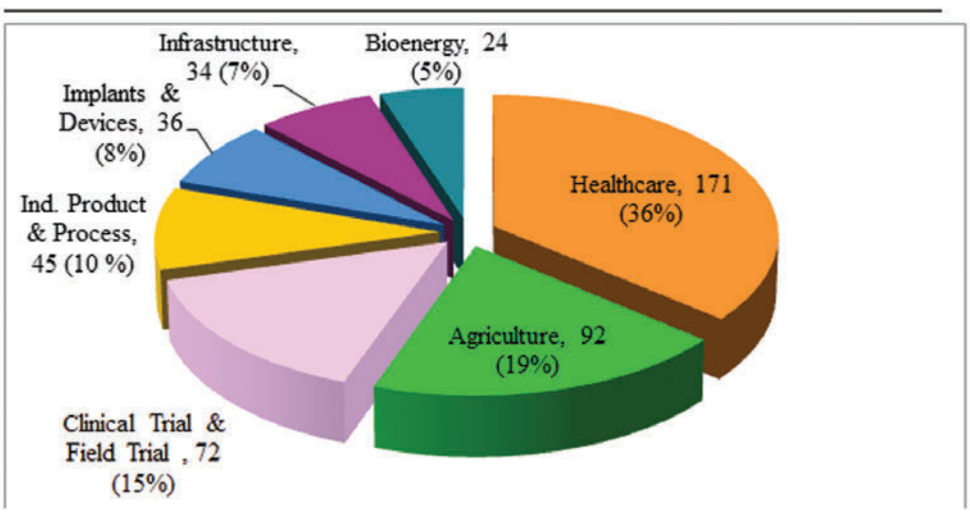


Fig 5: Sector wise projects received under BIPP (2008-12) (DBT - BIRAC Innovators Compendium: 2012)

3. India's Biotechnology Industry

The biotechnology industry has been evolving over three decades in India, beginning in 1978 in Bangalore when Biocon, the country's first biotech company was established as a producer of industrial enzymes. The enactment of the New Patents Act, 2005 created a paradigm shift in research and development in the sector. Before that, India had a patent protection for process rather than product, which created a certain complacency by not emphasising the development of new products. The New Patents Act of 2005 enforces product patents, thereby spurring firms and research institutions to undertake innovation (*EBTC, 2012*).

Companies have entered the biotech sector in India primarily through four distinct routes. The early entrants were large industrial/ pharmaceuticals companies which identified biotechnology as a growth engine for the future (*Biocon, Wockhardt, Nicholas Piramal*). Thereafter, the pure play biotech starts-ups focused on production of recombinant drugs, bioinformatics and custom services (Shantha Biotech, Bharat Biotech, Strand Geneomics, Syngene); software companies which grafted biology branches onto strong IT stems (Wipro, TCS, Satyam); and more recently industrial conglomerates which have diversified into biotechnology (Reliance Industries among others). Many industrial firms are developing various collaborations in R&D, manufacturing for foreign companies, technology acquisition-based production, and services such as contract research, clinical trials and marketing. (*Palinitkr, 2005*)

South India, with biotech hubs in areas such as Bangalore in Karnataka and Hyderabad in Andhra Pradesh, is the largest hub for biotech companies. In 2010, the number of biotech companies in South India was 172. In fact, almost half of the biotechnology companies in India are based out of the state of Karnataka. Apart from Karnataka, states such as Andhra Pradesh, Maharashtra, Tamil Nadu and Kerala have been proactive in supporting the biotech sector by establishing world-class biotech parks and clusters. Nearly 350 companies operate in the biotechnology sector in India. Among the most successful are Biocon, Serum Institute of India, Panacea Biotech, Nuziveedu Seeds, Reliance Life Sciences, Quintiles, Rasi Seeds, Novo Nordisk, Shantha Biotechnics, Venkateshwara Hatcheries, Indian Immunologicals, TransAsia Biomedics and Mahyco.

Foreign players are also establishing their presence in the Indian biotech space. An example is the Denmark-based global biotech company, Novozymes, which partnered with Bangalore-based Sea6 Energy in January 2012 for exploratory research and joint development of a process for the production of biofuels from seaweed. Novozymes will provide research and develop and manufacture enzymes for the conversion process, while Sea6 Energy will contribute its offshore seaweed cultivation technology. Lonza, a global leader in the production and support of pharmaceutical and biotech products, is planning to set up a manufacturing base in India with an investment of USD 150 million at Hyderabad.

In a similar move, India-based Clinigene International, a subsidiary of Biocon, and the Seattle-based Pacific Biomarkers Inc. (PBI), announced a collaborative agreement in January 2012 to address the specialty biomarker and high-end clinical trial laboratory needs of the global pharmaceutical and biotechnology industry. Clinigene offers end-to-end clinical and laboratory services for accelerating clinical research while PBI provides premier biomarker and specialty efficacy testing services to the drug development industry. This partnership with Clinigene provides PBI access to India, an emerging hub for drug development and contract research. *(http://www.ebtc.eu/pdf/Indian_Biotechnology_Sector-Overview_VO1.pdf)*

India’s biotech industry is based on indigenous R&D, collaboration R&D, manufacturing for foreign companies, technology acquisition-based production, and services such as contract research, clinical trials and marketing. The industry is comprised of sectors specializing in biopharma, bioservices, bioagri, bioindustrial, and bioinformatics (*Majumdar and Kiran, 2012*). Figure 6 shows that the biotech industry has registered growth of 15.08 per cent for the financial year 2012-13 (*Biospectrum, June 2013*). The Association of Biotechnology Led Enterprises (*ABLE, 2012*) estimates the sector’s value at around USD4 billion in 2011. Various estimates suggest that the sector is poised to increase to USD10 billion by 2015.

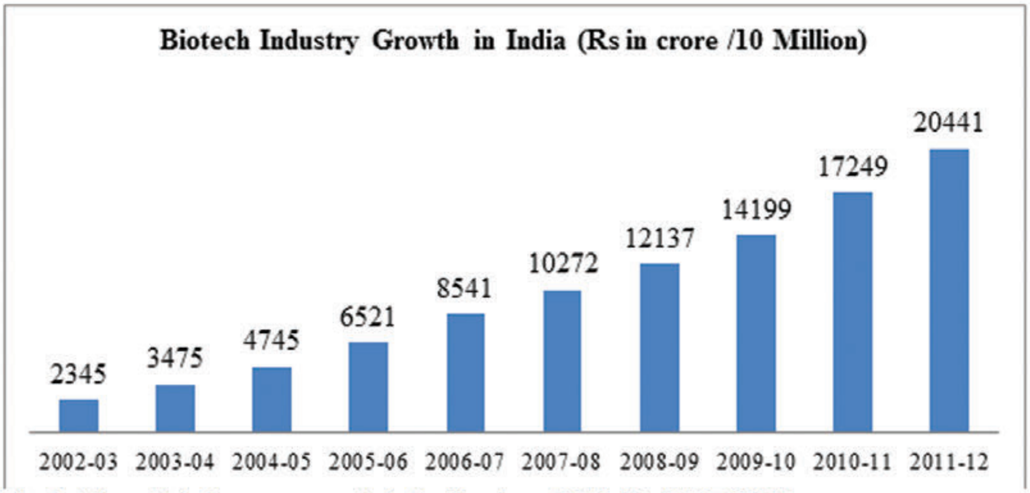


Fig 6: Biotech industry growth in India since 2002-12 (DBT 2012)

According to the eleventh annual Indian Biotech Industry survey by Biospectrum-ABLE, India’s biotech companies are grouped into five major sectors as in Table 3:

- BioPharma: includes vaccines, therapeutics and diagnostics;
- BioAgri: includes genetically-modified seeds, molecular markers and related products;
- BioServices: includes contract research and manufacturing services (CRAMS) and clinical research services;
- BioIndustrial: includes enzymes for food, leather and textiles, pharmaceuticals, detergents and energy applications; and
- BioInformatics: includes information technologies to develop tools for drug discovery, and informatics based services.

Table 3: Botech Industry revenue 2011-12

Segments	2011-12 Total Revenue Rs. In Crore	2010-11 Total Revenue Rs. In Crore	Changes (%)	Share (%)
Bio-pharma	12679	10645	19.00	62
Bio-services	3749	3245.97	15.50	18
Bio-agri	3050	2480	23.00	15
Bio-industrial	696	625.94	11.20	3.5
Bio-informatics	266	252.43	9.60	1.5
Total	20441	17249.34	18.50	

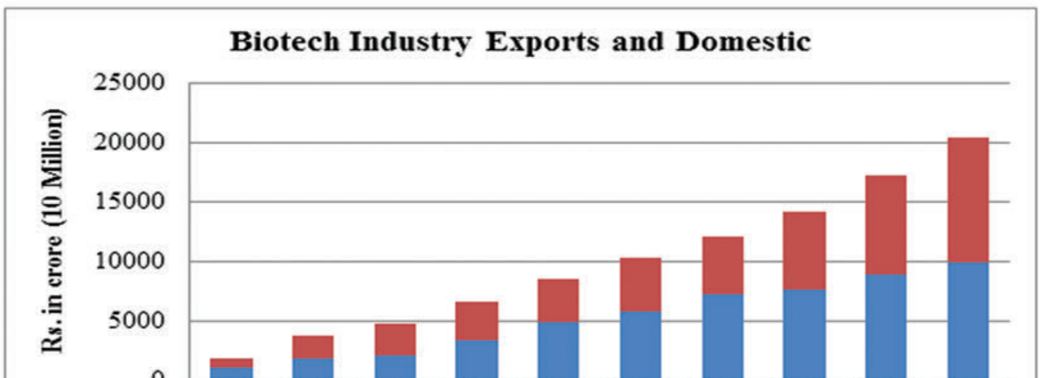
(Biospectrum 2013)

Bio pharma accounts for 62 per cent of the total revenues of the biotechnology sector, bio-services for 18 per cent, bio-agri for 15 per cent, bio- industrial for 3.5 per cent, and bioinformatics for 1.5 per cent.

The biotechnology sector is expected to offer huge investment opportunities in the coming five to 10 years in the areas of vaccines, bioactive therapeutic proteins, contract research, clinical trials, bioinformatics, medicinal plants, animal biotechnology, seri-biotechnology, stem cell biotechnology, bio-fuels, bio-pesticides, bio-informatics, human genetics and environmental biotechnology.

The Indian biotechnology industry is expected to garner revenues of USD11.6 billion by the year 2017 (*investindia, 2010*). Key factors driving this market growth are rising investment from foreign companies, increasing R&D and infrastructure investments from the private and public sectors, emerging markets for contract research, increasing clinical capabilities in drug discovery and rising opportunities to outsource manufacturing functions to India.

Growth has been mainly fuelled by the rise in domestic business, export and innovative product development. The share of biotech domestic sales revenue exceeds export revenue (Figure 7).



	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Export	855	1948	2744	3164	3604	4540	4985	6668	8398	10599
Domestic	975	1817	2001	3357	4937	5732	7152	7531	8852	9842

Fig. 7: Biotech industry export and domestic growth since 2002-12 (Biospectrum 2013)

India's pharmaceutical industry is the world's third-largest in terms of volume and stands 14th in terms of value. A recent study by ICRA projects industry growth of 10-12 per cent during 2013-14. With drugs worth $80 billion expected to go off patent over the next four to five years, Indian companies are lining up strong product pipelines of pending Abbreviated New Drug Applications (ANDAs). Biosimilar, vaccines and diagnostics devices are emerging as the key growth areas in the Indian biopharma sector (*Ernst & Young*).

4. Biosimilar Drugs

India's biopharmaceutical industry is actively engaged in the production and marketing of biosimilar drugs which account for >25 per cent of the growth of India's biopharma. They include human insulin, human growth hormone, granulocyte colony stimulating factor (G-CSF), Erythropoietin, and Streptokinase. The drugs are 40 per cent to 80 per cent cheaper in India. Dr. Reddy's Laboratory launched "Reditux" in April 2007 which was 50 per cent cheaper while Peg-grafeel (pegfilgrastism) was priced at USD184.69 which is 95 per cent cheaper than in the United States. Business opportunities abound in the biosimilar drug industry, where an estimated 48 products with sales of $73 billion are due to be off patent in the next decade.

In terms of recombinant therapeutics, there are about 25 available in India, 15 of which are manufactured within the country. In all, 20 companies are engaged in production and marketing of biosimilar drugs in India. About 50 brands of biosimilars are commercialized in the country and about 72 recombinant drugs are in different phases of trial.

Globally, India exports vaccines to 150 countries. The major players in vaccines are the Serum Institute, Shantha (now part of Sanofi), Bharat Biotech and Panacea Biotech etc. Serum Institute is the world's fifth-largest vaccine producer and supplies almost 50 per cent of all vaccines to UNICEF/WHO (*ABLE, 2012*).

Stem cell research is revolutionising the biotech sector not only in India but across the world, with its potential for the development of therapy for many untreatable diseases through cellular replacement. The Government of India has supported more than 55 programmes on various aspects of stem cell research. An increasing number of private and public institutions in India are becoming part of this revolution. India's first stem cell clinical trials were conducted in 2011 for four diseases: osteoarthritis, diabetes Type-II, liver cirrhosis and chronic obstructive pulmonary disease (COPD).

The bioservice sector has experienced growth of 18.99 per cent over the past five years. Many firms are engaged in offering services for clinical trials, contract research etc. Clinical trials create numerous opportunities for a number of associated industries such as in vitro diagnostics, education, and data management.

The bioagri sector is segmented into hybrid and transgenic seeds, biofertilizer and biopesticides. In 2012, India had almost 10.8 millon hectares of land under cultivation, which represents an enormous leap from the 50,000 hectares in 2002. Bt cotton contributed 77 per cent of the revenue in this sector (*Biospectrum, 2013*).

Top 20 companies: More than 350 companies operate in the biotech sector. Table 4 shows the top 20 companies of India which engaged in development and marketing of products in different segments of biotech. In biopharma, the highest revenue of Rs, 1041 Crore is contributed by Serum Institute of India; in bioagri Rs 745 Crore comes from Nuziveedu Seed; in bioindustry Rs, 297.66 Crore comes from Novozymes South Asia and, in diagnostics, a total of Rs. 225 Crore is contributed by Tulip (*Biospectrum*, 2012).

Sl.No	Company	Segment	Revenue in Rs crore 2010-11	Revenue in Rs crore 2011 -2012	% change over
1	Serum Institute of India	Biopharma	1708	1041	64.07
2	Biocon	Biopharma	1676.4	1483	13.04
3	Nuziveedu Seeds	BioAgri	745	610	22.13
4	Reliance life sciences	Biopharma	693	490	41.43
5	Novo Nordisk	Biopharma	647.28	462	40.1
6	Rasi Seeds	BioAgri	392	371.88	5.41
7	Panacea Biotec	Biopharma	384	928.41	-58.64
8	Bharat Biotech	Biopharma	326	265	23.02
9	Ankur seeds	BioAgri	325	250	30
10	Mahyco	BioAgri	314	359	-12.53
11	Bharat Serums	Biopharama	298.32	226	32
12	Novozymes South Asia	Bioindustry	297.66	242	23
13	Elilily	Biopharma	290.16	204	42.24
14	Indian immunologicalas	Biopharma	282.23	269.07	4.89
15	Sanofi Pasteur india	Biopharma	258	16.68	61.02
16	Glaxosmithlines	Biopharma	257.66	177.51	45.15
17	Tulip	Diagnostics	225	185.63	21.21
18	Advanced enzymes	Bioindustrial	180	154	16.88
19	Halfkine bio pharmaceutical	Biopharma	175.7	86	104.3
20	Krishidhan Seeds	Bio Agri	173.8	276.13	-37.06

(Biospectrum 2012)

Partnerships/acquisitions: Acquisitions or partnerships have brought unprecedented change in the Indian biopharma sector by providing a base for the development of R&D infrastructure. They also provide conducive conditions for the gradual development of domestic industry and for commercializing the products of Indian companies. Companies pursue acquisitions for a number of reasons including commercialization of product, development agreements, supply agreements or a stake in ownership (Table 5).

Table 5: Acquisitions/ partnerships (2010)

Company	Acquisitions/ partnerships company	Type
Ranbaxy Laboratories	Biovel Life sciences	Acquistion
Ranbaxy Laboratories	Pfenex	Development agreement
Cipla	MabPharm and BioMab	Stake acquisition
Piramal Healthcare	BioSyntech	Acquisition
Astra Zeneca	Intas Pharma	Supply agreement
Greater Pecific Capital LLP	Accutest Research Laboratories	Majority stake acquisition
Pfizer	Biocon	Commercialization agreement
Rallis India	Metahelix Life science	Majority Stake Acquisition
Strides Acrolab Limited	Inbiopro solutions	Stake Acquistion

Source: (ABLE India, 2012)

By acquiring India-based Biovel Life Sciences, Ranbaxy is now able to access Biovel's research and development capabilities in biogenetics. It has also signed a development agreement with US-based Pfenex for the marketing rights for producing human growth hormone (*Asiabiotech, 2010*).

In 2013, Biocon entered an agreement with Mylan for the global development and commercialization of Biocon's generic insulin analog products (long lasting insulins), which has a potential global market of USD11.5 billion.

5. Conclusions

India's biotech industry is vibrant as is evident from the growth in revenue in its products and benchmark services. It is knowledge-intensive sector, driven by innovations, competence building and research infrastructure. The Indian biotechnology sector presents various advantages in terms of a lucrative return on investment. Some of these advantages are:
Structural: India's billion-plus population base offers a huge market for biotech products and services. Moreover, rising purchasing power is fuelling demand for healthcare services. A key factor in this is the expansion of the Indian middle-class population, which is expected to rise to 550 million by 2025, up from 50 million in 2010.
Low labour cost: India offers a low-cost and skilled labour force, which is a key reason why it attracts outsourced research activity from global biotechnology companies.
R&D investment by biotech firms: Biotech firms are increasingly using India as a base to undertake focused research and development activities. This is assisted by the increase in government funding for product innovation and research in the biotech sector.

However, the growth of the sector is affected by certain limitations, which include the lack of quality human resources of the right kind, weak entrepreneurial skill and limited availability of venture capital and investment in R&D from industry. Industry remains hesitant about public private partnership through collaborations with universities or public research institutes. Even the role of industry in human resource training has not risen to the required level in terms of quality and quantity.

Another limitation is the complicated biotech regulatory framework which involves agencies in four to five ministries within the government through the Drug Controller General of India (DCGI), the Review Committee on Genetic Manipulation (RCGM), the Genetic Engineering Approval Committee (GEAC), the Director General of Foreign Trade (DGFT), etc. These agencies jointly regulate the development, manufacture and supply of biologics, making it a very complex regulatory system. Countries with successful pharma and biotech industries have a single regulatory agency such as the European Medicines Agency (EMA), US FDA, Therapeutic Goods Administration (TGA), Agência Nacional de Vigilância Sanitária (National Health Surveillance Agency Brazil) (ANVISA) etc., that oversee and regulate all aspects of the industry. Notwithstanding this, however, the Government of India has a focused approach to developing this sector to a globally competitive level, by utilizing its key assets of a large pool of skilled personnel and capabilities for basic interdisciplinary research. These limitations are being addressed through the National Biotechnology Development Strategy (NBDS).

References

- Dubey, R. (2004). Biotechnology destination in India. Journal of International Business and Law.1: 205-210.
- Gandhi, B. M. and Gupta, S. V.(2004). Indian biotech sector: achievements & successes, Asia-Pacific Biotech News. 8 (17): 962-964.
- Joshi,K., Mehra,K., and 'et al'.(2013). Biotechnology Education in India: An Overview, Policy Futures in Education. 11 (1). www.wwwords.co.uk/PFIE
- Kumar, A., Srivastava, L. (2011). Biotechnology industry in India: Opportunities or challenges, African journal of business management. 6 (44): 10834-10839.
- Majumdar,M. and Kiran, V. (2012). Imbibing Social Entrepreneurship in Biotechnology. Business Systems Review. 1 (1): 27-38
- Natesh, S. and Bhan, M.K. (2009). Biotechnology sector in India: strengths, limitation, remedies and outlook. Current Science. 97(2): 157 – 169.
- Palnnitkar, U. (2005).Growth of India biotech companies, in the context of the international biotechnology industry. Journal of Commercial Biotechnology. 11(2) : 146-154.
- Singh, Kr, A. (2011). Biotechnology: The New Horizon for Indian Leadership. VSRD Technical & Non-Technical journal. 2 (3): 144-159.

Books

- Chaturvedi, S. (2002). Status and Development of Biotechnology in India: An Analytical Overview. Research and Information System for the Non-Aligned and Other Developing Countries.
- Prahalathan, S., Kumar, A. and 'et al'. (2010). Biotechnology industry in India: opportunities for growth. Export-Import Bank of India. Quest Publication, India.

Reports

- Annual report of Department of Pharmaceuticals. (2011-12). Ministry of Chemicals & Fertilizers, Government of India..

• Dash, S. P., (2012) Indian Biotechnology the Roadmap to the Next Decade and Beyond, A Report by Association of Biotechnology Led Enterprises (ABLE) for the Department of Biotechnology, Government of India.
• DBT – BIRAC Innovators Compendium. (2012). Department of Biotechnology, Government of India.
• Doing business in India (2012), Ernst & young.
• National Biotechnology Development Strategy (2007), Department of Biotechnology, Ministry of Science & Technology, Govt. of India.
• The Eleventh Survey of Indian Biotech Industry ,(2013), Biospectrum
• The Indian Biotechnology sector: Investments, Growth and Prospect (2013), Indian Brand Equity Foundation,
• Ranbaxy to Acquire Bangalore Based Biovel Life Sciences (2010), Asia biotech, Vol 14, pp 26.
• Report of the Working Group on Biotechnology 12th Plan (2012-2017), 2011, Department of Biotechnology, Ministry of Science & Technology, Govt. of India
• Sharma,P., (2012). Innovative R & D in Biotech sector
• Seuba, X. and Correa, C. (2010). Biotechnology in India: Its Policy and Normative Framework
Web links
• Asia Tradehub, (2013), infrastructure, <http://www.asiatradehub.com/ >, 2013.
• BIRAC, (2013), Biotech park , <http://www.birac.nic.in/webcontent/gci2_guidelines.pdf >, 2013
• Business Update, (2013), Industries: Biotechnology < http://business.gov.in/Industry_services/biotechnology.php> (2013)
• Business standard, (2013) Pharma industry to grow by 10-12% in FY14: ICRA <http://www.business-standard.com/article/companies/pharma-industry-to-grow-by-10-12-in-fy14-icra-113070700213_1.html>, 2013.
• DBT, (2013), policy and programme , <www.dbtindia.nic.in/>, 2013
• Department of Biotechnology and Bioinformatics Centre, (2013),Bioinformatics <www.bioinfobubpl.nic.in/>, 2013
• DST (2013), Budget, <www.dst.gov.in/ >, 2013
• Department of Industry policy and promotion , (2013) , FDI Policy , < www.dipp.nic.in>, 2013
• Data Portal India, (2013), Area wise number of ongoing project in biotechnology <http://data.gov.in/dataset/area-wise-number-ongoing-projects-6th-march-2013>, 2013
• Economic Times, (2010), Pharma, engineering to topple IT as big paymaster, <http://articles.economictimes.indiatimes.com/2010-06-08/news/28423319_1_salary-hikes-manufacturing-sector-survey>, 2013
• European Business and Technology Centre , (2013), Indian Biotechnology Sector- Overview <http://www.ebtc.eu/pdf/Indian_Biotechnology_Sector-Overview_VO1.pdf> (2013)
• Foreign Investment Promotion Board , (2013), FDI policy, <www.fipbindia.com/>, 2013
• Investindia,(2013),Investment opportunity, <http://www.investindia.gov.in/?q=biotechnology-sector >, 2013
• Maria, A., Ruet, J and 'et al. 'Biotechnology in India. Report commissioned by French Embassy in India < http://www.cerna.ensmp.fr/Documents/AM-JR-MHZ BiotechReport.pdf>, 2013
• Modern Pharma, (2013), Funding in biotechnology: A wavering graph <http://modernpharma.in/specials/funding-in-biotechnology-a-wavering-graph/1286.html>, 2013
• Ministry of Finance, (2013), Tax incentives, < www.finmin.nic.in/>, 2013
• Pursuit and Promotion of Science : The Indian Experience" (2002), Chapter: 32 <http://www.iisc.ernet.in/insa/ >, 2013
• Rajkumar S. Adukia ,(2006) , biotech park <http://www.caclubindia.com/books/manual_sez_ftwz_ifsc/Ch%2023.asp>(2013)

Leveraging The Diaspora For Reverse Brain Drain

11.

Skilled Migration and Development:

Scientific Diasporas as Drivers of Science and Technology in the Home Countries

Dr. Gabriela Tejada

Cooperation and Development Center
Swiss Federal Institute of Technology, Lausanne
gabriela.tejada@epfl.ch

Abstract

The interest in capitalizing on scientific diasporas' knowledge and networks to the advantage of developing countries has become more pronounced given the escalation in international skilled migration and realization of the potential benefits to home countries from human capital abroad. This paper provides an overview of the experiences of a selection of countries in trying to engage emigrated scientists and skilled professionals in their development processes. Scientific collaborations, joint publications, temporary visits, and academic exchanges are ways in which scientific diasporas' knowledge can be channelled to their homelands. By describing the specific conditions and environments that enable or hinder the implementation of concrete initiatives and policies, this paper discusses main determinants that ensure thriving positive linkages, which can contribute to strengthening national science and technology systems. It demonstrates that enabling structural settings and supportive policies, together with a welcoming environment provided by local society, are required.

Keywords: **scientific diasporas, skilled migration, science and technology, knowledge transfer, development**

1. Introduction

Alternative ways to address the world knowledge divide between the North and the South are especially important in the current context in which knowledge-based activities and the technological revolution have profoundly altered some of the basic coordinates of the world in which we live. In the present context of knowledge-based economies, as argued by David and Foray (2002), innovation tends to be almost the only alternative countries have for advancing. The significance that knowledge holds for competitiveness and progress persists as something indisputable and therefore the differences in terms of science and technology potential and human capital availability between the North and the South remain a crucial challenge. Knowledge has always been at the core of economic growth and the progressive increase in social well-being (*Foray 2004*) (*Stiglitz 1999*), and the ability to innovate and create new ideas and knowledge have traditionally constituted a development fuel (*David and Foray 2002*).

While the proliferation of new information and communication technologies, as well as the increase in the knowledge world bank symbolized by these technologies, offer developing countries possibilities to reach higher levels of prosperity and productivity than ever before, their limited access to scientific knowledge and the slow advancement in technological innovation represent a considerable challenge.

A broadening of the focus from a national perspective to a global one in terms of science has been consolidated, and international cooperation has grown as a result of the internationalisation of science and education. Yet, new poles of science have emerged and the competition among countries in terms of the procurement of talented human capital for innovation and knowledge production has, ironically, increased. Also, the expansion of communication and information technologies, which enhances possibilities of knowledge production, deployment and transmission, and enables interconnections among scientific communities, is in fact augmenting global disparities (*Hollanders and Soete 2010*). As Bolay (2012) argues, at the international level, technological progress has not significantly reduced poverty and widespread inequalities within world regions, but it in fact “contributes to these disparities” (p. 6).

The disparities in the levels of development between world countries and regions are associated with the contrast in human capital investment as well as in the production of knowledge in the long term, as argued in the UNESCO Science Report 2010. The gap in R&D investment shows that, while industrialized countries invest on average 2.3 per cent of their GNP, developing and least developed countries only invest 1 per cent and 0.2 per cent respectively. Dramatic inequalities are also shown in the world share of researchers insofar as 62.5 per cent of world researchers are concentrated in industrialized countries (totaling 3,655.8 researchers per one million inhabitants –r/m), while the figure for developing countries is 37.4 per cent (580.3 r/m) and for the least developed countries only 0.5 per cent (43.4 r/m) (*Hollanders and Soete 2010*).

The growing inequalities and contradictions associated with these trends have encouraged recent debate on the possible alternatives to facilitate a more equal production and distribution of world knowledge and to make its use fairer for the benefit of the less advanced countries. Two important changes at the global level influence the discussion. First, the motivation of countries to reinforce their capacities to both generate and acquire innovative knowledge and technology in order to promote socioeconomic progress, is based more and more on international co-operation. While science and the production of knowledge have been traditionally dependent on international connections and exchanges, the intensification in international scientific cooperation has made it an influential instrument for the advancement of countries.

This can be perceived in the increasing trend of researchers from different countries writing scientific articles jointly, a practice that, in the last decade, has been more obvious for emerging and developing countries, as they have seen a greater increase in the number of countries with which they can collaborate than developed countries (*Vincent-Lancrin 2006*). Second, new processes and dynamics reveal a major structural change given that state entities are losing power as the main constitutive and acting units in the world order.

The power of global networks illustrates the participation of new actors, modifying the predominance of states as the main organizers of collective life and creators of national identities (*Castells 1996, 1997*). The expansion of new transnational actors promoting knowledge transfer through decentralized forms of cooperation for the benefit of more disadvantaged countries is increasingly relevant.

Both the intensification of international cooperation and the increased relevance of transnational actors have been affected by the rise in the international migration of scientists and skilled professionals in the last decades, opening new dimensions for collaboration between developed and developing countries. While world development calls for an effective transfer of knowledge from regions in industrialized countries where it is in abundance, to regions in less developed countries where it is scarce, the current flows of skilled human capital usually follow the contrary course, from South to North, attracted by better opportunities and career prospects in high-income industrialised countries.

Migration flows from developed to developing countries represent today the fastest-growing component of international migration (*Özden et al. 2011*). A recent study shows that between 1990 and 2000, OECD countries registered an increase of 20 per cent in the number of immigrants from developing countries with a primary education, while the increase in those with a third level education doubled (*Özden, Rapoport and Schiff 2011*).

Traditionally, large-scale flows of human capital from the South to the North have been an important concern for developing countries of origin, based on the idea that this affects their valuable knowledge bank and hinders their socio-economic progress. In the last two decades, the continuous rise in international skilled migration has encouraged the discussion of new policy options, either for promoting, regulating or taking advantage of it, as well as an increasing academic interest in understanding its magnitude, characteristics and effects. This evolution responds to the advancement both in scale and scope as well as in the complexity of international migration.

Skilled migration should be seen, as stressed by Castles (2010), as a complex and multidimensional phenomenon which is part of current social transformation processes. A new perspective that has gained attention in this context is the diaspora option, which replaces the traditional view, emphasizing skilled migrants as a permanent loss, by a vision considering them as potentially beneficial resources for countries of origin. More concretely, scientific diasporas made up of emigrated scientists and skilled professionals have gained recognition as promoters of research and the transfer of knowledge, contributing to scientific, technological and socio-economic development in their home countries.

This paper explores the strategies and policies that a selection of countries have established to engage their scientific diasporas into their development processes. It observes three countries which have been pioneers in the implementation of mechanisms for capitalising on diaspora resources for the advancement of the science and technology sector. All three countries have shaped creative forms of cooperation schemes with their skilled communities abroad. Based on a review of the policies and an evaluation of specific national experiences, this paper provides insights on the conditions and environments that enabled or hindered the implementation of concrete initiatives engaging scientific diasporas in the studied countries. All three countries are discussed separately and then a summary of the main factors influencing transnational cooperation and capitalization of scientific diasporas is presented in the conclusions in the final part.

2. Theoretical framework

Reference to skilled migration in the last decade, both in academic research and policy discourse, has tended to discuss new concepts and perspectives in an attempt to explain the linkages between migration and development. While research has aimed mostly at understanding the magnitude, characteristics and impact of skilled migration, policy options try to find ways to take advantage of the emigrated human capital that remained abroad to the benefit of national development.

In this context, two main issues have influenced the generation of new alternative ways to understand and evaluate international skilled migration. First, the view of skilled migration as a definitive loss for developing countries and benefiting only developed countries of destination, as interpreted by the nationalist perspective of the "brain drain" from the 1960s, was not sufficient to move from the general discourse to the establishment of concrete policies that could cope with this phenomenon. While this perspective saw the return option as the sole alternative to recover the "lost capacities", in praxis more often than not, repatriation programmes were unsuccessful.

Only a few countries in South Asia, for example, the Republic of Korea and China, experienced satisfactory return practices at a certain level, as a response to adequate scientific and technological structures, further incentive policies and conducive domestic environments (*Yoon 1992*) (*Song 1992*) (*Saxenian 2005*) (*Wiesbrock 2008*). Nonetheless, other world regions were not able to reproduce this model; for instance, countries in Latin America were particularly concerned about the examples seen abroad and their impossibility to follow suit *(Pellegrino 2001*).

Second, the observation of skilled migrants' behaviours and experiences in the destination countries made evident that they, as transnational actors, do not have an affiliation automatically attached to the particular geographical place where they physically are located but, rather, are able to hold multiple identities and to be connected to their host and home countries simultaneously (*Levitt and Glick-Schiller 2004*).

As a result, skilled migration started to be considered as an existing valuable human capital based abroad and subject to be mobilized to the advantage of the home country (*Meyer and Charum 1995*), replacing the traditional emphasis of irreversible loss and uncertain return by a feasible alternative of "long distance association and multiple connections" (*Meyer 2010 p. XV*). Transnationalism became then a popular theoretical framework in the study of migration and its linkages with development (*Glick-Schiller et al. 1992*) (*Portes et al. 1999*) (*Portes 2001*) (*Vertovec 2004*) (*Faist 2010*). Transnationalism sees migrants as carriers of their own identity without being uprooted from their home country while abroad, and praises their ability to maintain several links over borders and connect with their communities of origin while belonging to multiple places at the same time (*Vertovec 2001*) (*Levitt and Glick-Schiller 2004*).

The diaspora option, encouraging interconnections between home and host countries enabling the transfer of knowledge, skills and further financial and social capital (*Tejada et al. 2013*), has acquired increased relevance ever since, and governments have attempted to intensify collaboration with diaspora communities, recognizing their own aspirations and interest to "give back" to their home countries, and trying to maximise their potential for development.

As part of this new perspective, the concept of scientific diasporas was coined at the beginning of the past decade (*Barré et al. 2003*), making reference to networks or organisations of emigrated scientists and engineers from developing countries living in industrialised countries and working together to promote joint efforts to encourage transfer of knowledge to their countries of origin through diverse forms of cooperation from a distance (*Tejada 2012*). Related to this are diaspora knowledge networks (DKN), established using information and communication technologies as tools for collective transmission of knowledge, and aimed at making the most of the resources and networks of skilled migrants to the benefit of the home country. According to Meyer (2007), DKN make available new policy options in the areas of innovation, science and technology, migration and development, and international cooperation.

Butler (2001) understands diasporas as communities established in diverse places outside the home country which act independently as a group in the host country, while they establish connections with their co-nationals situated both in the home country and all over the world.

Diasporas' transnational actions are the result of communitarian practices, and therefore, as argued by Faist (2010), they should be understood as owning a collective identity. Both the unifying common ethnic identity and collective relationship of loyalty towards the home country (*Bordes-Benayoun and Schnapper 2006*), and the capacity to make creative contributions equally to home and host countries (*Sheffer 1986, Cohen 1997*) are among the main characteristics of diasporas.

Consideration of the significant role that diasporas can play in home country development also came into fashion in the global discussion on international migration, particularly when addressing the migration and development nexus, raising attention to the multiple ways in which emigrated communities can potentially and factually contribute to their home countries. For example, in 2005, the Global Commission on International Migration pointed out that "diasporas should be encouraged to promote development by participating in transnational knowledge networks" (*GCIM, 2005*).

In a similar vein, the Global Forum on Migration and Development (GFMD) has addressed repeatedly the issue of diaspora engagement in its roundtables since its first meeting in 2007. As a response to the increasing interest of governments in diaspora issues, IOM organized in 2013 the Diaspora Ministerial Conference (DMC) as the first high level event dedicated to the question of diasporas, providing the opportunity to exchange experiences on diaspora engagement and empowerment aimed at enhancing their role as development partners. The summary of the DMC discussions stresses the participants' recognition of diasporas' propensity "to build bridges between states and between societies" and urges strategies both at local and global levels aimed at harnessing their potential .

The literature and empirical studies on transnationalism and migration and development look at the factors associated with diaspora engagement, highlighting that migrants' individual characteristics and profiles, as well as the social and institutional contextual aspects, both in host and home countries, have an influence in terms of enabling or hindering the positive effects. In the following sections, I look at the experiences and efforts of three countries (Colombia, Moldova and India) engaging scientific diasporas to their development strategies, and I examine the determinants and conditions that enabled or hindered the success of such initiatives.

3. Examples of diaspora engagement for science and technology development

3.1 Colombian experience establishing a scientific diaspora network

To put the Colombian experience into context, I present first a brief overview of the evolution of science and technology policies in the country in the last decades. Notwithstanding major sociopolitical challenges, Colombia is considered to be one of the most stable and fastest-growing economies in Latin America. In the science and technology sector, the Colombian Institute for the Development of Science and Technology, Colciencias, was created as the entity in charge of science and technology in the country as far back as 1968; yet, the Colombian government began to recognise the importance of science and technology related activities for socioeconomic development only at the end of the 1980s, leading to the formulation and implementation of major policies in this area. Still, the lack of interest in building a long-term national scientific policy suggested that science and technology was not a top priority for the country.

At this time, Colombian policies for linking the competences of its scientists and skilled professionals based abroad with the home country were limited to the establishment of strategies to encourage their physical return and, taken as a whole, this policy was not successful. Diverse incentives were offered by the government to Colombian returnees trying to ensure their sustained return, but the conditions in terms of infrastructure and suitable environment made them recognise that their accumulated skills and knowledge gained abroad were not satisfactory, with the result that many of them decided to leave, again attracted by better professional prospects in research and academic institutions abroad.

In the mid-1990s, Colombian economic growth declined dramatically, prompting a considerable drop in national expenditure in science and technology in the years to follow, which fell from 0.55 per cent and 0.56 per cent of GDP in 1995 and 1996, respectively (the highest level during the decade), to the lowest level of 0.32 per cent of GDP in 1998 and 1999 . The year 2008 marked a turning point with the ratification of the new Colombian Law on Science, Technology and Innovation replacing the previous policy framework that had been in place since 1990, with a context promoting an interdisciplinary model linking academia and research with the national productive sectors. Science, technology and innovation became central issues for the development of the country, and Colciencias was transformed into an administrative department responsible for managing the National Fund for Science, Technology and Innovation, with a substantial increase in its budget over the following years.

As a result of these efforts, Colombia experienced a significant improvement in the sector of science and technology as well as in terms of its scientific potential represented by the increase in the number of persons dedicated to research in the last decade. A systematic rise in the national expenditure in science and technology is observed, from 0.3 per cent of GDP in 2002 to 0.44 per cent of GDP in 2012 . However, this still lags behind the goal of 1 per cent of GDP established by the Colombian government in the National Development Plan 2006-2010 for 2010 and the goal of 1.5 per cent of GDP for 2019 with half of this coming from the private sector.

The data reveal that the private sector has taken a significant position in science and technology, and it is expected that this will only grow in the years to come. In terms of the numbers of human resources dedicated to research, these increased by more than double in the last decade, rising from 7,426 in 2000 to 16,123 by 2010. Similarly, the number of doctoral theses completed per year grew from 19 in 2001 to 73 by 2010, with an average of 37.5 theses completed during the period 2001-2010. Notwithstanding the importance of this positive evolution, the Colombian national science, technology and research system still has a long way to go in terms of knowledge generation. In this evolution, international scientific cooperation has been an important leverage, and it is expected that it will be intensified in the years to come.

When speaking about diaspora engagement policies to help enhance science and technology development, Colombia is a world case in point. The country was the first to put the idea of the scientific diaspora option into practice with the creation of the Caldas Network of Scientists Abroad (Red Caldas), which was regarded as the most advanced version of an alternative option for the "brain drain" (*Meyer 2001*) (*Tejada 2010*). The status of science and technology policies in Colombia at the time the Caldas Network was created was a special one.

At the beginning of the 1990s, there were several drastic social and economic changes, which were mainly caused by the shift to a more open economic regime than the previous protectionist one. Various sectors of the economy were exposed to international competition, and one of their most pressing concerns was how to enhance their own competitiveness. In terms of the science and technology sector, the Colombian government perceived the need to mobilise its external resources in order to develop national scientific capacities, Colombia being a country with a small, dispersed and mainly inward-oriented scientific community. The risk of scientists being isolated led Colombian institutions to consider the importance of maintaining and strengthening the connections with Colombian scientists and skilled professionals abroad and also to explore the most appropriate mechanisms for their engagement in home country development.

An analysis of the situation leads us to believe that the country's committed support for implementing specific policies for the engagement of the scientific diaspora in reinforcing national scientific capacities was based on four complementary factors. First, the emergence of electronic networks and use of the information and communication technologies for worldwide inter-connectivity at the beginning of the 1990s. Second, the presence of skilled Colombian migrants in top research and academic institutions around the world who were highly motivated and willing to contribute. Third, recognition of the potential gains the home country could obtain from collaboration with Colombian scientists abroad. Fourth, the belief that the Colombian national system of science, research and innovation was sufficiently adequate and capable of benefiting from collaborations with skilled Colombians abroad.

While the combination of these elements inspired the subsequent idea of creating a network of Colombian researchers abroad, it should be stressed that the transnational activities of skilled Colombians abroad stemmed from their own individual or collective initiatives, with the government intervening only when the importance and the potential of migrants' practices became evident (*Tejada 2010*). In fact, the creation of Colext (Red de Colombianos en el Exterior) in 1990 was a pioneer initiative of Colombian scientists out of the country to communicate and connect with other Colombian researchers based in institutions around the world. This structure was taken over in 1992 by the Colombian government, represented by Colciencias, to create the Caldas Network. The Caldas Network operated through its nodes in different countries, establishing links with important Colombian universities, with the aim of establishing collaborative research projects between Colombian research groups and Colombian scientists based in universities and research institutions abroad.

The Caldas Network was created as a very practical way to recover the skills and capacities of the skilled Colombians overseas, without attempting their return to the home country. In a very flexible way, the network promoted diverse forms of cooperation with research groups and with scientists in Colombia, such as: exchange of information on cooperation opportunities, organization of conferences and scientific events, trainees in research laboratories and groups, as well as joint preparation of research projects.

After a dynamic launch propelled by great enthusiasm and expectations, the Caldas Network lost momentum at the end of the 1990s. While official voices stress the main reason for this was the lack of financial support for the projects combined with the general crisis in the economy and the country's science and technology sector, as evidenced by a financial crisis of Colombian institutions and universities (C*haparro et al. 2006*), it is certainly true that the Colombian government was not in the position to provide long-term support to the network. Furthermore, the institutional capacity to host the projects in the local context was insufficient, hindering the potential impact of the network.

The weak and highly fragmented Colombian scientific community, which had only little interaction with it, as well as with its colleagues abroad, and the lack of tools for the implementation of cooperation projects, were additional stumbling blocks limiting the functioning of the Caldas Network. As a result, many frustrations set in among the members of the Colombian scientific diaspora, who had placed great hopes in the project. The Caldas Network is remembered today as an innovative strategy designed to harness the capacities and resources of the scientific diaspora. However, it is also evoked as a project that created many hopes, but which ultimately failed to provide the appropriate response.

Linked to the Caldas experience are some associations of skilled Colombians abroad, which are still running successfully and which can be viewed as good practices of diaspora engagement. One of these is the Association of Colombian Researchers in Switzerland (ACIS) , which in the past functioned as the Swiss node of the Caldas Network. ACIS was created by a group of Colombian scientists and engineers based in Swiss academic and research institutions as a platform for exchange and promotion of scientific collaboration with Colombia.

The overall aim of ACIS is to contribute to the advancement of science and technology in Colombia through the exchange and transfer of knowledge. The functioning of ACIS is an example of the current global trend towards a decentralized and collective means of knowledge production (*Tejada 2012*) and is based on a thorough use of information and communication technologies as an instrument for knowledge transfer. The dual purpose of making knowledge available to the public and fostering its reproduction and circulation make ACIS what is called a knowledge community (*Foray 2004*). Throughout their organised collective activities based on joint aspirations, ACIS has played an important role by gathering the Colombian scientific community in Switzerland, and has contributed to the field of science and technology in Colombia through the creation and reinforcement of a critical mass in key development areas such as the environment, medicine and information and communication technologies.

The experience of ACIS illustrates that both community identity and intensive mobilisation encourage participation and actions from a distance which benefit the country of origin. We observe, with the example of ACIS, that associative actions may play a key role in capitalizing on the effects of scientific diasporas. We see also that when members of knowledge communities act as a group and strengthen their skills in an organised manner they facilitate collective influence in the country of origin, becoming agents of change (*Tejada 2012*).

The Colombian example shows that the formation of scientific diaspora associations, and the implementation of research projects involving scientists in the diaspora and their counterparts in the home country, are two of the most elaborat, successful practices of the Colombian scientific diaspora making an impact on science and technology in Colombia. However, it illustrates also that diasporas' engagement in transnational cooperation faces important obstacles. The case of ACIS shows that continuous financial and institutional support has limited the scope and durability of its actions.

Furthermore, despite the interest of the Colombian government in capitalising on diasporas' knowledge and skills, shown through various recent initiatives implemented, committed and sustained support for diaspora engagement remains unclear, while a strong policy strategy in this regard is still lacking. Also, the Colombian scientific diaspora still has to overcome its scepticism towards public actions, given the fact that Colombian institutions have created great expectations for their scientists abroad on several occasions in the past, without actually going on to give them the capacity to fulfil them. An important task in this regard is to promote ownership of the new public initiatives by diaspora associations and organizations.

3.2 Moldovan policies engaging scientific diaspora and promoting migration and development linkages

The Republic of Moldova, a small country in southeast Europe landlocked between Ukraine and Romania, became independent in 1991 after the fall of the Soviet Union. During its transition to a democracy and market economy following its independence, the country experienced enormous pressure, similar to that of other Eastern European countries, with a significant decline of economic and social indicators, limited access to basic public services, and impoverishment of a large segment of the population.

Emigration from Moldova has happened at different stages, going from barely any flows of Moldovans leaving the country during the early 1990s to large flows of workers from the agricultural and related sectors searching for better employment and income prospects abroad following the collapse of the Russian economy due to regional financial crises in 1998 and 1999. Due to Moldova's high level of dependency on the Russian economy, the country faced an extreme breakdown which was much worse than in other former Soviet republics, and this stimulated emigration.

At the turn of the century, emigration of the Moldovan labour force increased progressively from around 100,000 in 1999 to more than 400,000 by the end of 2005 (*Lücke, Mahmoud and Pinger 2007*). While at first these migration flows were mostly of less skilled labour workers, flows of scientists, skilled professionals and students increased in the following years. Despite the fact that emigration is a relatively new phenomenon in Moldova, the country has, at present, one of the highest emigration rates in the world.

The uncertain situation of science and technology in the country has had a significant impact on skilled migration. In the first ten years after independence, a hard economic crisis and long political transition ignored science and technology as a national priority, with the result that from 1990 to 2000, public investment in this sector was drastically reduced from 0.73 per cent of GDP to only 0.18 per cent (*ASM 1990-2009*). Insufficient funding, inadequate wages and deficient infrastructure affected the activities related to science, research and innovation in the country. Furthermore, management and promotion of science remained conservative, with a regressive rather than encouraging legislative framework triggering an important emigration of scientists and skilled professionals.

The annual reports of the Academy of Sciences of Moldova (ASM) show that, from 30,000 scientific researchers that the country counted in 1990, the amount reduced to less than 5,000 in 2004, representing a fall of 83 per cent of the country's scientific potential in one and a half decades (*ASM 1990—2009*). By 01 January 2011, Moldova counted only on 5,216 employees registered in research and development activities of the country, according to data from the Moldovan National Statistics Office . An important additional driver of recent Moldovan skilled migration, mostly from young people, is the disconnection between the national education system and the real opportunities offered by the labour market, which causes a great competition for scarce job positions in Moldova and motivates a search for better professional prospects abroad (*Gaugas 2004) (IOM 2012*).

As shown recently by IOM (2012), Moldovans working abroad either on a temporary or permanent basis represent around 25 per cent of the total economically active population. IOM data series for the period 2005-2012 show gradually increase in yearly emigration from Moldova and illustrates that an estimated 25 per cent up to 30 per cent of the working age population is involved in a migration project at any moment during such period. On a similar note, a recent study by OCDE (2012) shows that 56 per cent of Moldovans, in the age segments between 15 and 24, as well as 37 per cent of Moldovans with third level education, would emigrate permanently if they had the opportunity.

Particular aspects of the socio-political context make Moldova stand out from other countries in Eastern Europe when discussing the challenges of skilled migration and the policy options for the home country (*Tejada forthcoming*). These are:

- Political instability and lack of full control over its territory (particularly the self-declared independent region of Transnistria);
- Lack of cohesive national identity due to a multi-ethnic population and historically rooted clashes influencing a continuous political debate between pro-Russia and pro-Western forces;
- Moldova being the poorest country in the region with 65 per cent of its population living below the poverty line (UNDP 2013);
- The country's high dependence on financial remittances which represent 23 per cent of Moldovan GDP and whose recipients account for 26 per cent of Moldovan households (*World Bank 2011*); and
- The good reputation and scientific excellence of Moldovan scientists and the country's science schools remain remarkable.

Due to the specific complexity of Moldova's socio-economic and political situation, this case study denotes an exceptional instance for looking at the challenges faced by a country going through a transitional stage and the policy options it has implemented in its efforts to link the emigrated scientists and skilled professionals to the national strategies of socio-economic progress. The country has implemented some concrete strategies and mechanisms both to promote retention of scientists and skilled professionals in Moldova, and encourage those who are based abroad to be linked to the country and/or eventually to return to it.

As a first important step towards that goal, in 2004, the government launched a national strategy aiming at ensuring sustained support and adequate funding to science and technology and research and development, and activities related to these sectors, including improved professional conditions and prospects for Moldovan scientists and researchers. This strategy included three main complementary basics: the endorsement of the Code on Science and Innovation by the Parliament; the acceptance of the Partnership Agreement between the government and the Academy of Sciences of Moldova (ASM); and the commitment to increase consequently the expenditure in science and technology in the following years. In addition to those three actions, a concrete strategy to establish and reinforce connections with skilled Moldovans abroad was put in place.

In this regard, the government of Moldova, under the auspices of ASM, launched in 2008 a strategy aimed at encouraging cooperation with the Moldovan scientific diaspora. Moldova's firm resolution to boost relationships with the scientific diaspora should be understood as grounded in two issues. First, the conviction that the country can benefit from cooperating with Moldovan scientists and skilled professionals based overseas. Second, the belief that the Moldovan national system of science, research and innovation is sufficiently adequate to welcome diaspora initiatives and respond to them by providing support in terms of suitable infrastructure and a conducive environment for enabling transnational cooperation (*Tejada et al 2013)*.

The Moldovan strategy, focused on skilled migration, is intended to curtail the negative impact caused by emigration from Moldova in general, and the loss of its highly skilled human capital in particular, by encouraging potential positive effects through the transfer of the accumulated knowledge and skills obtained by Moldovans working abroad. As part of the Moldovan strategy to encourage cooperation with the scientific diaspora, two concrete initiatives were recently put in place. The first of these is the programme for the temporary return of Moldovan scientists and young researchers, established under the EU-Moldova Mobility Partnership scheme by IOM and ASM. IOM Moldova has been in fact a crucial player in enhancing the migration and development dialogue in the country, as well as in boosting the diaspora question in the policy agenda. The second initiative is the research project conducted by the ASM in collaboration with the Ecole Polytechnique Fédérale de Lausanne (EPFL) meant to "connect the scientific diaspora of the Republic of Moldova to the scientific and socioeconomic development of the home country"— a study which outlined the parameters of the Moldovan scientific diaspora and the propensity of its members either to return or to engage in home country development initiatives. The study found that while skilled Moldovans abroad do feel positive about their professional and study experiences overseas, they are also motivated to contribute to development in Moldova, and it identified concrete determinants required to boost such contributions such as improved socio-economic prospects, political stability, and adequate infrastructure and services in Moldova, as well as concrete instruments for engagement (*Tejada et al 2013)*.

Additional practical initiatives that Moldova has put in place as part of the strategy of cooperation within the scientific diaspora are: 1) Creation of the Scientific Moldovan Diaspora Network, aimed at supporting communication, exchanges and collaboration between Moldovan researchers abroad and the scientific community in the home country. 2) Creation of a database of Moldovan scientists living abroad as well as a forum for discussion to facilitate exchanges. 3) The creation of the ASM Certificate of Merit Award, which recognises the outstanding results in science and innovation of the scientific diaspora, and also its help in promoting the scientific heritage of Moldova abroad.

Beyond the focus on skilled migration, the Moldovan government, while seeking to curtail the flow of emigration, is sensitive to the needs and concerns of Moldovans abroad, and therefore has put in place diverse policies encouraging dialogue with the diaspora, such as the National Plan of Action for Diaspora Management formulated by the Bureau of Inter-ethnic Relations (BIR); the organization of the annual "Diaspora Fair" since 2007 by the BIR, aiming at reinforcing the partnership between the Moldovan government and Moldovan migrants, by discussing the most pressing issues of interest to both sides and finding ways for Moldovan migrants to contribute to Moldova's progress and participate in the design of country policies.

As far as financial remittances are concerned, highlighting the tangible benefits in terms of a lifeline to recipients from the transferred money, which accounts for 26 per cent of Moldovan households (*Orozco 2008*), the government acknowledges the key role of these people as a vital source of financial inflows with an important socio-economic impact in the country (*IOM 2009*). Since the remittances are mainly used for daily needs, such as buying food and clothes, paying rent and making home improvements, they are hardly impacting deficient structural conditions. However, several on-going institutional initiatives have been put in place recently to promote the use of remittances for investment purposes (for example, the PARE 1 + 1 Programme).

The case of the Republic of Moldova shows that the initiatives targeting diasporas are taking place on a top-down basis at a national level headed by the Moldovan government. There is a clear institutional move to tap scientific diasporas' knowledge, skills and further resources and stimulate their transnational cooperation initiatives that may benefit the development process of the country. The promotion of return, temporarily or permanently, of Moldovan scientists and skilled professionals is another alternative option being fostered. However, for the country's capacity to manage and benefit from the transfer of knowledge and skills from skilled migrants, both through return or from distance collaborations through diaspora engagement schemes, only a conducive environment offering attractive career prospects, job opportunities and adequate infrastructure, quality of life and political stability in Moldova can make the pro-diaspora policies have an effective capitalising impact on home country development in the long term.

3.3 Experience of the Indian diaspora transferring knowledge and technology

When speaking about migration and diaspora contributions, India is certainly a world case in point for several reasons related to the particularities of the migration process from the Sub-continent. One of these reasons is that the magnitude of the Indian diaspora is very significant. The third-largest worldwide after the British and the Chinese in terms of size and spread, the Indian diaspora was about 10.7 million in 1979, representing 1.6 per cent of the national population at the time. Today, the number of people of Indian origin living abroad, estimated at 20 million at the turn of the century, is now believed to have risen to 25 million (*MOIA, 2012*).

Another important reason is related to India's high quality of human resources, which has made the country an important place of origin of a significant number of workers who emigrate to almost every country in the world. While many low skilled workers have emigrated to the Gulf and countries of the Middle East, high skilled Indians have deemed the USA and other industrialized countries such as the UK, Canada and Australia as the most attractive traditional destinations in the last decades.

Yet, over the past few years, diverse countries in continental Europe are emerging as new destinations for skilled Indians (*CODEV-EPFL, IDSK, JNU, ILO 2013*). According to recent data from the OECD, the Indian community in OECD countries was around 1.9 million (about 2.6 per cent of the total migrant population in OECD countries' area) in 2008 and approximately 4 per cent of these had a third level education. Furthermore, about 5 per cent of the highly skilled population of India immigrated to OECD countries (*OECD 2008*).

Another reason is the fact that an increasingly significant number of skilled Indians emigrate through the academic stream as students. Some estimates indicate that over 150,000 third level students leave India every year to study abroad (*Khadria 2008*). While Indian students tend to continue their education in academic and research institutions in the USA or the UK, increasing numbers have been moving to other destinations such as Australia, Germany, France, Canada, New Zealand and Singapore, as well as other countries in continental Europe.

Over the last decade, the share of Indian students among all foreign students registered in third level education in OECD countries increased from 4 per cent in 2001 to 7.3 per cent in 2009, signifying the second biggest group of students from non-member countries, surpassed only by Chinese students (*OECD 2011*). Mostly in European destination countries, the retention of Indian students as long-term skilled workers for national labour markets after completing their studies is occurring more and more as part of their strategy to attract skilled personnel as an economic buffer to meet skill shortages in specific sectors.

Destination countries are adapting their policies in this regard and are implementing specific international student policies as tools in the international competition for skilled persons (*Kuptsch 2006*) (*Mosneaga 2010*). A recent study on host country environments for diaspora engagements offers a comprehensive policy review of France, Germany, the Netherlands and

Switzerland with respect to their institutional settings and migration policies, with a focal point on Indian skilled professionals and students (*Tejada et al. forthcoming*). The conclusions of this study indicate that host countries' settings are important in pulling skilled migrants but also in how they enable the transfer of knowledge to the home countries. Host country environments together with policies and structural settings provided by these countries facilitate the mobilisation of skilled Indians' resources and their engagement in knowledge transfer and further transnational activities.

There are diverse ways in which the Indian diaspora has contributed to socio-economic development in India. One tangible way has been through financial remittances whose total amount has not only made India the worldwide top recipient but has been considerably increased in the last decades.

Data from the World Bank show that remittances from India grew six-fold between 1990 and 2000, rising from $2.1 billion to $12.3 billion, and they increased almost five-fold in the last decade, reaching US$55 billion in 2010 (*World Bank 2011*). The transfer of financial remittances is only one type of contribution; yet the Indian case has experienced other ways in which Indians abroad, concretely skilled professionals, have taken part in initiatives linked to home country development, in the form of knowledge and technology transfer or encouragement of investments and entrepreneurial activities both from a distance and upon return.

Another element that has aided India as a country benefiting from positive effects of skills migration is the collective action of Indian engineers and technicians who mobilised many of their co-nationals into active associations and networks in the Silicon Valley region of the USA during the late 1990s, contributing to the reinforcement of India's scientific and technological capacities through knowledge and technology transfers as well as in the form of investment and business linkages (*Saxenian, 2005, 2006*). While the Indian experience in information technologies (IT) and the creation and strengthening of the software industry with the help of skilled Indians from the diaspora would seem to be a good example, it is also important to look at the costs that are involved, given the fact that many other economic sectors that are important for Indian development have been neglected, which would seem to indicate a major need to normalise unequal sector growth in IT by means other than R&D and higher education.

Return migration has been considered as another option and a powerful tool for development in the case of India. Several studies attribute return migrants, who count on knowledge and technical skills accumulated overseas, with an important role in economic development upon their return to the home country. Even though the return of skilled migrants may be highly beneficial for the home country insofar as they bring improved levels of knowledge and skills with them and may create employment and entrepreneurial opportunities, the return option has still not been comprehensively explored concretely, and the determinants influencing the process of transferring the knowledge of skilled Indians upon return have not been fully understood.

Advancement on this issue has been made recently by a study exploring the effects of skilled

Indians' international exposure on their professional and social position after their return to India, and the difficulties they face in the dynamics of transferring the skills they have gained abroad (*CODEV-EPFL, IDSK, JNU, ILO 2013*).

This study shows that while skilled Indians in Europe associate their development aspirations to their return plans and believe that Indian society can benefit from their accumulated know-how, they face a number of difficulties within the course of knowledge transfer to the local context. Skilled Indians are highly motivated to contribute the knowledge, skills, experience and ideas that they have gained while working abroad to their employment and professional activities in India, but a reality check shows that local work culture, resistance to change, lengthy bureaucracy and lack of basic requirements in terms of infrastructure limit their potential.

This shows how home country environment matters as well. As evidenced by this research, while skilled Indians have positive feelings about contributing to development activities in their home country, they show a lack of trust in India being able to provide the necessary enabling environment to trigger the capitalisation of their accumulated knowledge and skills gained overseas (*CODEV-EPFL, IDSK, JNU, ILO 2013)*.

India has experienced in recent years an increase in the number of skilled Indians returning to their home country. Many skilled professionals, mostly but not exclusively from the IT sector, are returning from the US, as well as the UK and other European countries, in some cases pushed by the economic downturn in the destination countries which leads to insecure job prospects, but also pulled by economic, career, entrepreneurial and business opportunities they see, together with the family ties that India has to offer. In addition to their perception of an enabling environment based on their views of good economic and social performance by India, their feeling of patriotism is an additional driving force motivating their return (*Chacko, 2007*) (*Finegold et al. 2011*) (*CODEV-EPFL, IDSK, JNU, ILO 2013*).

In terms of policies, the Indian government has recognised the potential advantages the country can obtain from collaborating with the diaspora, while it relies on India having sufficient capacity to facilitate and provide a conducive environment to host such cooperation. As a consequence, the country has implemented concrete innovative policy strategies to benefit from the resources of the Indian diaspora. For example, a ministry dedicated to the non-resident Indians, the Ministry of Overseas Indian Affairs (MOIA), was set up in 2004 as proposed by the Report of the High Level Committee on Indian Diaspora, created as early as 2000 with a view to exploring the possibilities of diaspora engagement, and with the mandate of connecting the Indian diaspora community with the motherland. Additionally, the Overseas Indian Facilitation Centre (OIFC), set up in 2007, aims at promoting investments of the Indian diaspora in India and facilitating business partnerships and advisory services related to investments for Indians based overseas. These two structures (MOIA and OIFC) initiate and manage most of the government actions regarding the Indian diaspora.

One initiative implemented by the MOIA, addressing concretely skilled Indians and encouraging knowledge transfer in particular sectors, is the Global Indian Network for Knowledge (Global-INK), which aims at creating a network by drawing on the knowledge, skills and expertise of Indians abroad and in India, in the areas of environment, healthcare, innovation and science and technology, and which functions as a portal of knowledge management, exchange and collaboration. A further initiative by the Indian government is the creation of the website Scientists and Technologists of Indian Origin Based Abroad (STIOs), which is aimed at mobilising overseas talent and expertise and contributing and sending knowledge back to India. The network provides its members with access to opportunities for collaborating with the Indian diaspora. The members, mostly Indians residing abroad who interact through this network, represent a wide range of industries, research institutes, laboratories, universities and businesses and they interact with counterparts back in India. Some specific examples of projects established to benefit Indian development, include the implementation of schemes involving short visits by Indian scientists to STIO laboratories around the world; the establishment of technology transfer corridors; and the creation of high-tech firms in India that use techniques and resources provided from abroad.

While concrete policy strategies from the Indian government to engage with the Indian diaspora were implemented some time back, and concrete initiatives are taking place, a recent study on skilled Indians in Europe and returnees shows that a majority both of diaspora and returnees have little knowledge of the various initiatives taken on by the Indian government to engage with its diaspora. This study suggests that the government needs to improve its communication about such policies with the diaspora community (*CODEV-EPFL, IDSK, JNU, ILO 2013)*.

Conclusion

The discussion of the issue of diasporas in the global dialogue on migration and development has moved from the recognition of their potential contribution to their home countries to the reflection on how governments' policies and strategies can enhance such linkages (A*gunias and Newland 2012)*. For this, it has been stressed that a good knowledge of diasporas is a necessary condition for the implementation of adequate policies to connect them to national development strategies, and therefore increasing importance is given today to empirical research and studies mapping diasporas' volumes, profiles and characteristics, as well as their conditions in destination countries and their connections with the home country. The adaptation of conceptual frameworks for the interpretation of the determinants and effects of diasporas' engagement is also taking place.

The country experiences presented here show that while skilled emigration may be determined by choice, professional career, academic opportunities and the globalisation of science and education, it is also fuelled by economic factors, limited employment and career prospects, and low level of wages in the countries of origin. Both contexts in countries of origin and countries of destination influence skilled migration. Scientists and skilled professionals from the diaspora in general keep connected to their countries of origin and have positive feelings about their possibility of contributing to development activities there. While in some cases diaspora transnational cooperation projects take place at the individual level and lack a collective organisation, more structured communitarian-based actions are taking place in other cases, which are considered as crucial for enhancing the scale and effect of transnational cooperation and for facilitating the influence in the home country. In fact, recent studies show how the ability to mobilize is a decisive factor in enhancing diasporas' potential (*Tejada and Bolay 2010) (Agunias and Newland 2012)*.

The aim of this paper was to provide an overview of concrete strategies and policies that a selection of countries have established to engage their scientific diasporas in their development processes. The three countries studied here have shown innovative forms of diaspora engagement and of institutional mechanisms for capitalising on their resources for harnessing positive impacts, particularly in the science and technology sector. The objective of this paper was not to offer a comparative analysis; neither was it to examine or suggest the possibility of replication of practices, given that these are based on specific case country contexts and historical backgrounds. The experiences shown take place in different geographical and political contexts, illustrating that the particularities of the concrete country context influence the ways scientific diasporas' knowledge and further resources can be channelled to their homelands.

While the diversity of the country contexts helps to explain why skilled migration can play a positive development role in some cases but not in others, it is evident, as stressed by de Haas (2008), that the possibility of influencing positive change in socio-economic terms in the home country by skilled migrants hinges both on the individual profile of the migrants themselves and on broad structural conditions. The experiences presented here show that adequate conditions and conducive environments for hosting transnational cooperation linkages and ensuring knowledge transfer, such as the availability of sufficient scientific and technological infrastructure, receptive and welcoming local culture, adequate environment for investing and creating employment and attractive career prospects, are all determining factors that have to accompany the implementation of initiatives and policies for engaging scientific diasporas in development efforts and harnessing positive impacts. In other words, while government initiatives may be important, the general political and socio-economic context in the home country seems to be the determining force in the capitalisation of diasporas' resources.

References

Agunias, D. R., & Newland, K. (2012). Developing a road map for engaging diasporas in development. A handbook for policymakers and practitioners in home and host countries. Geneva and Washington, D.C.: International Organisation for Migration and Migration Policy Institute.

Academy of Sciences of Moldova (ASM). 1990-2009. Annual reports on the activities of the Academy of Sciences of Moldova: years 1990-2009. Chisinau: ASM Printing House.

Barré, R., Hernández, V., Meyer, J-B., & Vinck, D. (2003). Diasporas scientifiques. Comment les pays en développement peuvent-ils tirer parti de leurs chercheurs et de leurs ingénieurs expatriés? Paris: Institute de la Recherche pour le Développement.

Bolay, J-C. (2012). Appropriate technologies for sustainable development. In Bolay, J-C., Schmid, M., Tejada, G. & Hazboun, E. (Eds.), Technologies and innovations for development. Scientific cooperation for a sustainable future (pp. 3-15). Paris: Springer.

Bordes Benayoun, Ch. & Schnapper, D. (2006). Diasporas et nations. Paris: Odile Jacob.

Buga, N. & Meyer, J-B. (2012) Indian human resources mobility: brain drain versus brain gain. CARIM-India Research Report 2012/4. Robert Schuman Centre for Advanced Studies; European University Institute.

Butler, Kim D. (2001). Defining diaspora, refining a discourse. Diaspora: A Journal of Transnational Studies, 10 (2), pp. 189-219.

Castells, M. (1996). The rise of the network society. The information age: economy, society and culture. Vol. I. Oxford: Blackwell.

Castells, M. (1997). The power of identity. The information age: economy, society and culture. Vol. II. Cambridge & Oxford: Blackwell.

Castles, S. 2010. Comprendiendo la migración global: una perspectiva desde la transformación social. Relaciones Internacionales 14, 41-168. GERI-UAM.

Chacko E. (2007). From brain drain to brain gain: reverse migration to Bangalore and Hyderabad, India's globalizing high tech cities. GeoJournal, 68, 2/3, 131-140.

Chaparro, F., Jaramillo, H. & Quintero, V. (2006). Promise and frustration of diaspora networks: lessons from the network of Colombian researchers abroad. Diaspora networks and the international migration of skills: how countries draw on their talent abroad. World Bank Institute. Washington, D.C.: World Bank.

CODEV-EPFL, IDSK, JNU & ILO. (2013). Migration, scientific diasporas and development: impact of skilled return migration on development in India. Final research report. http://infoscience.epfl.ch/record/188059/files/Migration_ScientificDiasporas_Development.pdf Accessed 15 August 2013.

Cohen, R. (1997). Global diasporas: an introduction. London: UCL Press.

David, P. A. & Foray, D. (2002). An introduction to the economy of the knowledge society. International Social Science Journal 54(171), 9-23.

Faist, T. 2010. Diaspora and transnationalism: what kind of dance partners?. Bauböck, R. & Faist, T. (Eds.) Diaspora and transnationalism. Concepts, theories and methods, (pp. 9-34). Amsterdam: Amsterdam University Press.

Finegold, D., Venkatesh, K., Winkler, A. & Argod, V. (2011) Why they return? Indian students in the United States. In Economic and Political Weekly, 46, 21, 21-25.

Foray, D. (2004). Economics of knowledge. Cambridge: MIT Press.

Glick-Schiller, N., Basch, L. G., & Szanton Blanc, C. (1992). Transnationalism: A New Analytic Framework for Understanding Migration. Glick-Schiller, N., Basch, L.G., & Blanc-Szanton, C. (Eds.); Towards a Transnational Perspective on Migration: Race, Ethnicity, and Nationalism Reconsidered (pp. 1-24). New York: New York Academy of Sciences.

GCIM - Global Commission on International Migration. (2005). Migration in an interconnected world : new directions for action. Report of the Global Commission on International Migration. Geneva: GCIM.

de Haas, H. (2008). Migration and development. a theoretical perspective. Working Paper 9. Oxford: University of Oxford, International Migration Institute.

Hollanders, H. & Soete, L. (2010). Le rôle croissant du savoir dans l'économie mondiale. Rapport de l'UNESCO sur la science (pp. 5-31). Paris: UNESCO.

IOM (2009). The socio-economic impact of the economic crisis on migration and remittances in the Republic of Moldova. Chisinau: IOM.

IOM (2012). Extended migration profile of the Republic of Moldova. Chisinau: IOM.

Khadria, B. (2008). International migration policy: issues and perspectives for India (IMDS project working paper series, WP no. 1, pp. 2–20). New Delhi: IMDS Project.

Kuptsch, C. (2006). Students and talent flow – the case of Europe: from castle to harbour? In C. Kuptsch & E. F. Pang (Eds.), Competing for global talent (pp. 33–61). Geneva: ILO.

Levitt, P., & Glick Schiller, N. (2004). Conceptualizing Simultaneity: A Transnational Social Field Perspective on Society. International Migration Review, 38(3), 1002-1039.

Lücke, M., Mahmoud T. and Pinger, P. (2007). Patterns and trends on migration and remittances in Moldova. Chisinau: IOM.

Meyer, J.-B. (2001). Network approach versus brain drain: lessons from the diaspora. International Migration 39(5), 91-110.

Meyer, J.-B. (2007). Building sustainability: the new frontier of diaspora knowledge networks. Working Paper No. 35. Bielefeld: COMCAD

Meyer, J.-B. (2010). Preface. Tejada, G. & Bolay, J,-C. (Eds.), Scientific diasporas as development partners: skilled migrants from Colombia, India and South Africa in Switzerland. Empirical evidence and policy responses, (pp. XV-XVII). Bern: Peter Lang.

Meyer, J.-B., & Charum, J. (1995). La 'fuite des cerveaux' est-elle épuiseé? Paradigme perdu et nouvelles perspectives. Cahiers des sciences humaines 31(4), 1003-1017.

Meyer, J.-B., & Wattiaux, J.-P. (2006). Diaspora knowledge networks: vanishing doubts and increasing evidence. International Journal of Multicultural Societies 8(1), 4-24.

MOIA (2012) Annual report 2011-12, Ministry of Overseas Indian Affairs. New Delhi: Government of India.

Mosneaga, A. (2010). Linking international student mobility to skilled migration: the case of Denmark. International Journal of Contemporary Sociology 47(1), 98-118.

OECD. (2008). A profile of immigrant populations in the 21st century: data from OECD countries. Paris: OECD.

OECD. (2011). Education at a glance, OECD Indicators. http://dx.doi.org/10.1787/eag-2011-en. Accessed 18 August 2013

OECD (2012). Resserrer les liens avec les diasporas. Panorama des compétences des migrants. Paris: OECD.

Orozco, M. (2008). Looking forward and including migration in development: remittance leveraging opportunities for Moldova. Chisinau: IOM.

Özden, C., Parsons, Ch., Schiff, M. & Walmsley, T.L. (2011a). Where on earth is everybody? The evolution of global bilateral migration 1960-2000. The World Bank Economic Review 25(1), 12-56.

Özden, C., Rapoport, H. & Schiff, M. (2011b). Five questions on international migration and development. The World Bank Economic Review 25(1), 1-11.

Portes, A., Guarnizo L. & Landolt, P. (1999). The study of transnationalism: pitfalls and promise of an emergent research field. Ethnic and Racial Studies 2(22), 217-237.

Portes, A. (2001). The debates and significance of immigrant transnationalism. Global Networks 1(3), 181-194.

Saxenian, A. (2005). From brain drain to brain circulation: transnational communities and regional upgrading in India and China. Studies in Comparative International Development 40(2), 35-61.

Saxenian, A. (2006). The new Argonauts. Regional advantage in a global economy. Cambridge: Harvard University Press.

Sheffer, G. (1986). Diasporas in International Relations. New York: St Martin's Press.

Song, H. (1992). From brain drain to reverse brain drain: three decades of Korean experience. Science, Technology and Society, 2(2), 317-45.

Stiglitz, J. (1999). Knowledge as a global public good. Kaul, I. Grunberg, I. & Stern, M. (Eds.) Global public goods. International cooperation in the 21st. Century, (pp. 308-325). New York and Oxford: UNDP and Oxford University Press.

Tejada, G. (forthcoming) Skilled migration, transnational cooperation and development contributions: evidence from the Moldovan scientific diaspora. Results of the project ASM-EPFL on Moldovan scientific diaspora (in press, forthcoming 2013).

Tejada, G., Hercog, M., Kuptsch, Ch. & Bolay, J.-C. (forthcoming). The link with a home country: a comparative analysis of host country environments for diaspora engagement. Sahoo, S. & Pattanaik, B.K. Global diasporas and development: Socio-economic, cultural, and policy perspectives. Springer, New Delhi (in press, forthcoming 2013).

Tejada, G. (2012). Mobility, knowledge and cooperation: scientific diasporas as agents of development. Migration and Development 10(18), 59-92.

Tejada, G. (2010). The Colombian scientific diaspora in Switzerland. Tejada, G. & Bolay, J.-C. (Eds.), Scientific diasporas as development partners: skilled migrants from Colombia, India and South Africa in Switzerland. Empirical evidence and policy responses, (pp. 199-313). Bern: Peter Lang.

Tejada, G., Dia, I.A., & Kwankam, F. (2010). Scientific diasporas from Colombia, India and South Africa in Switzerland, concluding remarks and implications for policy and research. Tejada, G. & Bolay, J.-C. (Eds.); Scientific diasporas as development partners: skilled migrants from Colombia, India and South Africa in Switzerland. Empirical evidence and policy responses, (pp. 487-513). Bern: Peter Lang.

Tejada, G., Varzari, V. & Porcescu, S. (2013). Scientific diasporas, transnationalism and home-country development: evidence from a study of skilled Moldovans abroad. Southeast European and Black Sea Studies 13(2), 157-173. http://dx.doi.org/10.1080/14683857.2013.789674

UNDP. 2013. Human development report 2013. The rise of the South: human progress in a diverse world. New York: UNDP.

UNESCO (2010). UNESCO Science Report 2010. The current status of science around the world. Paris: UNESCO.

Vertovec, S. 2001. Transnationalism and identity. Journal of Ethnic and Migration Studies 27(4), 573–82.

Vertovec, S. (2004). Migrant transnationalism and modes of transformation. International Migration Review 38(3), 970–1001.

Vincent-Lancrin, S. (2006). What is changing in academic research? Trends and futures scenarios. http://www.oecd.org/edu/ceri/37481256.pdf. Accessed 12 August 2013.

Wiesbrock, A. (2008). Return migration as a tool for economic development in China and India. Working paper 3. International Migration and Diasporas Study Project. New Delhi: IMDS Project, JNU. http://www.jnu.ac.in/library/IMDS_Working_Papers/IMDS_Dec_2008_WP_3_31-500001.pdf. Accessed 13 August 2013.

World Bank. 2011. Migration and remittances factbook 2011. Washington, D.C.: World Bank.

Yoon, B.S. (1992). Reverse brain drain in South Korea: state-led model. Studies in Comparative International Development 17(1), 4-26.

Developing a Science and Technology Policy for Trinidad and Tobago

Policy, Research and Intelligence Unit, NIHERST
(julie.david@niherst.gov.tt)

Developing a Science and Technology (S&T) Policy for Trinidad and Tobago (T&T) is timely and critical. With a GDP per capita of around US$20,300 in 2011, this Small Island Developing State is one of the richest countries in the Western Hemisphere with some resources to invest in Research and Development (R&D). S&T is also seen as critical in helping to diversify the economy away from its heavy and traditional dependence on oil and natural gas.

A snapshot of the status of S&T in Trinidad and Tobago reveals persistent challenges. Among these, the historically low level of public funding for R&D undermines the potential of the country's active S&T practitioners, while a low absorptive capacity suggests the need to upgrade the national S&T infrastructure, build human capital and strengthen international linkages. In addition, the weak, and at times, incomplete or non-existent application of scientific knowledge and appropriate technology across sectors impedes progress in solving some of the country's most pressing developmental problems.

While T&T's economic progress over the past 20 years has been remarkable, an increased use and application of S&T certainly could help mitigate some of the island's most pressing problems. For example:

- The use of modern technologies in the areas of early detection, crime analysis and classification, data sharing and system integration could combat the persistence and severity of violent crimes eroding citizen security;

- The adoption and adaptation of appropriate technology, combined with a knowledgeable and well-trained cadre of medical professionals, could bring about earlier and more accurate diagnoses of illnesses as well as more efficient and effective methods of treatment. In addition, with a wider dissemination of scientific knowledge on health and wellness, T&T's citizens could feel empowered in preventing chronic diseases such as diabetes and hypertension;

- The development and enforcement of sound, sustainable building codes and infrastructural regulations could lower T&T's susceptibility to the effects of natural disasters such as earthquakes and hurricanes; and

- The creation of an enabling environment for research and development through fiscal incentives, improved physical infrastructure, and a transparent, efficient regulatory regime could help T&T overcome its low propensity for product and process innovation.

Research shows that other S&T challenges include the lack of awareness and trust in intellectual property protection for locally produced innovations, as evidenced by low levels of patenting activity by residents of Trinidad and Tobago. The absence of a strong political enabler for S&T has been a perennial problem as this situation has stymied the growth and development of S&T within the country.

However, some positive trends in S&T have also been observed in the data, namely the rising levels of tertiary level enrolment and graduation from local universities and higher education institutions, the rapid adoption of consumer technologies by citizens over the past decade, and the small but gradually emerging wave of new local entrepreneurs incorporating ICTs and the creative industries.

The recently-completed draft Policy treats with many of the issues identified above. Among them, it seeks to strengthen institutional linkages among academia, government and industry; to establish new networks with Trinidad and Tobago's scientific diaspora; to increase the amount and variety of S&T outputs, including patents, new products and services; and to dovetail with other relevant national policies in the pursuit of the overall development objectives of the Government of the Republic of Trinidad and Tobago.

A brief recap of the policy development process for the National S&T Policy features the assumptions which must be met if the policy is to achieve its desired objectives and the many challenges encountered - some cultural, technical and administrative- in crafting public policy solutions in Trinidad and Tobago.

The Policy assumes the following:

- S&T will play a greater role in national development strategy, especially when development is viewed from a long-term perspective.
- The Government of the republic of Trinidad and Tobago will view S&T as a critical bi-partisan development tool, and will therefore invest to upgrade the physical and institutional infrastructure necessary to support the national S&T system.
- Institutions responsible for implementing the Policy will be internally flexible and externally empowered by the Government of the Republic of Trinidad and Tobago to collaborate and experiment with policy initiatives in order to meet constantly evolving challenges.

Because of the dynamic nature of S&T, it was decided that the policy development process be highly inclusive. The Policy is therefore driven by the views and needs articulated by stakeholders - from academia, industry, civil society and government - as they are most alert to the ways in which S&T affects their academic, commercial and social circumstances.

Because of the inclusive nature of the S&T Policy development process, the bulk of the initial desk research contributed towards the preparation of an S&T Policy Consultation Paper. This document was circulated to key stakeholders for feedback. As a guide to discussion, the paper briefly explored the current S&T landscape in Trinidad and Tobago, identified a series of problems, and proposed a variety of potential solutions for participants to discuss. Most importantly, it challenged stakeholders to identify what they saw as the most critical issues regarding S&T nationally, and to detail collectively their preferred pathways towards strengthening the national S&T system. Following on from the consultation paper, NIHERST hosted a series of stakeholder workshops on the Policy between October 2012 and January 2013, involving the following stakeholder groups:

- Research, Education and Training Institutions
- Business Community Stakeholders
- Civil Society: North and Central Trinidad
- Civil Society: Tobago
- Government Ministries, Departments and Agencies
- Civil Society: South Trinidad.

At each workshop, discussion questions were circulated with each set of questions tailored to the priorities of each stakeholder group. At the end of each workshop, responses from participants were noted and summarised, so that by the end of the final workshop, the NIHERST team had a strong idea about the consensus of needs and desired interventions by each group. Some of the emergent themes that cut across stakeholder groups were as follows:

- Acknowledgement of the need for major improvements to Science, Technology, Engineering and Mathematics (STEM) education in T&T, from pre-primary to post-doctoral levels;
- Low levels of trust in government agencies with responsibility for S&T;
- A lack of awareness of the S&T support services currently offered by the State;
- Weak or non-existent coordination and collaboration among ministries and agencies leading to fragmentation of S&T support services, confusion and disillusionment among stakeholders, and 'silo' behaviour by state entities; and
- A relatively high degree of trust in NIHERST as an independent body to coordinate S&T-related matters, including governance and the oversight of R&D funding.

The consultation paper was also published on the NIHERST website and online feedback was solicited. While the number of online respondents was relatively low, they represented a wide range of ages and sectoral occupations including students, faculty, civil society, inventors, public servants and entrepreneurs. This suggests that online stakeholder engagement can reach a large, diverse audience and can, therefore, become a more prominent policy development tool, once there is a strong promotional effort to sensitise citizens to the option.

With the national priorities defined by stakeholders, the Policy Research and Intelligence Department at NIHERST began drafting the Policy in February 2013. Further and more detailed stakeholder input was derived from a series of one-on-one interviews with representatives of critical S&T institutions, and these were conducted alongside the Department's preparation of the draft Policy. As new information and data have come in from a multitude of sources, the Policy has been continuously amended so that it best reflects extant reality.

Appendix

INSCITED

International Conference on Science and Technology for Economic Diversification

OPENING CEREMONY PROGRAMME

June 4, 2013

Chair of Proceedings:
Dr. Rawatee Maharaj-Sharma, Chair of INSCITED Planning Committee

6:30PM National Anthem of Trinidad and Tobago

Invocation

- **Welcome Remarks**
  Prof. Prakash Persad
  Chairman of the Board of Governors
  NIHERST

- **Greetings from OAS**
  Dr. Jorge Duran (Representing the General Secretariat)
  Chief of Science, Technology and Innovation
  Department of Economic Development, Trade and Tourism
  Organization of American States (OAS)

- **Greetings from NISTADS**
  Dr. Kavita Mehra
  Senior Scientist
  National Institute of Science, Technology and Development Studies (NISTADS)
  India

- **Greetings from Costa Rica**
  Dr. Keilor Rojas
  Vice Minister of Science and Technology
  Costa Rica

- **Entertainment Interlude**

- **Keynote Address**
  Dr. Jeffrey Pullicino Orlando
  Chairman
  Malta Council for Science and Technology

- **Feature Address**
  Dr. The Hon. Rupert Griffith
  Minister of Science and Technology
  Trinidad and Tobago

- **Closing Remarks**
  Mrs. Maureen Manchouck
  President
  NIHERST

8:00PM – 9:30PM Cocktail Refreshments

Ministry of Science and Technology

NIHERST

ORGANIZATION OF AMERICAN STATES

NISTADS

INSCITED

International Conference on Science and Technology for Economic Diversification

Conference Programme

Hilton Trinidad Hotel and Conference Centre, Port of Spain

June 5 - 7, 2013

INSCITED is a platform for engagement and collaboration between national and international experts, policy makers and researchers in science and technology, higher education, training and labour markets. Its aim is to provide policy guidance and solutions to support economic transformation and sustainable development. The main topics are "Inclusive Growth and Economic Diversification", "Technology and Sustainable Development" and "Human Capital Development in a Globalised Setting".

Day 1

Inclusive Growth and Economic Diversification

Session 1 9:00AM - 10:10AM

◇ **Opening Remarks by Dr. the Hon. Bhoendradatt Tewarie, Minister of Planning and Sustainable Development , Trinidad and Tobago**

◇ **Feature Speaker: Inclusive Growth and Economic Diversification**
- Mr. Jwala Rambarran, Governor, Central Bank of Trinidad and Tobago

Session 2 10:35AM - 12:10PM

S&T policy for supporting inclusive growth, economic diversification and sustainable development

◇ **Economic Benefits of Publicly Funded Research and the Rationale for Public Funding** - Prof. Ben Martin, University of Sussex, United Kingdom

◇ **Health and Economic Development in a Small Country** - Prof. Karl Theodore, Centre for Health Economics, University of the West Indies, St. Augustine, Trinidad and Tobago

◇ **Economics and Policy Issues in Energy and the Environment**
- Prof. Gordon MacKerron, University of Sussex, United Kingdom

Session 3 1:10PM - 2:45PM

◇ **Knowledge Systems for Supporting Public Decisions** - Dr. Jason Blackstock, University College London, United Kingdom

◇ **The Plan of Action of Panama: Innovation, SME's and Engineering for Growth** - Dr. Jorge Duran, Organization of American States

◇ **The Role of Science, Technology and Innovation Policy in Economic Diversification** - Mr. Michael Lim, United Nations Conference on Trade and Development, Switzerland

Session 4 3:00PM - 4:30PM

◇ **Innovation in Mexico: Challenges and Opportunities** - Dr. Maria del Pilar M. Perez Hernandez, National Polytechnic Institute, Mexico

◇ **Evaluation of Innovation Clusters in India and CARICOM: Policy Frameworks and Institutional Mechanisms** - Dr. Debashis Bandyopadyhay, Council of Scientific and Industrial Research - CGCRI, India

◇**Strategy for Policy Dialogue on Science and Technology and Innovation in the Caribbean: Output of the EUCARINET Project-** Mr. Joseph Williams, Caribbean Community (CARICOM) Secretariat

Day 2

Technology and Sustainable Development

Session 1 9:00AM - 10:10AM

◇ **Opening Remarks by Dr. Keilor Rojas Jiménez, Vice Minister of Science and Technology, Costa Rica**

◇ **Feature Speaker: Technology and Sustainable Development** - Prof. Prakash Persad, Chairman, NIHERST

Session 2 10:35AM - 12:10PM

Promoting Technology Transfer in Various Sectors and SMEs

◇ **Jamaica Energy Dilemmas** - Prof. Anthony Clayton, University of the West Indies, Mona, Jamaica

◇ **Skills Development in Greening Economies: The Indian Case** - Dr. Kasturi Mandal, National Institute of Science Technology and Development Studies, India

◇ **Inclusive Growth and CARICOM Economies: Considerations in Developing a Green Growth Framework** - Mr. David Anyanwu/ Dr. Debbie Mohammed, University of the West Indies, St. Augustine, Trinidad and Tobago

Session 3 1:10PM - 2:45PM

◇ **Domestic Solar Energy: A Viable Alternative in Trinidad and Tobago** - Mr. Kiron Neale, 2013 Commonwealth Caribbean Rhodes Scholarship Winner

◇ **Strengthening Agricultural Science, Technology and Innovation Systems: Lessons for Policy** - Ms. Judith Ann Francis, Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA) , The Netherlands

◇ **Development of Biotechnology in India: Role of Public Policies** - Dr. Kavita Mehra, National Institute of Science Technology and Development Studies, India

Session 4 3:00PM - 4:10PM

◇ **Outline of the Draft National Science and Technology Policy for Trinidad and Tobago** - Mr. Robert Martinez / Ms. Julie David, Policy Research and Intelligence Unit, NIHERST

◇ **Panel Discussion: Towards a National Science and Technology Policy for Trinidad and Tobago** - Prof. Prakash Persad, Dr. Keilor Rojas, Dr. Jeffrey Pullicino Orlando and Prof. Ben Martin

Day 3

Human Capital Development in a Globalised Setting

Session 1 9:00AM - 10:10AM

◇ **Opening Remarks by The Hon. Fazal Karim,**

Minister of Tertiary Education and Skills Training, Trinidad and Tobago

◇ **Feature Speaker: Human Capital Development in a Globalised Setting** - Dr. Jason Blackstock, University College London, United Kingdom

Session 2 10:35AM - 12:10PM

Emerging Patterns of Higher Education - Open and Distance Learning Policies and Systems

◇ **Democratising Higher Education through Open Education Resources (OER): What are the Possibilities?** - Prof. Asha S. Kanwar, Commonwealth of Learning, Canada

◇ **National Research and Education Networks in the Caribbean: The Case for Trinidad and Tobago**- Mr. Gerard Ahee, Project Officer, Distance Learning Secretariat, Ministry of Tertiary Education and Skills Training

◇**Enabling ICT in your Businesses -** Mr. Selwyn Ramroop, Managing director, Alliance Software and Technology Systems Limited

Session 3 1:10PM - 3:00PM

Leveraging the Diaspora for reverse brain drain

◇ **Skilled Migration and Development: Scientific Diasporas as Drivers of Science and Technology in the Home Countries** - Dr. Gabriela Tejada, Cooperation and Development Center, Swiss Federal Institute of Technology Lausanne, Switzerland

◇ **ICTs, Caribbean Diaspora and Knowledge Mobility Management: Networking the Caribbean Economy** - Dr. Chanzo Greenidge, Project Management Unit, Intra-ACP Migration Facility, Brussels, Belgium

◇ **Globalization and Transnational Migrations: How Does Brain Drain Become Brain Gain?** - Dr. Akanmu Adebayo, Professor of History & Director of the Center for Conflict Management, Kennesaw State University, Georgia, USA

Closing Remarks

Ministry of
Science and Technology

NIHERST

niherst.gov.tt

oas.org

NISTADS

nistads.res.in