IIIEE Theses 2012:20

The Case for Green Roofs

Exploring green roof policy as a tool to increase urban sustainability.
A Case Study of Port of Spain, Trinidad & Tobago

Cherisse R. Braithwaite

Supervisor
ÅkeThidell

Thesis for the fulfillment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2012

Published in 2012 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

"To whom much is given, much is expected."

First and foremost, I would like to acknowledge and express my gratitude to God, in whom I have unwavering faith. This entire experience has served to reinforce the faith that all my steps are guided.

*"Courageous risks are life-giving, they help you grow, make you brave, and better than you think you are."*Joan L. Curcio

Secondly, I want to express my immense appreciation for my parents, Richard and Paula who have always wholeheartedly encouraged and supported me on whatever path I wanted to take. Also, thanks to my wonder twin, Chantal, for selflessly encouraging me like a good big sis and building me up when I felt defeated.

It is easy to take those risks when you have such an unwavering support system and for that I am eternally grateful. My family is my rock and because of them, I have indeed grown, become braver and risen up to be better than I thought I was.

To Anthon, thank you for your support, unbelievable patience and constant encouragement. You have made this experience much easier than it is supposed to be.

A HUGE thank you to my friends, especially to the ones I have all but ignored in this pursuit of higher learning. It is only because I believe in the strength of our friendships that I know I will be forgiven for that neglect (hopefully!) and, if that is not enough, I will buy you all drinks (I might even throw in some sushi for you, Alex). Thank you all for the encouraging words, prayers and supportive ears when I needed it most.

To the staff of the IIIEE: Thank you for the opportunity to work with you all. You have indeed changed my perspective on academics as well as life. Thank you to my supervisor ÅkeThidell, for your assistance during the thesis process.

To my B17 (B.B.E) batchmates: The family that we have grown into was a great source of support. You are all amazing individuals with an even more amazing talent for uplifting one another and inspiring each other. **Grattis!** We did it! I know we will all go on to do great things and I hope our paths cross sometime in the future (you will always have a place to stay in Trinidad and Tobago…I expect a full house for Carnival).

I would also like to thank the readers of this thesis, especially those who may have played a part in its fruition.

While Trinidad and Tobago, to many, is just another dot in the atlas, it is MY dot, and I am immensely proud that through this research, I have been able to contribute in my own small way to its sustainability and preservation.

Abstract

Trinidad and Tobago is a country with a long history in the hydrocarbon industry. This makes the country one of the wealthiest in the Caribbean region and most poised to be at the edge of innovation and sustainable technology use. However, unsustainable urban development practices have resulted in increasing negative impacts. Governments world-wide have been introducing policies and regulations to promote green roofs in urban buildings. However, the technology is relatively unexplored in Caribbean environments such as Port of Spain, Trinidad and Tobago. This thesis examines the major drivers for a green roof policy in Port of Spain, ex ante, as well as explores the potential barriers that would be encountered based on the experiences of other past programs and initiatives with environmental sustainability goals.Case study approach is adopted to investigate the background and case context of Port of Spain using the implementation routes for green roof policy globally with special focus on Singapore to frame the research.The paper concludes by providing further suggestions and actions that can help mitigate these existing barriers.

Keywords: green roofs, green building, Trinidad and Tobago, urban development, Caribbean

Executive Summary

"The nature, which we have on our roofs, is a piece of earth that we have killed so that we could build a house on the spot"

F. Hundertwasser

Problem Definition

- **Green roofs are well established in European contexts and have been incorporated into urban development strategies.** LimitedResearch is available for the tropical climate context, especially for small island developing states in the Caribbean. Green roofs are relatively unexplored as urban sustainability and resilience tools in Trinidad and Tobago, but are done for more aesthetic value.
- **Ex ante research is a necessary step before green roofs are explored as a viable tool that should be integrated into government strategies.** Due to the unexplored nature of green roofs within the local context. exploratoryresearch to guide planners and policymakers of these small island states interested in incorporating green roofs into overall national development strategies

Findings

- **Several countries in both temperate and tropical climates have encouraged green roofs in urban areas.** The best policy route is dependent on the dynamic system of local conditions.
- **Green roofs have several benefits and costs that are prioritized differently depening on local dynamics.** Green roofs take various forms and have different benefits dependent on the local social structure, economic profile and environmental concerns.
- **Urgent motivations to use green roofs exist within the urban area of Port of Spain on the Caribbean small island state Trinidad and Tobago.** Climate change, sea level rise, increasing damages due to weather events all highlight the urgent need for environmentally sustainable methods of building
- **There are several stakeholders within the urban development sector of Trinidad and Tobago.** Urban development policy involves several players and several government authorities and agencies. Strategic interviews with key stakeholders have been conducted to document perceptions of barriers, drivers, opportunities and concerns for a potential green roof policy.
- **Stakeholder perspectives are important to inform policy makers and investor with ideas and options for a locally specific green roof policy.** Effective stakeholder engagement is essential for the development and enforcement of a green roof policy due to the shared knowledge, expertise, visions and ability to build adaptive capacity for long term success.

Analysis

- **A pervasive lack of environmental sustainability awareness exists among the public, industry players and government decision makers.** Development is viewed as antagonistic to environmental protection and has resulted in unsustainable development and a constant cycle of damage and repair instead of prevention.
- **Minimal incentivesfrom government** :high upfront costs of green roofs are identified as the top barriers to the implementation. Life cycle analysis is not commonly consulted in the local environment.

- **There is a need for increased baseline data and research to inform standards and regulations.** Incentives for research, energy auditing as well as innovation. Collaboration and systems of diffusing information efficiently to the correct stakeholders is necessary.
- **Continuous education of sustainable development principles (and raising the triple bottom line) needs to be integrated at all levels of education** Building a supportive local environment includes professional training, school-age environmental education as well as course curricula at institutions of higher learning to include sustainability modules.
- **There is a high level of central governance which tends to underrepresent stakeholders with environmental sustainable agendas.** High perceptions of corruption, industry inertia towards innovation frustrate attempts to integrate new technologies with longer payback periods. Additionally, changing central government administrations result in stagnation of sustainable development projects and policy reforms. Stakeholder collaboration and partnerships empower stakeholders and decentralize power.

Discussion and Conclusions

- **Green roof policy should be integrated into wider government policies for green building techniques.** Building code based on international best practices are a good preliminary step but local research is needed to quantify benefits and justify change. Urban Development policy within Trinidad and Tobago needs reform
- **Environmentally sound technologies such as green roofs need supportive mechanisms for local experimentation, innovation and development.** As green roofs are an emerging technology in Trinidad and Tobago, it is best to incentivize the technology first through appropriate policy and then utilize the data obtained to adapt policy in future.
- **The success of a green roof policy is directly connected to the legislative background and system of governance within Trinidad and Tobago.** New integrative forms of governance, such as Transition management should be explored by the Government of the Republic of Trinidad and Tobago (GORTT) to push a transition to a sustainable city at all levels of society.

It is not the intent of this thesis to advocate for the use of green roofs or any green building policy as a panacea for the negative impacts of poor practices while unsustainable development continues in the country. Moreso, the goal of this thesis is to explore to what extent green roofs could alleviate the current sustainability challenges, due to past unsustainable processes, and how decision and policy makers could proceed to affect change.

Table of Contents

List of Figures

List of Tables

Abbreviations

GORTT Government of the Republic of Trinidad and Tobago

UNFCCC United Nations Framework Convention on Climate Change

MOLG Ministry of Local Government

IDB Interamerican Development Bank

UWI University of the West Indies

NSDS. National Spatial Development Strategy

ESCI Emerging Sustainable Cities Initiative

1 PROBLEM DEFINITION

Academic study of green roofs has produced vast amounts of literature within temperate climate contexts such as Europe and North America. There is a far smaller amount of research available for the tropical climate context, especially in the Caribbean subregion. There is a lack of research to guide planners and policymakers of these small island states interested in incorporating green roofs into overall national development strategies. In Trinidad and Tobago, green roofs are rare, and those that exist have not been explored as urban sustainability and resilience tools, but are done for more aesthetic value.

This thesis seeks to contribute to the body of knowledge of green roof policy application by using academic literature of the theories, research and practical solutions green roofs applied within the country context of Trinidad and Tobago. Strategic interviews have been conducted to compile and document the perceived barriers, drivers, opportunities and concerns held by key stakeholder[1]s within urban development as well as to map their roles and responsibility in any potential green roof policy.

This thesis contains an overview of green roof technology as well as the ideas and theories underlying their application. This research then identifies and discusses the relevant benefits, costs and challenges for the local context, describing the potential use of different interventions for the integration of green roofs in national development strategies.

While it is not possible to determine and assess which policy tool is the best route as that is highly dependent on the system of local conditions which can be highly dynamic; this thesis seeks to present the theories and trends in green roof policy worldwide, with specific focus on stakeholder perspectives to better provide policy makers and investors in Trinidad and Tobago with ideas and options for a locally specific green roof policy. The goal is to explore the concepts, ideas and options of this so that local planners and decision makers in the urban development sector will have the knowledge necessary to decide what options are best suited to local conditions(Forbes, 2010)

Currently, slightly over half of the population of Trinidad and Tobago is concentrated in the urban areas and settlements at the foothills of its northerly mountain range, an area which includes the capital city of Port of Spain(Nagy, 2011) According to UN-Habitat in 1990 the urbanization level in Trinidad and Tobago was 69.1% and 77.9% respectively in 2010. This is above average for the world and similar to mainland Latin America(IDB, 2011).
Due to the higher population density and concentration of administrative activities in the city, challenges within Port of Spain (such as flooding, climate change adaptation, energy costs and greenhouse gas emissions) have a major impact on sustainable development of the country as a whole. Metropolitan areas have a very important role as centres of innovation and information and knowledge can flow easily (OECD 2006).

Port-of-Spain is one of five (Montevideo, Port-of-Spain, Santa Ana (El Salvador), Trujillo (Peru), and Goiânia (Brazil) cities that the Inter-American Development Bank (IDB) has included in its pilot programme, Emerging Sustainable Cities Initiative (ESCI). The initiative was launched in 2010 with the goal to foster collaboration between cities and to develop long-term strategies for environmental, fiscal, and urban management and sustainable development, especially in the face of expected climate change impacts.(Staff, 2012b).

[1]'any person or organization, who can be positively or negatively impacted by, or cause an impact on the implementation of a green roof policy mandated by the Government of the Republic of Trinidad and Tobago (GORTT).

Innovative green building techniques involving the creation of green infrastructure can be used as tools to mitigate these increasing challenges and can be actively encouraged within urban planning strategies. Green infrastructure, for the purposes of this research, is defined as "a planned network of multifunctional green spaces, developed and managed as a vital part of meeting the environmental, social and economic needs of communities" (Oberndorfer et al., 2007)Green roofs are a type of green infrastructure that can also be classified as a green building technique, as it is manmade, and developed as a part of a building structure.

While green roof research and application in the tropics has recent beginnings, there are established benefits in the climactic region that include stormwater[2] retention and increased energy efficiency of buildings. Green roofs have therefore already been incorporated into urban infrastructure planning in tropical climates to limit urban flooding events and increase building energy efficiency .e.g. Singapore and Hong Kong

This thesis seeks to identify the role that green roofs, and ergo, green building techniques, , can play as part of an overall sustainable urban development strategy in Port of Spain, Trinidad. For the purposes of this research, the term 'green roofs' refers to vegetated rooftops (living gardens, green roofs and terraces). This research proposes to contribute to the knowledge in the area of green roof policy application through the analysis of green roofs as a mitigation tool for urban sustainability & resilience challenges faced by Caribbean small island states; identification of barriers and drivers of the use of green roof policy, and the identification of key actors and their roles in the implementation of green roof policy, and potential interventions based on previous successful implementations.

The overall goal of this thesis is to assess the best routes for establishing a green roof policy given the different perspectives, motivations, costs, physical characteristics, regulatory infrastructure, and social dynamics through focusing on the city of Port of Spain, Trinidad and Tobago.

1.1 Research Questions:

How can green roof technology be encouraged in the urban development sector of Trinidad and Tobago

Sub Questions

What are the technical and non- technical barriers and drivers of a green roof policy in Trinidad and Tobago?

What are the most appropriate policy tools to encourage the diffusion of green roofs in Trinidad and Tobago?

[2] 'Stormwater' describes water that originates from precipitation events.

1.2 Intended Audience

This thesis research is intended for the following groups of people, among others:

Policy Makers: Government bodies form a major resource as those who conduct the process of policy making have the most immediate ability to create an enabling environment for green roof technology transfer as well as understand and apply the effective policies globally that are presented in this thesis.

International Organizations andNon governmentalOrganisations(NGOs): There are many powerful donor and international organizations and NGOs that are involved in promoting sustainable development in Trinidad and Tobago who play the role of advocate and can influence policy reform and development.

All urban development sector stakeholders, and sustainable development stakeholders in general in Trinidad and Tobago will find this research of importance in order to understand the sector in Trinidad and Tobago.

2 Research Methodology

The research in this thesis is being conducted prior to the development of a green roof policyin Trinidad and Tobago. This ex ante approach, done before the action is adoptedresults in information about the policy problem and proposed policy outcome. Ex-ante policy assessment informs the preparation of policy proposals, impact assessment and consultations with external stakeholders.

This prescriptive approach to policy analysis relies on literature review and background study to provide valuative and prescriptive information regarding the goals of a future policy. Multiple sources of evidence were used during data collection: academic literature, policy archival data, telephone and in-person interviews were used in this study to ensure validity and a wider array of evidence strengthening the data collected(Bergman, 2008).

Preliminary research was done to identify relevant data regarding tropical green roof systems. Experts within the field were contacted for guidance on completed research and overall feasibility of the study. Organization coordinators were consulted to help frame the research so it would be of best relevance and usability to current initiatives and future policymakers. Further information was sought by contacting key persons within the urban development sector in Trinidad & Tobago. 'Snowball sampling' was used to an extent as contacts were established based on referrals from interviewees.

2.1 Research Design and Analysis

Figure 1 below graphically represents the research process developed by the author for conducting this research. The research follows a case study approach using other cases to frame more detailed research. (Yin, 2003)The figure is intended to clarify the research design, and how the analysis was conducted. The research consisted of three main stages: data collection, data analysis with the use of an analytical framework, and final considerations.

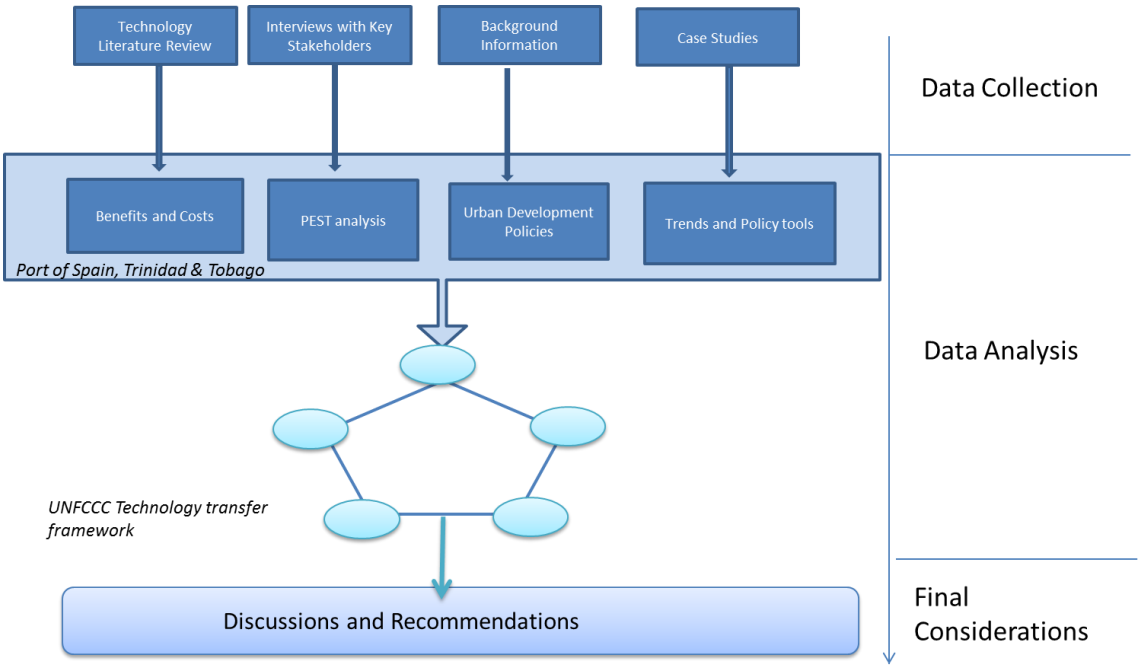


Figure 1 Research Design developed by Author

2.1.1 Data Collection

Data collection consisted of a review of academic literature, legal literature, a review of case studies, identification of key stakeholders, a series of semi structured interviews with relevant stakeholders, analysis of literature and data collected and final considerations.

(i) Literature Review

Background data was obtained from both primary sources; published by agencies or individuals involved as well as from secondary sources both electronically (publicly available online) and as published works. Information from the mass media, specifically archives from online newspapers was also utilised as guidance for some research.

Academic literature on key concepts such as urban sustainability, resilience, policies; green roof technology and application was reviewed. These were sourced through relevant books, journals, periodicals and reports based on searches via Summon (accessible through Lund University).

Green roof policy trends and examples of implementation routes in other countries are briefly introduced for the purpose of demonstrating the several ways used to implement green roof policy. Special focus is paid to the country of Singapore for the above mentioned reasons.

(ii) Stakeholder Interviews

Stakeholders were selected because of their role and previous experiences in the decision chain for public and private construction of buildings and urban infrastructure in Port of Spain (consultation process, permit application, design, construction and contracting). Many stakeholders held multiple roles within the sector.This was done through a preliminary review of the decision chain of the typical urban building in Port of Spain as well as through information from preliminary fact finding interviews with experienced professionalsA list of interviewees with their roles is included in Appendices 1 and 2.

Interviews with stakeholders were initiated, planned and executed in the following steps. People holding positions at local authorities, organsiations, academic and research institutions and businesses that play a role in urban planning and green infrastructure, relevant to this thesis were contacted via e-mail. Initial emails included a brief introduction and description of the thesis' scope

The interviews were carried out a one to one basis in person (with the exception of 2 conducted over the telephone) with the interviewer giving background information about her Masters' Degree programme and the context of the research thesis as well as the purpose of the interview questions and answers was to provide data for analysis for the Thesis. Interviewees were asked to identify their background, their experience and current role in urban development in Trinidad and Tobago; their knowledge of existing policies and their relation to other stakeholders. Additionally, their perceived barriers and drivers to the development of green infrastructure policy were also recorded. The answers to the questions were recorded via dictophone. the semi structured format of the interviews allowed for improvisation with follow up questions and clarification of relevant concepts and idea and references.

TTGBC Meeting

The Trinidad and Tobago Green Building Council (TTGBC) is a body of 'multidisciplinary building professionals committed to achieving sustainable building in Trinidad and Tobago'(Archer, 2010)

A formal meeting of the TTGBC was also attended by the interviewer on 27th June 2012, which gave opportunity to note several stakeholder perspectives in an open feedback format. The author's presence and intent was made known beforehand by the board of the TTGBC and notes were made on the several perspectives that were brought up. Major topics of discussion included green building techniques, strengths, challenges, constraints and suggestions for the way forward. Due to the nature of this forum, speakers' names were recorded. However, as members of the TTGBC, they represent a stakeholder group, and their perspectives have been utilized in this thesis as well.

2.1.2 Observation/Site Visit

A preliminary visit to the Scandinavian Green Roof Institute (SGRI) in Augustenborg, Sweden was conducted to further understand the practical application of green roofing and to ask initial questions to field experts. The visit was facilitated by Elsa PersdotterLindström, Superintendent of the Augustenborg Green Roof. This visit took place on May 2nd 2012.

Through this site visit the author acquired a first-hand understanding of the structure of green roofs and potential for application and research. The formal visit to the SGRI was followed by a walking tour of the town of Western Harbour as the Green roofing in the area is interconnected with other green infrastructure developments as part of the overall drainage system of the town(Peter Stahre, 2003). Photographic documentation was also made of this field visit and copies can be viewed in Appendix 5.

2.2 Data Analysis

2.2.1 Stakeholder Perspectives

Interview responses were collected and categorized using a PEST framework for structural guidance.PEST Analysis is widely-used tool that helps identify risks and classify influences on a policy. It is a useful strategic tool for understanding the potential and direction for policy development and alignment with original visions

2.2.2 UNFCCC technology transfer framework

The PEST framework is used as a tool during predevelopment of policy to classify factors and identify factors that require deeper analysis. Data collected was categorized for further analysis using the United Nations Framework Convention on Climate Change (UNFCCC) framework for technology transfer. This framework has been developed to be applied to low carbon technologies and can be used to examine the factors influencing the transfer of 'environmentally sound technologies' such as green roofs, in developing countries(Morsink, Hofman, & Lovett, 2011). The technical and non-technical factors researched through literature review and interviews flow naturally into the UNFCCC framework and can be discussed as potential areas of action, rather than just identifications of challenges and constraints.

Using theframework, this thesis investigates the enabling environment, technology needs and capacity building efforts needed to facilitate efficient green roof technology transfer in Trinidad and Tobago, and to identify existing policies for potential integration.

2.3 Final Considerations

The discussion and conclusions portion of this thesis serves as a reflection on the findings and analyses of the relevant green roof policy deployment options discussed. The overall macroenvironment wherein a green roof policy lies is discussed as well as the concept of technology transition management, which is required to push a technology transition to green roofs. Arguments provided under this section are mainly based on the recommendations of the author, gained through the analysis process.Reccomendations for further research are presented as well.

2.4 Scope and Limitations

2.4.1 Scope

The thesis is focused primarily on green roof policy implementation and does not provide an in-depth analysis into the technical engineering and design of a tropical green roof. Some basic information on green roofing applications and relevant costs/benefits have been included for the purpose of clarifying questions of feasibility of green roof technology overall. While green roofs are a type of green infrastructure installation and widely used as a green building technique, this thesis does not investigate or analyse other types of green infrastructure/ green building developments in detail.

The research was undertaken using a case study approach with Port of Spain, Trinidad as the key focus area due to its importance as an administrative hub for the country and Caribbean region. Additionally, Port of Spain, as the capital, possesses the majority of state owned buildings in the country. The availability of current urban sustainability information through the IDB ESCI allowed for the most accurate current analyses to be done for the area of Port of Spain.

Other countries that have established green roof policies have been investigated to frame the research of Port of Spain.

2.4.2 Limitations

The GORTT Cabinet of Ministers was reorganised during the research period and at the time of research, clear portfolios and roles and responsibilities for the newly created Ministries had not been made public. Therefore, responsibility for implementation and development is generally credited to the Government of the Republic of Trinidad and Tobago (GORTT).

Widely researched quantitative or technical data on green roofs is not available for the Caribbean countries in which they exist (Jamaica, Barbados). As such, alternative applications in regions sharing similar climates have been explored to validate the feasibility of green roofs in a tropical climate.

Some interviewees asked for confidentiality and were assured that while their responses would be utilized in data collection and analysis direct quotations would not be attributed to them. Many stakeholders held common perspectives and therefore referencing responses to a single source would be misleading. In this thesis, all stakeholder perspectives that were identified during the interview phase and used in the analysis have been identified even if not specifically attributed to a single interviewee.

3 CHAPTER 2: FINDINGS

3.1 Green Infrastructure: Urban Green Spaces

The 'Thematic Strategy on Urban Environment' developed by the European Commission suggests that Green infrastructure is of even greater importance in cities as this is where environmental, economic and social dimensions meet most strongly. Urban issues regarding sustainability are particularly complex and it is recommended that local authorities use integrated approaches to manage this complexity. (Comission, 2011)

Green Infrastructure[3] refers to physically or functionally connected natural and man-made, rural and urban structures which provides essential elements for the maintenance of ecosystem services such as clean water,productive soils and attractive recreational areas. Green Infrastructure often ensures efficient and sustainable land use by integrating multiple functionsor activities on the same piece of land(Youngquist, 2009).

Roof Gardens/Green Roofs can be considered a type of green infrastructure, falling under the category of (manufactured) urban green space (UGS). UGS can refer to green spaces in parks and other natural areas in cities and are considered important for maintaining a high quality of life in increasingly urbanized societies.(Chiesura, 2004; Tian, Jim, & Tao, 2012)

2.1.1 Green Roofs

For the purpose of this thesis, the term "green roof(s)" is defined as

"a roof system that is an extension of the existing roof, which involves a high quality water proofing and root repellant system, a drainage system, filter cloth and a lightweight growing medium and vegetative cover"

(Forbes, 2010)

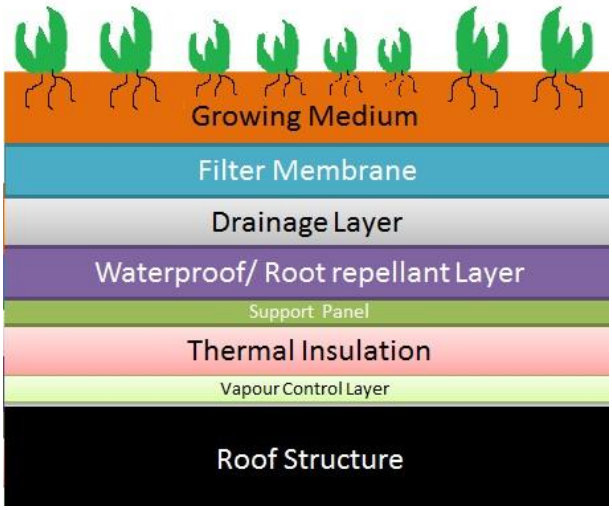


Figure 2Generalised Levels of a green roof (Adapted from: (Townshend, 2007))

It is important to note that the term 'green' is not being used in the familiar meaning of "sustainable" or "environmentally friendly" which would imply a roof that is more energy efficient, uses renewable energy, rainwater harvesting etc. In this thesis, a "green roof" is

simply a rooftop covered with a type of integrated, living, vegetated medium.(Forbes, 2010) . "Green roof" is used as an umbrella term for a number of different growing systems that are placed on the rooftops of buildings, either partially or totally covering the roof structure. "Roof garden", "sky gardens", rooftop garden", "vegetated rooftop" "eco-roof", "extensive green roof" or "intensive green roofs" all describe the different types and designs of growing mediums placed upon traditional roofs Regardless of form or function, green roofs are characterized by the integration of the vegetation with the roof infrastructure.(Townshend, 2007)

LEED (Leadership in Energy and Environmental Design), an internationally recognised point based green building certification, recognizes green roofs as a technology with wide range of environmental benefits and as a singular feature on a building can earn projects points in 3 of 6categories, which is unusual for a single design.

Theoretically, virtually any plant can be used for green roof application, if suited to the climate and grown in appropriate medium with adequate water(Oberndorfer et al., 2007). Plants which are tolerant of the extreme weather conditions found on rooftops are most often used to vegetate a green roof as the plants face 'extreme conditions' due to no natural canopy and increased direct exposure to weather changes. It is recommended that native, hardy species are used(Personal Communication: E.P Lindström 2012) Local agricultural research and experimentation is necessary to assess the appropriate cover for different contexts

There are generally two (2) categories of green roofs: extensive and intensive. Details are shown in Table 1.

Table 1: Types of Green Roofs (Adapted from: (Gail Lawlor, 2006; Mui, 2007; S Peck, 1999))

Extensive Green Roof	**Intensive Green Roof**
Thin with low weight: growing medium depth between 5-15 cm with a weight increase of between 72.6-169.4 kg /sf when fully saturated.	deeper soil and greater weight; depths vary according to plant requirements, ranging from a minimum of 200mm depth for grass and shrubs to up to 2000mm depth for tree planting
Relatively low capital cost	higher capital costs
low plant diversity	increased plant diversity, more complex ecosystems
minimal maintenance requirements Plants are fertilized only until they are established, maintenance consists of few visits a year for weeding of invasive species, safety and membrane inspections (schamber)	more demanding maintenance requirements
Can easily be retrofitted onto many existing structures. (Dunnett and Kingsbury 2004).	More suitable for particularly sturdy, newly developed structures
Often inaccessible:	Often made accessible, with more diverse use of the roof space e.g.. for recreation,

	agriculture
Suitable for large areas of roofs with sloped 0 - 30°. *Sloped and curved roofs need additional horizontal strapping to prevent slippage of the growing medium and plant layers when they become wet.*	
Often no need for irrigation and specialized drainage systems.	Need for irrigation and drainage systems requiring energy, water, materials
Less energy efficiency and storm water retention capability.	More energy efficiency and storm water retention capability.
Less technical expertise needed, Easier for planning authority to demand as a condition of planning approvals.	More complex systems and greater expertise needed
 *Figure 3 Extensive green roof inAugustenborg, Sweden (Source: Author)*	 *Figure 4: Intensive green roof at the SGRI, Augustenborg Sweden (Source: Author)*

The overall benefits of green roofs are well documented across green infrastructure literature. The range of benefits that green roofs can provide.

Commonly cited impacts of green roofs in particular are as follows:

- Increased energy efficiency of buildings;
- Reduced Urban heat island effect;
- Stormwater management effects;
- Improved urban air quality;
- Psychological health effects
- Potential for urban agriculture
- Job creation: suppliers, manufacturers, design and engineering professionals
- Urban social services e.g. recreation, noise reduction, increased real estate value,

(S Peck, 1999)

.

Not all of these benefits however are relevant for the context of Port of Spain. Green roofs have different benefits/costs and priorities dependent on the regional context and manner in which applied (climate, economic context etc)(D. Banting, H. Doshi, J. Li, & Missios, 2005) The key benefits that are relevant to Port of Spain are assessed further in Data Analysis as a tool for cross cutting solutions to high priority sustainability issues locally.(Townshend, 2007)

Modular green roofs, including 'rooftop gardens' the vegetation and planting medium are in containers covering all or most of the roof while with a non-modular system, the planting medium is a continuous layer over the entire green roof. Freestanding planters placed on top

of a roof, that are commonly seen in Trinidad are not recognized as a true green roof although, there are circumstances where pots or planters may provide a practical solution and an acceptable, similar greening effect (Townshend, 2007).

3.2 Case Context: Trinidad and Tobago

The Republic of Trinidad and Tobago is a two island nation state in the Caribbean. Both islands lie in the tropical climatic zone, between 10°-12°N latitude and 62° W longitude, to the northeastern edge of the South American country of Venezuela. The combined landmass of the islands together is five thousand, one hundred square kilometers (5100 sq. km.)(The International Bank for Reconstruction and Development, 2012)

Trinidad is the larger of the two main islands, with an area of approximately four thousand eight hundred square kilometers (4,800 sq. km). Tobago is smaller with an area of about three hundred square kilometers (300 sq. km) and lies thirty kilometers (30 km) to the northeast of Trinidad. The combined population is estimated at 1.3 million with an annual growth rate of 1.2 percent. Due to historical patterns of colonization and development, Trinidad's population is concentrated in urban areas along the west coastal areas and at the foothills of its northerly located mountain range. Tobago's population is concentrated in the southwestern end of the island.

Due to its prime location with easy access to North and South America; the country is regarded as an excellent international business investment site. This is supported by relatively open foreign investment and trade policies, including taxation agreements, bilateral investment treaties which aim to reduce investment barriers resulting in an open investment climate.Remittances[4] to Trinidad and Tobago are much less than most of the countries in the region, being US$69 per capita as compared with the overall for Caribbean and Latin America of US$114 per capita. (Kirton, 2010)

By regional standards, the country is highly industrialized with a dominant petroleum based economy and a small but rapidly growing tourism industry concentrated mainly in Tobago. In 2009, energy resources accounted for approximately 40% of Trinidad and Tobago's GDP and 80% of its exports.

The nation is currently transitioning from an oil based economy to a natural gas based economy. Approximately half of the country's natural gas is exported to foreign markets.

Trinidad and Tobago is ranked as thefifth largest exporter of LNG in the world and the single largest supplier of LNGto the United States, providing two-thirds of all LNG imported into the UnitedStates since 2002. Further, the growth of the economy is highly dependent on downstream industry consisting of oil and natural gas by-products.(Commission, 2009)

As a result of this regionally atypical reliance on heavy industry, Trinidad & Tobago has become one of the most developed nations in the Caribbean and is listed as one of the 70 High Income countries in the world. The OECD removed Trinidad and Tobago from its list of Developing Countries needing assistance in 2011(OECD, 2009)Trinidad and Tobago has one of the highest GDP (Gross Domestic Product) of the Caribbean at $22,483,115,868(The International Bank for Reconstruction and Development, 2012).

Trinidad and Tobago's human and social development, as measured by the composite human development index (HDI) value for 2011 is 0.760 and is therefore considered to be in

[4]The earnings sent by emigrants back to their countries of origin

the 'high human development' category positioning the country at 62 out of 187 countries and territories ranked.(LLP, 2008)

3.2.1 Urbanization in Port of Spain

Small island states located in the tropics, such as Trinidad and Tobago have characteristics that make them particularly vulnerable to the effects of ongoing climate change including sea level rise and increased frequency of extreme events.(Nobuo Mimura, 2007)

Urbanization is a phenomenon that affects the environment in various ways. One of the most detrimental effects is that the ecological processes can be altered and the natural services provided by these processes are often lost permanently. One example of a manmade ecosystem which can be developed to replace the lost natural services, is vegetated or green roofs.(Carter & Fowler, 2008).

The Latin America and the Caribbean (LAC) region has the highest rate of urbanization in the developing world with the region's urban population almost doubling in size between 1950 (41%) and 2010 (80%). (IDB, 2011)

The major urban areas in Trinidad and Tobago include the cities of Chaguanas (67,433), San Fernando (55,419) and the capital city of Port of Spain (49,031). In the past decade there has been steady growth in urbanization (annual rate of 2.9%, 2005-10 estimated)leading to an increased demand for land in the urban areas (Ramlall, 2010). The urban systems of Trinidad are characterized by a high degree of 'urban primacy' with a large proportion of urban populations residing in the main City-ports: Port of Spain and San Fernando and spreading along linear axes of development (Rudo Udika, 2010). Economic activity in the LAC region is concentrated in the urban areas with 60-70% of the regional gross domestic product (GDP) produced in cities(IDB, 2011).

Figure 5: Port of Spain,Trinidad and Tobago (Source: author)

The city of Port of Spain comprises an area of 12.3 km2 with an estimated 50 000 residents (3% of the population). The area has the highest population density in the country, with a population of 3 966 persons per square kilometre. (Beard, 2012)

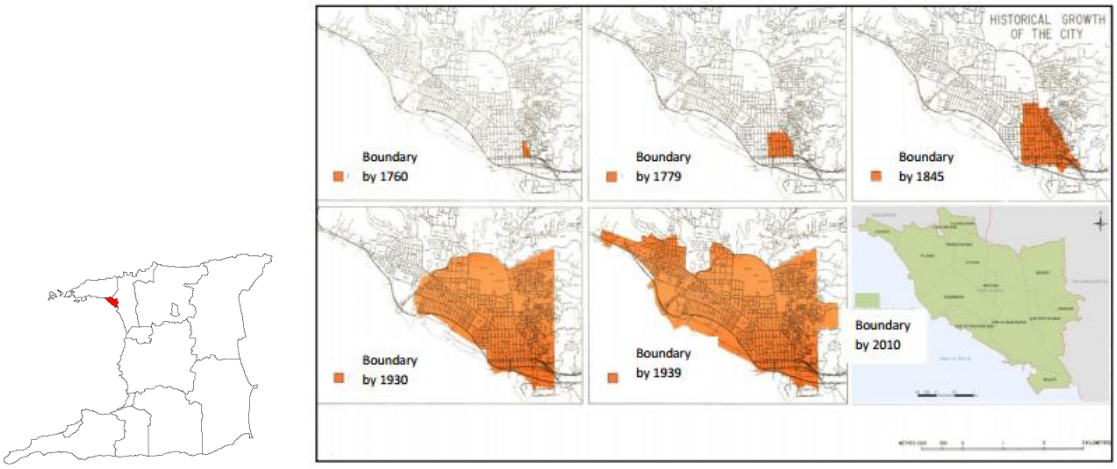


Figure 6: Physical Expansion of Port of Spain 1987-2010 (Source: GORTT)

Port of Spain's ability to grow and develop, despite physical boundaries such as the Gulf ofParia and the Northern Range have been overcome by land reclamation projects and increasing hillside development with significant evidence of urban sprawl along the 'East-West corridor', a major roadway leading from the northwest to the northeast(Ramlall, 2010).

In Trinidad and Tobago, the growth of urban areas is due, in large part to urban sprawl and conglomeration of the metropolitan areas into suburban areas, in addition to internal migration of people to the city centers.(IDB, 2011)The area known as 'Greater Port of Spain' extends into adjacent regional corporations[5] holds a total population of approximately 320 000 persons (approximately 25% of the total population).(Beard, 2012).

Port of Spain serves as an important administrative and economic center for the country as well as the CARICOM region. Interventions made in urban areas gain more influence in Latin American and Caribbean region due to the predominance of urban populations. In this way, attempts to achieve sustainable development goals in should include a large portion of work concentrated in the cities.(IDB, 2011)

The city of Port of Spain is located on the Gulf of Paria, on the northwest coast of the island of Trinidad. The city has a municipal population of 57,000 (2010 census), and a transient daily population of 250,000. It is and is part of a larger municipal area stretching from Chaguaramas in the west to Arima in the east with an estimated population of 600,000.

As the capital city of Trinidad and Tobago, Port of Spain includes a large concentration of state, civic, government and diplomatic buildings as well as being the country's commercial centre. It also has a strong remaining legacy of buildings and street patterns that reflect progressive stages of colonial, post-colonial and modern development and evolution(LLP, 2008)

The attempts to curb the effects of overuse of ecosystem resources caused by urbanisation are classified as sustainable urbanization. Many international organizations (e.g., UN Habitat, World Bank, OECD, and European Commission) have attempted to define the process of sustainable urbanization in attempts to promote its practice.

Commonly used definitions include;

Sustainable urbanization refers to the a dynamic process that combines the pursuit of environmental, social, economic and political–institutional sustainability at all levels of

[5] Diego Martin and San Juan/Laventille

development, urban and rural areas, with links at the national and global levels (Shen, Jorge Ochoa, Shah, & Zhang, 2011)

Urban Resilience can be defined as an urban area's ability to prepare for, respond to, and recover from significant threat with minimal damage to public safety and health, the economy, and security" of a given urban area(Coaffee, 2008)

Using traditional indicators of vulnerability, Trinidad and Tobago does not appear to be among the most vulnerable of the Caribbean islands, however, the country is nevertheless at risk for major sustainability challenges. (Gowrie, 2003),

The Port of Spain area has experienced a rapid increase in the negative environmental effects of traditional construction/design/building exacerbated by extreme weather events. This partially evidenced by a damaging flash flood which occurred on August 11th 2012 (Appendix 8) resulting from the passing of Hurricane Isaac, in which there were tentative damages of $109,943,600 Million TTD[6] and 2 related deaths(Staff, 2012c).

A report prepared by the Ministry of Planning and the Economy of Trinidad and Tobago (in preparation for the Rio +20 Conference on Sustainable development in 2012) assesses the current status of sustainable development in Trinidad and Tobago and identifies current challenges to achieving sustainability.

Highlights of the assessment include the identification of critical challenges in adapting to

> "*Climate Change and Sea Level Rise , regulation of Natural and Anthropogenic (Man-made) Hazards, Management of Wastes, Conservation of Coastal and Marine Resources, Freshwater Resources, Land Resources, Energy Resources, Loss of Biodiversity Resources, Unsustainable Transportation patterns*"(Ministry of Planning and the Economy, 2011)

Port of Spain has been recently included in an Interamerican Development Bank (IDB) programme called the Emerging Sustainable Citites Initiative (ESCI)(Staff, 2012b).The preliminary diagnostic assessment done by the IDB (Figure 7 Preliminary IDB Sustainability Assessment) reveals that many key indicators in Port of Spain received a red (minimum sustainability) rating. These included the areas of managing urban growth and environmental protection, appropriate urban infrastructure and facilities (including drainage), waste management, public safety, urban mobility, participatory planning and enforcement.

The initiative aims to target local governments and citizens within the chosen cities to develop areas of high priority for the sustainability of the areas.

During the ESCI's pilot phase, a team of sector experts from the IDB made a comprehensive and rigorous diagnosis and evaluated challenges that affect sustainability in each city in order to prioritize areas of action.

---

[6] 1 TTD= 1.09 SEK

112,808,730.20 SEK

Figure 7 Preliminary IDB Sustainability Assessment Source:(IDB, 2012)

The preliminary diagnostic assessment done by the IDB (Figure 7 Preliminary IDB Sustainability Assessment) reveals many key challenges that received a red (minimum sustainability) rating. These included: managing urban growth and environmental protection, appropriate urban infrastructure and facilities (including drainage) and waste management.

The identification of the pressing sustainability challenges for Port of Spain highlights the need for environmental protection as well as updated urban infrastructure and drainage facilities to combat urban flooding events (IDB, 2012). Green infrastructure such as green roofs may be seen as a potential cross cutting solution address these high priority areas.

Research into the relationship between green infrastructure, legislation and stakeholders is especially useful for the medium term (2014-2016) projections of the IDB ESCI. In the medium projects that focus on promoting economic development and training are prioritized.

While the IDB ESCI diagnostic assessment has taken a first step of identifying the urban sustainability issues faced by Port of Spain, Trinidad, there is currently no extensive research done on the role of green infrastructure as a tool to aid in high priority areas of action.

The concept of sustainable cities is insufficient and it is important to understand the methods and strategies needed to achieve this vision. Much of the responsibility for the creation of these sustainable cities lies with urban policy makers and urban planners. Traditionally development, takes priority oversocial and environmental goals, and urban planners must act to "arbitrate between conflicting interests" in an effort to achieve mutual objectives (Potter

1995). Urban planning instruments facilitate the process for sustainable development.(Ramlall, 2010)

3.2.2 Urban Development Policies in Trinidad and Tobago

Investigation of the national legislation in Trinidad and Tobago is important to making green roof policy widespread and consistent.

Development plans in Port of Spain have evolved from simple plans focusing on the Central Business District (CBD) to more complex strategies seeking to address dynamic challenges. The Capital Region Plan of 1975 sought to expand the boundaries of the development plan beyond the central business district (CBD) and the Port-of Spain Plan of 1987 first acknowledged the need to curb growth and invest in environmental restoration initiatives rather than encouraging the, then current, patterns of development. Development standards demand that all development initiatives obtain planning approval from the relevant authority. Planning approval for development in Trinidad and Tobago is determined by the Town and Country Planning Division who seeks to ensure that any development undertaken is in accordance to the development plans established. Another urban planning instrument governing planning in Port-of-Spain is land use zoning. At the international level, the 1992 UN Earth Summit in Rio de Janeiro was the catalyst for "Local Agenda 21", a popular program in Europe in which local authorities implement strategies for sustainable development

(i) Town and Country Act

Urban development in Trinidad and Tobago is governed by the national planning framework as described in the Town and Country Planning Act of 1969 (chapter 35:01) (TCPA. Chapter 35 of the TCPA sets out provisions for the orderly and progressive development of land in both urban and rural areas. It also makes provision for the granting of permission to develop land and for other powers of control over land use.(Ministry of Planning and Sustainable Development, 1960)

The Town and Country Planning Division of the Ministry of Planning and Sustainable Developmentis steering the process of reviewing the National Physical Development Plan (NPDP) of Trinidad and Tobago(GORTT, 2012). One of the outcomes of this new plan is the National Spatial Development Strategy (NSDS). The National Spatial Development Strategy is set out by the current GORTT Administration to create one overarching policy document for all development in Trinidad and Tobago. The NSDS will clarify the designation of major land uses, national and sector goals, and guide on the arrangements of major infrastructure and the location of major facilities. The NSDSwill present the national urban development strategy as it involved the analysis of the current situation as well as a harmonisation of the fourteen (14) Regional Development Plans (from the different Municipal Corporations)

It is currently being drafted and at the time of this research is not available. It was indicated that all necessary stakeholders for urban development are represented in the NSDS development planning task force (Personal Communication:Raymond, 2012).

(ii)Ministry of Local Government Regional Development Plans

The Regional Planning Programme is an initiative implemented by the Local Area and Regional Planning and Development Unit within the Ministry of Local Government.The goal of the programme is to decentralize development planning through the facilitation of the preparation of Development Plans for the fourteen (14) Municipal Corporations of Trinidad and Tobago, including Port of Spain.

Draft Development Plans are prepared by consultants on behalf of the Ministry of Local Government for each Municipal Corporations in Trinidad. The plans will set out the vision for the Corporations and will describe the ways in which land and buildings will be used, what type of development is to be encouraged and how regeneration will be sparked in the municipal corporation in the next ten years The general goal of the Regional Development plans are to empower the Municipal Corporations in Local Area and Regional Planning and Development Control activities. The framework for execution of these responsibilities will be guided by the Consultant that was given the consultancy to develop a Local Area and Regional Development Planning Process for the Ministry of Local Government. Through this program, consultants have completed the Urban Design framework that all plans must conform to regarding guidelines on green space (LLP, 2008)

(iii) Environmental Management Act

The Environmental Management Authority (EMA), the primary environmental management arm of the Government is mandated to write and enforce laws and regulations for environmental management primarily through the enforcement of the Environmental Management Act (EMA, 2012). The EMA also has a role in educating the public about the nation's environmental issues and to control and prevent pollution, as well as conserve natural resources. The EMA attempts to facilitate collaboration among Government Agencies, NGOs and community-based organizations. (EMA, 2012)

The EMA also has recently adopted a role in urban planning as there are designated activities outlined in the Environmental Act whereby special EMA approval is needed before any decision is made by Town and Country Planning or Ministry of Local Government.In these cases, environmental impact assessments of the construction plans are required for review before approval.

3.3 Local Stakeholder Perceptions

Due to the urban development structure of Trinidad and Tobago, the policy route taken by GORTT to implement green roof policy will have to be multi-sectoral. Development of a policy will rely heavily on the collaboration of multiple stakeholders.

Preliminary consultations, prior to any policy implementation and development in the form of interviews are effective identifying different factors that may pose a challenge to the development of a green roof policy.

In the process of this thesis research, questions were posed to representatives of the key stakeholder groups to identify the factors that would influence green roof policy implementation within the local context, based on previous experiences with similar initiatives.

PEST (Political, Economic, Social and Technological) riskanalysis is a commonly used tool used in the preliminary stages of decision-making as a precursor to classify opportunites and threats to policy reform. PEST categories were used as a framework to classify the identified macro-environmental factors influencing potential policy instruments. These identified challenges can be used in the case of green roof policy creation to focus the discussions about policy-formulation in future phases of the green roof policy cycle.Selected stakeholders were asked during an open interview to brainstorm constraints and potential challenges and drivers and opportunities (*italicized*) of a government driven, national green roof policy in Port of Spain and their answers were analysed and categorized according to the PEST categories and are presented below.

Political	**Economic**	**Social**	**Technical**
Urban development is taking a more prominent roles in several upcoming pieces of legislation, including the NSDSand the TTBS Building Code	High initial costs of technology	Lack of awareness among policy makers	*Potential for collaborative effort and knowledge sharing within CARICOM region (Jamaica & Barbados)*
Annual budget creates 'shortcut' for funding for green roof projects	Short term focus on upfront cost by industry players versus long term payback periods.	Lack of accessible, comprehensive baseline data resources	Construction sector immaturity and low levels of accountability
Lack of collaboration and consultation with relevant governmental divisions regarding urban development.	*"First mover" opportunities for businesses, developers and architects to develop expertise and competitive advantages in a new field*	Lack of value placed on environmental sustainability country-wide	Lack of collaboration amongst interest groups
Low direct government incentives for Innovation, R&D	*Eco-tourism opportunities*	Lack of building code standards.	Relatively few green roof experts in the region

Lack of political commitment to establish energy saving and energy efficiency policies.	*Increase International competitiveness*	Lack of LEED accreditation and green building education amongst builders	Low competition for 'green' projects but likely to intensify
Continued dominance of hydrocarbon industry and lack of diversification initiatives.	*Potential for small scale urban agriculture to reduce food import bill*	Ignorance and lack of knowledge on the need and benefits of green buildings	Construction industry 'inertia'.
High perception of corruption at all levels of decision making and questionable procurement practices	*Green Roof implementation can be phased in using low cost/ low commitment initiatives e.g. rooftop gardens*	Local Market is heavily interested in quick returns (short payback period)	Less data collection on the state of the environment in Trinidad and Tobago than previously done.
Large portion of Government-owned buildings in Port of Spain	*Can capitalise on the desire to be seen as a modern business destination.*	"Wait and see" attitude of stakeholders in the construction industry	Major Focus and R&D on solar cell development and large scale renewable energy projects rather than energy efficiency.
High dependence on central government administration.	*Opportunities to access funding from international sustainable development agencies*	Ignorance and lack of knowledge on the need and benefits of green buildings	Potential for Research into country/region specific innovations e.g. cocoa roof
Lack of collaboration and consultation with relevant divisions regarding urban development.	*Potential for small scale urban agriculture to reduce food import bill (job creation)*	General perception that green buildings would be prohibitively expensive,	High initial costs of technology :
Lack of building code standards.	*Green Fund may be able to provide funding.*	Lack of strong private consumer demand for green building techniques	Structural integrity concerns.
Lack of visible commitment to environmental sustainability within government driven projects.	*The annual budget allows for "fast track" of experimental initiatives.*	Low industrial, commercial and public awareness on energy efficiency	Opportunity for research into c ountry/region specific innovations and offer patents.
Recent instability in government administrations.	Market preference to maximise space use, "driven by the dollar"	'Brain-drain' trends among educated labour force.	
High fuel subsidy	Inexpensive fuel costs locally reduce importance on energy efficiency	Antagonistic view of environmental regulation preventing development	
	Loss of rooftop storage space, cost implications to replace	Safety and privacy concerns regarding accessible green roofs.	

	Developers are beginning to see the increasing requests for green developments from foreign clients.		

4 Green Roof Policy

There are numerous social and private benefits provided by green roof systems.(Carter & Fowler, 2008) Many of the benefits of green roofs are not only internalized by the building owner bearing the cost of the green roof installation, but are externally shared with the public. Significant public benefits that are derived from green roof systems justify public intervention through the development of government driven green roof policies.

Existing green roof policies worldwide, have attempted to intervene and encourage green roofs through several methods: creating technology standards, performance standards, direct financial incentives, and indirect financial incentives. (Carter & Fowler, 2008)

Many cities around the world have incorporated policies to encourage green roofing and other rooftop greening initiatives. These policies have taken different forms however there are generally six phases in the development of any green roof policy(Gail Lawlor, 2006)The policy phases are not rigid and may overlap or be rearranged in order dependent on feedback loops that may exist in between phases. The specific stages identified in green roof policy implementation. Different countries that have implemented green roof policies can be classified at some stage in this generic framework.

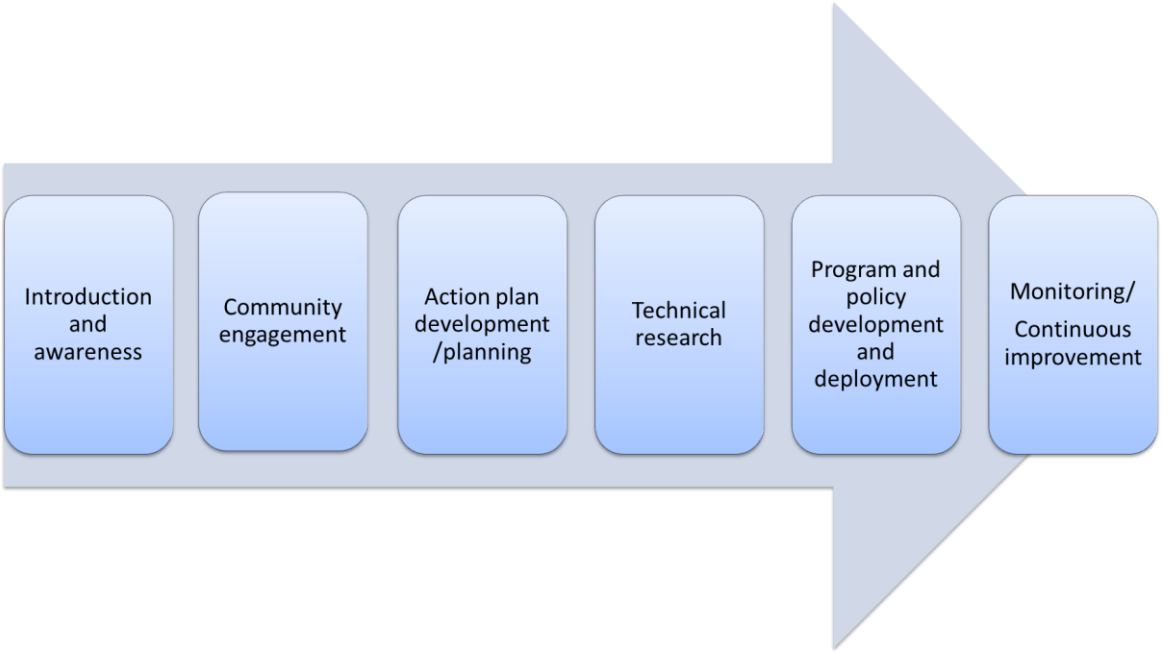


Figure 8 Generic Green roof policy development process (Adapted from:(Gail Lawlor, 2006)

4.1 Comparative Case Study: Singapore

Singapore is a country of 699 sq. km comprising one main, densely populated island and approximately 60 smaller islands extending past the tip of the Malaysian peninsula. The population is approximately 5,183,700 in 2011.(Newman, 2010)

The climate of Singapore is classified as tropical in climatewith no distinct seasons and the temperature stays relatively stable throughout the year.

Singapore was once covered with natural tropical jungle vegetation and wetlands but the island is now more than 60 per cent residential, commercial and industrial developments.

Land reclamation has been a common activity, replacing expansive coastal mangrove forests with development projects increasing the island's area by 20%.Singapore lies in the same climatic zone as Trinidad and Tobago and has proven to be a leader in the field of tropical green roof research and experimentation. Singapore's reputation as the 'City of Gardens' makes it a likely candidate for being the forerunner in this type of research.

Motivations and Policy Development

The Government of Singapore spoke of its commitment to rooftop greening through an address given by the Prime Minister of Singapore in June 2001, in which he stated:

"'To demonstrate the Government's commitment to high-rise greenery, the public sector will take the lead in implementing sky deck greenery in our public housing estates and public buildings' (Singapore Government Press Release, Speech by Prime MinisterGohChok Tong, 26 June 2001)."

The Urban Redevelopment Authority has stated,

'*In the next phase of making Singapore a City in the Garden, moving greenery upwards into the sky and closer to homes is the way to go.'*(Urban Redevelopment Authority, 2010)

Singapore's adoption of green roof policy fits in the government's overall agenda of promoting the city as the "Garden City." Singapore is a small island with tropical temperatures and heavy rain, much like Trinidad and Tobago. Because of the scarcity of land, high-density developments are more common, however, like Port of Spain, is an area of highest population density within the country. Singapore officially refers to the use of green roofs under the overall greening strategy as part of "Skyrise Greening."(Gail Lawlor, 2006)

Singapore's Urban Redevelopment Authority actively encouraged the use of vacant flat roofs as roof gardens and vegetated rooftops. Development guidelines were reviewed to include floor area exceptions for the space used for green infrastructure installations (such as green roofs). Previous to this policy development planted roofs had already been incorporated on some parking lotsand on state owned housing and commercial buildings in Singapore but had not been analysed scientifically to influence policy decisions.

Singapore's motivations and growing interest in increasing the amount of'skyrise greenery' in the city is due to greater awareness of the environmental benefits of roof gardens as well as the important consideration of increasing energy efficiency. Singapore imports most of its energy and freshwater due to its lack of natural resources in these areas. Singapore has many streams and reservoirs, but lacks sufficient fresh water and more than half its water is imported(Gail Lawlor, 2006).

Knowledge transfer and consultation through inter-ministerial government collaboration and knowledge gathering visits to well established green roof policy makers worldwide (Germany and Canada) formed a major step in developing the green roof strategies (Gail Lawlor, 2006).

As green roofing application in the tropics was a relatively new area of research, technical research needed to be gathered before any further steps were taken to encourage the technology through policy instruments. A major technical study on the benefits of a green roof was conducted by Wong et al. This study was being done at the early stages of green roof development and 'ramp up' in Singapore therefore at the time of the study, knowledge of roof gardens usage was limited and 'no prior analysis' had been made on roof gardens(Wong, Chen, Ong, & Sia, 2003).

The study included primary data gathering and analysis of the different types of green roofs and their effect on energy efficiency on a 5 storey building in Singapore. Different types of vegetation and soil thickness combinations were used and it was reported that an energy savings of 15% was observed on a common flat roof that had been vegetated with native shrubbery and 300mm of clay soil(N. H. Wong et al., 2003).

The research also included a survey of architects and developers to better understand the opportunities and obstacles to the technology in the country, similar to what has been done in the findings of this thesis. After these initial stages of technical research initiatives on the life cycle costing and energy benefits of green roofing in Singapore, the Government included green roofs as an acceptable measure for density bonuses(Gail Lawlor, 2006).

Responses from the survey indicated that any expansion of development policies to include the incorporation of green roofing would be highly dependent on the awareness and appreciation of the concept from the end users. The study suggests that it is not only important to increase academic research into the technology but it is also very important to clarify perceptions and usage of rooftop vegetation to residents and other 'end users'. The success of any new legislation would be hinged on the public's receptivity to the technology.

Singapore's Green Roof Policy

National Parks Board of Singapore introduced the temporary 'Skyrise Greenery Incentive Scheme'. This scheme is a time limited direct financial incentive, under which 50% of installation costs of green roofs and 'vertical greenery'is provided.
Participation in the scheme is allowed on a 'first come, first serve' basis until 2015 (dependent on funds).
Mixed commercial & residential developments and some individually assessed cases are eligible for this scheme. This includes offices, retail establishments, business parks, industrial, institutional, community building, hotel, hospital (approved case-by-case).("Skyrise Greenery Incentive Scheme," 2012)

Singapore uses gross floor exemptions as an incentivization tool for integrating green roofing within their urban development strategies(Shepherd, 2010).Gross floor area (GFA) measures a development's size and intensity. This GFA concept allows owners and/or developers of the area to choose the amount of 'neutral' areas within the building. Under the Urban Redevelopment Authority's regulatory framework, areas of greenery are exempted in the calculation of the building's gross floor area, green spaces and installations, including green roofs are incentivised.

"All covered floor areas of a building, except otherwise exempted and uncovered areas for commercial uses are deemed the gross floor area of the building for purposes of plot ratio control and development charge."

Accessibility and usability of the green roof are not criteria for exclusion from GFA although developments can be reviewed on a case by case basis.

- Gross floor area (GFA) exemption for sky terraces and rooftop pavilions
- Guidelines encouraging balconies in residential developments
  (Urban Redevelopment Authority, 2010)

Research and educational programs are facilitated by the demonstration projects. Publicinformation from the ongoing research is made publicly available for civil and professional stakeholders. (National Parks)

In addition to the goal of the garden vision of the city, the urban greening is utilized for environmental benefits such as mitigating the urban island heat effect and improving the air quality.

Lessons from Singapore

From a geographic and climate perspective, Singapore has many similarities to Trinidad and Tobago. In this sense, focusing on Singapore is valuable as due to the lack of long term

research, there is a misconception that green roofs are not beneficial or feasible on a large scale in the climatic region.

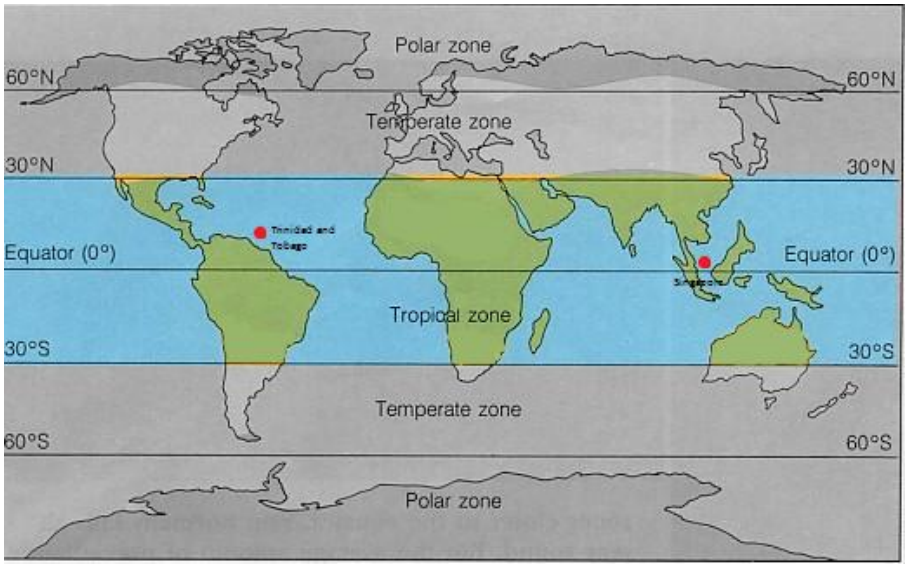


Figure 9: Map highlighting Tropical zone showing relative locations of Trinidad and Tobago and Singapore

The commitment to "green" urban Singapore follows naturally from a culture which has historically valued gardens and has had a long history of integrating green spaces into the urban environment (Newman, 2010).

The vertical greening programs are a natural extension of this mindset. The energy profile of Trinidad and Tobago is very different from Singapore, with a fuel subsidy that masks the 'true' costs of the externalities of fossil fuel usage in the country. The reasons for the introduction of green roofs would lean more towards the side of increasing urban sustainability and resilience to natural events rather than savings in fuel costs. Increasing the quality of life and health of the city population would also be a high motivating factor. The Singapore approach taken to encourage green roofing in areas with high-density development or where green roofs might increase real estate value could be applied in Port of Spain relatively easily.

Providing incentives through flexible development requirements can work where green roofs can provide amenity space or where green roofs can improve the esthetics of the development.

In addition to the compensation measures through the GFA, Singapore has a strong educational and promotion program amongst the public that will also be essential for any successful green roof policy programme or initiative in Trinidad and Tobago considering the relative novelty of environmental sustainability. Observations in Singapore indicate that there is a marked increase in rooftop gardens in new commercial and residential developments. One measure of increased green roof construction is the increased presence of green roof technology suppliers in Singapore, a new emerging industry.

4.2 Trends in Global Green Roof Policy

To encourage the development of green roofs, green roof policy can take a "command and control" approach by mandating performance or technology standards while others focus on market-based approaches using tax incentives or government subsidies. Many policies use a

combination of both, sometimes starting with a market based approach, and then setting mandates as more is learned. Policies generally are revisited over time with new information and research. (Carter & Fowler, 2008)Due to differing cultural and political systems, it is acknowledged that what has been applied in the Singapore context may not be completely transferable to other countries, including Trinidad and Tobago, therefore, a variety of successful implementation routes is presented in table

Table 2: different policy routes taken by different countries (Adapted from(Mui, 2007) and (Gail Lawlor, 2006; Miller, 2008))

Country	**Policy**	**Policy Approach**	**Local Motivations**
Switzerland	Time Limited Incentive campaign (1996-1997, 2005-2006). Mandate (2002) - all new flat roofs must be living roofs, every 5th flat roof = green roof. Criteria and guidelines in building regulations. (Basel)	Command and control, direct financial incentives, Building standards	Energy savings Increased biodiversity
Germany	**NATIONAL** National building standards and regulations (FLL) **BERLIN** Mandates : targets for permeable surfaces (e.g. green roofs in new and renovated Buildings) **MUNSTER:** Time Limited incentive programs Stormwater fee reduction. Incentive campaign **STUTTGART:** Financial incentives for voluntary green roofs 50% reduction in stormwater tax Mandates: "Flat roofs (0 to 15 degrees inclination) are to be planted over a proportion of at least 60% of the roof surface	Command and control (mandatory targets), Nation-wide standards, incentives	Stuttgart: urban climate was very sensitive to the effects of heat, air pollution and flooding. Nationally: Poor air quality and urban heat island effect concerns
USA	**Federal legislation** Clean Energy Stimulus	Incentives-based	**CHICAGO** Urban heat island effects and

	&Investment Assurance Act andEnergy Policy Act of 2005: tax credits **CHICAGO ILLINOIS** Energy conservation code – mandate for minimum solar reflection level. Higher densities allowances with green roof. Grant program Stormwater reduction credit. **PORTLAND OREGON** Mandate 70% green roof coverage for municipal buildings. Floor area bonuses 35% reduction in stormwater management charges. 'Ecoroof' incentives ($5 USD per square foot funding) Green building Policy **NEW YORK CITY, NEW YORK** State Green Building Construction Act will require that all new government buildings adhere to green building standards **SEATTLE WASHNGTON** Floor Area Ratio bonus in its building code. Developers may build an extra 3 sq.ft per foot of green roof they construct without additional permits.	Mandates	poor air quality **PORTLAND:** Pollution from stormwater runoff **NEW YORK:**: Urban heat island effects, stormwater runoff
Austria	**LINZ** Mandate: green roofs for new buildings over 100m Financial subsidies – up to 30% of construction costs.	Subsidies Mandates	
Japan	**TOKYO** City Target for green roof coverage – 30km of green roofs. Mandates: minimum 20% of roof to be green roof on new	Incentives Subsidies Mandates	High energy consumption and urban heat island effect

	buildings over 1000m and on new public buildings larger than 250m informal incentive program that provided a free consulting service		
Canada	Mandate: green roofs on all new development above 2,000m² of Gross Floor Area, with coverage requirements from 20-60%. • Green roof construction standards. • 'Ecoroof' incentive grants.		Reduction of stormwaterrunoff, especially in areas overflow of combinedsewers; Reduction of urban heat island effect and replacement of displaced green space Increased building energy efficiency Urban agricultures
Denmark	**COPENHAGEN** Mandate: All new flat roofs with up to 30° slope in storey buildings, and in private and public buildings have to be vegetated. Roof performance standards.		City target of becoming the world's first carbon neutral capital by 2025.
United Kingdom	**SHEFFIELD:** Mandates: Green Roof must cover at least 80 % of the total roof area.'		Initial interest in biodiversity and rare species habitat conservation.

5 Chapter 4: DATA ANALYSIS AND DISCUSSION

It is necessary for the GORTT to find the most appropriate policy and measures that fit the local environment. The identified challenges, constraints and threats need to be overcome before any successful policy can be implemented. .This can only be done through the development of a base of knowledge and competencies among all stakeholders to reduce the risk and overcome the construction industry inertia.
Data findings from the data collection phase fall into two spheres for analysis and discussion:

- Technical factors: Drivers[7] and barriers[8] relevant to green roof technology within the local context.
- Non-technical factors: Drivers and barriers relevant to the policy environment; including policy development and integration into urban development strategies in Trinidad and Tobago

5.1 Technical Factors

5.1.1 Technical Drivers of Green Roof Technology in Port of Spain

(i) Urban Heat Island Effect

The urban heat island effect is the term given to developed or urban areas that are measurably hotter than nearby lesser developed areas. Paved surfaces, traditional building materials (asphalt, steel and concrete) provide many surfaces which prevent natural heat loss which takes place during the night as the buildings block the cool air flow in these urban areas(Oberndorfer et al., 2007). In Trinidad and Tobago, the urban areas such as Port of Spain are reported to be on average 2-3 degrees higher than in more rural settlements(Soma, 2003). Concern regarding the effects of urban heat islands on human health often prompts the development of strategies for reducing the urban heat island effect that have included the implementation of green roofs worldwide.

The Minister of Energy and Energy Affairs, The Hon. Kevin Ramnarine of Trinidad and Tobago at the "UK-UWI Renewable Energy Seminar and Workshop", stated his observation that the building that houses his own ministry's office, The Waterfront Towers,has less than optimal energy usage. He claims the building is "constantly heated by the sun during the day, with no insulation to reduce the impact". He continues "The Waterfront Towers are an example of buildings that were clearly not outfitted with any sort of energy efficiency in mind."(Renwick, 2012)

[7] A policy driver is a condition that exists that motivates the creation of a policy to address the condition

[8] A policy barrier refers to situations that pose a challenge to the implementation of a policy

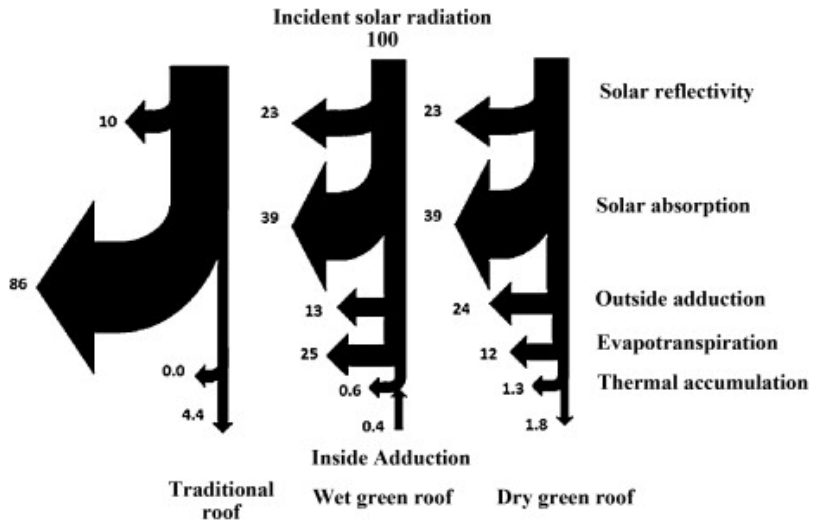


Figure 10Comparison of the energy exchanges of the dry or wet green roof with a traditional roof, summer season (Source:(Lazzarin, Castellotti, & Busato, 2005)

Green roofs counteract the heat island effect by cooling the air through the natural processes of evaporation and evapotranspiration, and keeping the rooms beneath the green roof cooler.

A study conducted in Singapore, shows that the high range of temperature difference between a vegetated roof and a traditional exposed roof can be as large as 18 degrees Celsius dependent on the composition of the planted surface (Nyuk Hien, Puay Yok, & Yu, 2007; OECD, 2004)

(ii) Increased Energy Efficiency of Buildings

One of the major benefits of green roof installation on a building is the increase in energy efficiency of the building through the insulating properties of the growing media, moisture content and vegetation. The insulating properties of a green roof are dependent on many factors, including the climatic region, the level of moisture in the air and the growing media.

Reduction the roof's temperature through shading and evaporative cooling lessen the heat absorbed into the building decreasing air conditioning costs while commercial buildings in northern climates consume approximately 25% energy in cooling and 25% in heating, in a tropical climate, the figure is likely 50% in cooling due to year round cooling requirements. This results in a higher net usage of energy per unit area as more energy is required to cool than to heat a building(Newton, 2010) so the energy savings would be greater for a typical commercial building in a tropical climate. In Taiwan, another tropical country, , the electric consumption of air conditioning systems can be cut down by 6% when the temperature was reduced by 1 °C.(Lin & Lin, 2011; Wong, Tay, Wong, Ong, & Sia, 2003)

According to the Urban Design Framework for Trinidad and Tobago, buildings in Trinidad and Tobago were traditionally designed to be naturally cool using passive design techniques[9] and only within the past couple decades has there been a new reliance on air-conditioning, and "now constructing buildings that would be uninhabitable without it."(LLP, 2008)

[9] Traditional design included open louvres, shutters, lattices for ventilation

Dr. Raymond Marcio Wright, in a pioneering book on renewable energy (RE) and energy efficiency in the Caribbean called "The New Agenda", described Trinidad and Tobago as the second least energy efficient country among a group of seven selected states in the region using an "energy intensity index" which he developedconsidering the measure of the energy efficiency of a nation's economy, calculated as units of energy used per gross domestic product.(Renwick, 2012)

Former Minister of Energy and Energy Affairs of Trinidad and Tobago, Carolyn SeepersadBachan, noted intentions to move towards more energy efficiency within the country, remarking that the use of less hydrocarbon based energy and electricity, would result in similar effects as an increase in production within the sector. (CARICOM)

.

As a signatory to the CARICOM Regional Energy Policy, the GORTT is obligated to promote energy and conservation.

> "*promote energy conservation, energy efficiency, reductions in energy intensity and establish appropriate measurement and monitoring standards and guidelines;*
>
> *b) Promote energy saving measures through introduction of fiscal incentives and other incentives;*
>
> *c) Implement intensive energy saving and energy efficiency programmes, which include energy audits of residential and commercial properties;*
>
> *d) Promote the use and installation of renewable technology in the construction, refurbishment and upgrade of public, commercial and residential buildings"*

(CARICOM, 2007)

Green roofs can offer an innovative way to tackle this low hanging fruit of wasted energy used in cooling buildings.

(iii) Stormwater Control

One detrimental practice common in urban areas is the covering of land with impervious materials, forming an obstruction that reduces the infiltration capacity of the soil, altering drainage systems and causing increased flooding. The natural water retention services provided by soil are costly to replace. Conventional stormwater drainage systems are used to reduce flooding but when compromised or inefficient, can create other environmental problems (e.g. stream bed erosion and banks from rapid stormwater flow, increased flow of pollutants)(Oberndorfer et al., 2007)

Green roofs can retain significant amounts of rainfall from small storm events which would otherwise flow quickly into the nearest receiving water body or drainage system (Carter & Jackson, 2007) With a traditional roofing system, rainfall hits the rooftop and quickly flows following a path of least resistance into the nearest gutter, drain or sewer system. Traditionally, in the interest of maintaining the roof's integrity, the goal is to have the roof shed water as quickly as possible. Unfortunately, this rapid runoff is one of the main reasons for urban flooding, especially in urban areas that have developed onto the drainage basins of rivers, such as Port of Spain. In the context of Trinidad and Tobago, stormwater management it is also identified as a pressing issue in urban resilience This is evidenced by the increasing number and severity of stormwater events in urban areas, including increased, rapid flooding within the CBD district of Port of Spain.(See Appendix 8). Due to the range

of range of negative impacts, the frequent flooding is considered a major disaster for the island.(Rudo Udika, 2010).

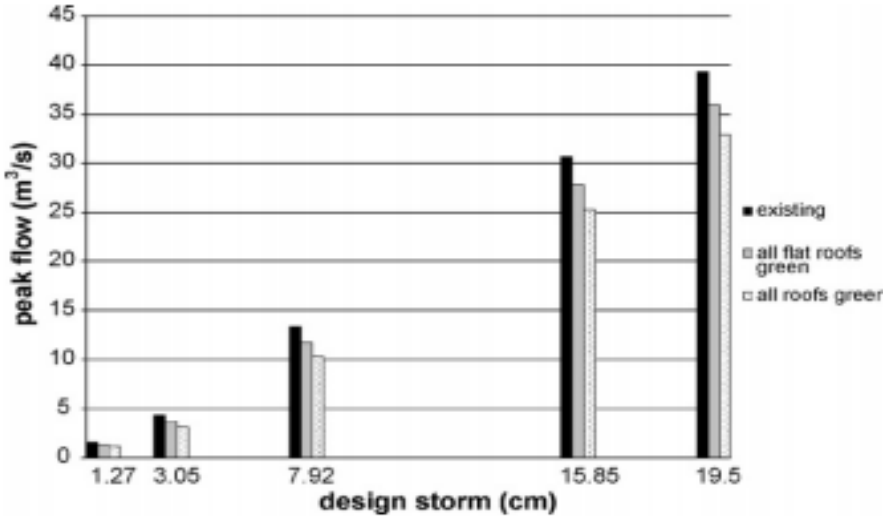
Flood management requires proactive approaches to urban land use planning for disaster risk reduction.(Rudo Udika, 2010)Stormwater management is a primary benefit of urban green roofs due to the prevalence of impervious surfaces in urban and commercial areas and inefficient stormwatermanagement/ drainage structures (Oberndorfer et al., 2007)This is likely to be the primary motivator of green roof installations in Port of Spain as well due to increasing damages from flash flooding (See Appendix 8). The Port of Spain area is "serviced" by the St. Ann's River (nicknamed the East Dry River) and the Diego Martin River which both lead out westerly to the Gulf of Paria. These waterways have remained largely unchanged since the city's beginnings (The International Bank for Reconstruction and Development, 2012)despite the increased level of development.This is exacerbated by a generally high level of careless dumping of refuse in streets of the city (a symptom of a larger solid waste management challenge nationwide) results in frequent blockage of existing, already compromised drainage channels(Rawlins, 2009)

The rivers often overflow their banks after rainfall events and have led to devastating floods in the commercial and residential areas of the Greater Port of Spain Area e.g. Downtown port of Spain CBD, St. James, Belmont, and Woodbrook. (See Appendix 8)

A study undertaken concentrating on widespread green roof application and the impact that could have on the hydrology of a real-world urban watershed environment, instead of the retention capacities of individual roofs demonstrated green roofs would significantly reduce the total impervious area and provide additional stormwater storage. (Carter & Jackson, 2007)

While this research is not entirely applicable to the environment of Port of Spain Trinidad, it shows promising potential as much of the flooding in Port of Spain is not due to the amount of rainfall, but the fast rate of surface flow down the hillside areas. Hydrologic modeling done as a part of this study, shown in Figure 11, demonstrated that widespread green roof implementationcan significantly reduce the rates of stormwater runoff, particularly for smaller events. The research recommends the use of vegetative roofs as a best management practice in urban watersheds to replicate the interception and evapotranspiration aspects of the water cycle found in environments without less disrupted ecosystems.(Carter & Jackson, 2007)

By retaining significant amounts of stormwater, green roofs can prevent stormwater system overflows. Peak stormwater discharge rates of stormwater are reduced, leading to a slower stormwater flow, leading to less flooding events and river erosion (Carter & Fowler, 2008) Potential increased levels of nitrogen and phosphorus due to leaching of organic matter, nutrients, and contaminants in the green roof structure can be remediated through research on more inert materials as well as selecting plants with maximum nutrient use(Oberndorfer et al., 2007)



.

Figure 11: Peak flows for design storms with different levels of green roofing (Source:(Carter & Jackson, 2007))

(iv) Improved Air quality

Port of Spain has a chronic traffic congestion problem due to the concentration of commercial activities in a relatively small and compact city area. Much of the traffic congestion in Port of Spain stems from the lack of available parking spaces in the city bringing traffic to an almost standstill in certain areas of downtown. The high volume of pedestrian traffic, interspersed with the cars downtown, not only contributes to the traffic congestion, but indicates high levels of direct human exposure to auto exhaust fumes. The Environmental Management Authority's last State of the Environment report regarding environmental vulnerability, in 2002, suggests that Trinidad is very vulnerable to damage from vehicular air pollution due to the high number of vehicles per capita(Agard & Gowrie, 2002). In addition to automobile exhaust, the country's largest landfill is located within the city limits.According to Caribbean Disaster Emergency Response Agency (CDERA), air pollution within Port of Spain caused by fires at the nearby landfill is a major environmental issue within Port of Spain (CDERA, 2003). Ground level air pollution is worse in hot conditions and poses a health hazard. Fires at the Beetham landfill site regularly create visible smog in Port of Spain.

Studies have estimated that 2000 m^2 of vegetation on a green roof can remove up to 4000 kg of airborne particulate matter(Rowe, 2011). One typical gasoline powered automobile produces approximately 0.016 g of particulate matter for every kilometer driven.It follows then, thateach square meter of green roof could offset the particulate emissions of a car that has driven approximately 16000 km. (Rowe, 2011)In Singapore, experiments resulted in reductions of sulphur dioxide and nitrous acid of 37% and 21%, respectively, in the air directly above a green roof (Rowe, 2011)Green roofs contribute to improved air quality as the plants absorb NOx (a common exhaust gas) and CO2,from the surroundings (USEPA, 2008).

(v) Climate Change Resilience

In the face of impending global climate change, small island states, such as Trinidad and Tobago are particularly vulnerable and are predicted to be the first regions to face the impending challenges.(Adger & Tompkins, 2004). In the case of Trinidad, as is common in the Caribbean, the major urban areas lie directly on coastal areas. Recent variations in sea level on the western Trinidad coast (Caribbean Sea) indicate that sea level in the north is rising at a rate of about 1 mm/yr, while in the south the rate is about 4 mm/yr(Nobuo Mimura, 2007).

Trinidad and Tobago also contributes to greenhouse gas emissions more so than other countries in the region. Trinidad and Tobago's CO2 emissions per capita have been increasing steadily since the 'oil boom' in the 1970s.(IEA, 2011)

Green roofs play a role in reducing CO2 in the atmosphere in two ways; the reduction in building energyneeds (also related to the urban heat island effect) and through carbon sequestration. Carbon is naturally stored in plant tissues through photosynthesis and into the soil(USEPA, 2008). Research suggests that a green roof will eventually reach a level of equilibrium where carbon used during plant growth will equal the carbon released in plant decomposition, but in its initial stages, the green roof ecosystem will serve as a carbon sink.(Rowe, 2011)

4.1.2 Technical Barriers to implementation of Green roof Technology

(i) High Initial Cost

One of the major constraints to the adoption of green roof policy is lack of upfront financial commitment. There is a perception in the region that green building on a whole is an expensive undertaking and this follows for green roofs in which there is a high initial up front cost with a longer term payback period. The market in the region generally tends to prefer more "flashy" designs, and green building is not considered attractive, just functional.

Installing green roof systems also involves costs in the form of additional expense for the local building owner in Port of Spain due to the novel nature of these systems.

General study in the field of green roofs does not focus on the economics of overall green roofing systems rather thanindividual roofs (Carter & Keeler, 2008). However, it has been shown that larger expanses on green roofs have dynamic synergistic benefits.(Ngan, 2004).

Some studies show a net savings over the life of the roof when green roofs are installed with the private and public benefits offsetting much of the extra up-front roof construction costs(N. H. Wong et al., 2003). However, this cost benefit analysis is specific to the situation with many factors to consider, maintenance costs, energy budget, accessibility of technology etc. One study compared green roof and traditional roof life-cycle costs over 60 years for a single roof in Oregon. They found the green roof to be 7% more expensive than the conventional roof for the time period (Carter & Keeler, 2008).

One study by Carter and Keeler, attempts to develop a cost benefit analysis (BCA) for the life cycle of extensive (thin layer) green roof systems in an urban watershed. The study then used these to compare to traditional roofing. The net present value (NPV) of this type of green roof currently ranges from 10% to 14% more expensive than its conventional counterpart(Carter & Keeler, 2008). This indicates that in the current environment, green roof may or may not be the lowest price option depending on the quantitative costs and benefits for the region it is being applied to.

Life cycle costs are not generally consultedbefore decisions are made on building construction in Trinidad and Tobagogenerally resulting in the least expensive (in the short term) technology/materials being utilized.

In local conditions, this cost benefit analysis will be highly influenced by the generally low fuel costs in Trinidad and Tobago, due to a governmental fuel subsidy of approximately 4 billion TTD annually (Staff, 2012a).

In current conditions, the capital expenditure required for a green roof general is expected to be higher than that a traditional roof, and the costs are usually justified with payback over the life cycle of the building, however if the fuel subsidy in Trinidad and Tobago remains, the payback period may not justify the upfront costs as fuel is relatively inexpensive. The removal of the fuel subsidy is a continual discussion amongst government officials in Trinidad and Tobago, and recently discussion regarding the phasing out of the subsidy indicates this is a step that will be taken eventually (Staff, 2012a).

(i) Loss of Rooftop Space

One impediment to the development of rooftop vegetation is the opportunity cost of the rooftop space being used as storage for electrical equipment (e.g. generators, pipes) etc. As roofs have not been to focus of many developments, they tend to become a convenient storage area. Having to redesign around this loss of rooftop space may incur costs to the building owners. Businesses may not welcome introduction of a green roof policy similar to the command and control approach mandating technology and performance standards taken by other countries due to the common practice of using the roof as general storage for electrical generators and heating, ventilation and air conditioning (HVAC) equipment.This is similar to constraints in Hong Kong where many of the buildings in the CBD, are narrow in design and cluttered with roof-top utilities(Tian et al., 2012).

Building owners may also be hesitant to install technology that could, in their perception, obstruct their ability to capitalize on the recent policy push for solar deployment in Trinidad and Tobago. The GORTT in the annual budget of 2010 introduced a tax exemption in the form of a wear and tear allowance on 150% of expenditure on solar equipment.

Green roofs and photovoltaic (PV) panels are utilized in conjunction in several countries (including at the Scandinavian Green Roof Institute in Augustenborg, Sweden) and the perceived conflict between the two technologies has proven to be without merit. Studies have actually demonstrated that the evapotranspiration form the plants on a green roof can have a very positive effect on the energy efficiency of PV panels. Field measurements in Hong Kong indicate a positive relationship with integration. PV panel shading and higher power output of PV panel is achieved from the green roof cooling effect. (Sam C. M. Hui, 2011). At higher temperatures, PVs are relatively inefficient. Black and grey roofs can get very hot in direct sunlight decreasing productivity by up to 25% and a value of -0.45% per degree Celsius(S Peck, 1999)

(ii) Structural Pressure on buildings

A green roof adds weight to the roof structure of buildings, which adds to the overall cost of the building due to the required extra materials, skillsets and design requirements.

As there are standard building codes mandated nationally, additional structural requirements for green roofs are therefore an additional cost for something that can be considered 'unnecessary' due to lack of statute.

Trinidad and Tobago lies on a seismic plate and many fault lines run through the urban areas. Though earthquake activity is generally mild, there is potential for large earthquakes in the Caribbean region. Any constructed building with a green roof must be able to withstand any potential seismic activity and not create a greater hazard.

There have been technological advances in green roofing, that have resulted in lightweight growing mediums and materials that significantly reduce the pressure on buildings from a wet soil roof. and it should be noted that in Augustenborg, after evaluation of the structure of the existing roofs on the buildings from the 1960s, it was determined that no extra reinforcement was needed to carry the extra load of the extensive green roofs.(Peter Stahre, 2003)

5.2 Non-Technical Factors

5.2.1 Analytical Framework: UNFCC Framework for Technology Transfer

The UNFCCC has defined a framework for identifying effective interventions to increase and improve the transfer of and access to environmentally soundtechnologies and knowledge. This framework has been used to provide structural guidance to the data findings and ex ante discussion of non-technical factors affecting green roof policy in Port of Spain. The five elements of the UNFCCC framework describe the overall landscape environment in which a technology transition occurs and therefore can be used to frame the discussion regarding non-technical drivers and barriers to the creation of a green roof policy.

The UNFCCC technology transfer framework defines five keyelements for meaningful and effective actions:

(1) **Technology information**; provision of information on technology parameters, economic and environmental impacts of environmentally sound technologies and mechanisms to address identified technology needs
(2) **Technology needs and needs assessment:**country-driven activities to determine technologypriorities through widespread stakeholder consultations;
*(3)***Enabling environments:** government actions, including the removal of technical, legal and administrative barriers to technology transfer, sound economic policy and regulatory frameworks to create a conducive environment for private and public sector investment in technology transfer;
(4) **Building of Local Capacities:** Processes for building, developing, strengthening, enhancing and improving existing scientific and technical skills, capabilities and institutions in developing countries to enable them toassess, adapt, manage and develop environmentally sound technologies
(5) **Mechanisms:**established channels for the facilitation and support of financial, institutional and methodological
activities to enhance coordination among stakeholders, to engage stakeholders in cooperative efforts to accelerate development and diffusion of these technologies and to facilitate the development of projects and programmes
(Parties, 2001)

This has been used to structure the findings and analysis of the researched opportunities, strengths, constraints and challenges to green roof policy development in Trinidad and Tobago. This can be used to guide strategies to properly manage the transition to green roofs and green building as well as inform strategies.

Innovation is a significant part in technology advancement (IEA, 2009). The "innovation chain" model (Figure 12) deduces that new technologies cannot rely on just market pull, but require the strategictop down push of research, development and demonstrations in earlier stages of research and development.(IEA, 2009; R. Kemp, Loorbach, & Rotmans, 2007)

Technology transfer involves more than the transfer of physical components as it also involves knowledge sharing and increasing local adaptive capacities, which can be quite complex. Local capacities policies, institutions, investments and research all influence the effectiveness with which technology can be absorbed and adapted(R. Kemp et al., 2007)In this way, the UNFCCC framework is ideal for further exploring the PEST factors that will influence the introduction of a green roof policy.

5.3 Technology Information

Physical and structural weaknesses in previously attempted projects have damaged the already smallmarket's trust in green roof technology. This mistrust seems to be misguided as it is not the roof technology itself that is not feasible, however the relative unfamiliarity with the technology among local contractors and a lack of accountability for the different parts of the roof that had been completed by different contractors (Personal communication: Newton, 2012). Green roofs have been done in Trinidad and Tobago successfully, and have not suffered the same fate (See Appendix 6) However they have been done more for aesthetic reasons and psychological benefits rather that an urban sustainability tool.

Local Research

As discussed previously, one of the major benefits of green roofing in urban areas is the ability to reduce a building's energy budget through reducing the amount of energy needed to heat/cool the building. However, in Trinidad and Tobago there is currently no comprehensive energy audit database used in the city and of specific buildings are not monitored. The lack of data reduces incentive to change the current energy usage path.

Better local research of green roof's total costs and benefits to society and to the private sector will aid in the design of policy instruments and educational materials that affect individual decisions about green roof construction(Carter & Keeler, 2008)

There is a need for an integrated innovation policy for the environment in order to increase the usefulness of innovation research and support policies. Innovation policy for the environment could be targeted to areas in which innovation is needed such as within the urban development sector.

Trinidad and Tobago is bound to several international agreements that justify the prioritization of research of energy efficiency technology such as green roofs. The Climate Change policy enacted by the GORTT includes regulations on urban development and lists goals to increase energy efficiency in buildings by developing a Green Building code that will seek to maximize renewable energy and energy efficiency and formulating of energy efficiency standards by the Trinidad and Tobago Bureau of Standards.

Many governments prioritisethe development of low risk projects that are close to market to reduce the money necessary for economic payback. This however puts environmental technology innovation at a disadvantage (Saeed Parto, 2007).

Technology Transfer& Knowledge Sharing

Technology transfer forms an important informing step in pushing a technological transition such as a shift in Trinidad and Tobago to green roofs. Technology transfer refers to the transfer of technological information from the research and development actors to the diffusion and deployment actors to be used as part of an overall transition, while technological transition refers to the entire process of changing from one dominant 'lock-in' technology to another. During the TTGBC meeting, it was recommended that one project from data collection to construction and monitoring being undertaken would be a more successful advocacy for green building techniques in the local environment was supported by members. An approach such as this was thought to have more public impact than smaller distributed projects. It was also suggested that this type of project could be undertaken as a private sector initiative but requires significant trust from a corporate body in the current local environment (TTGBC)

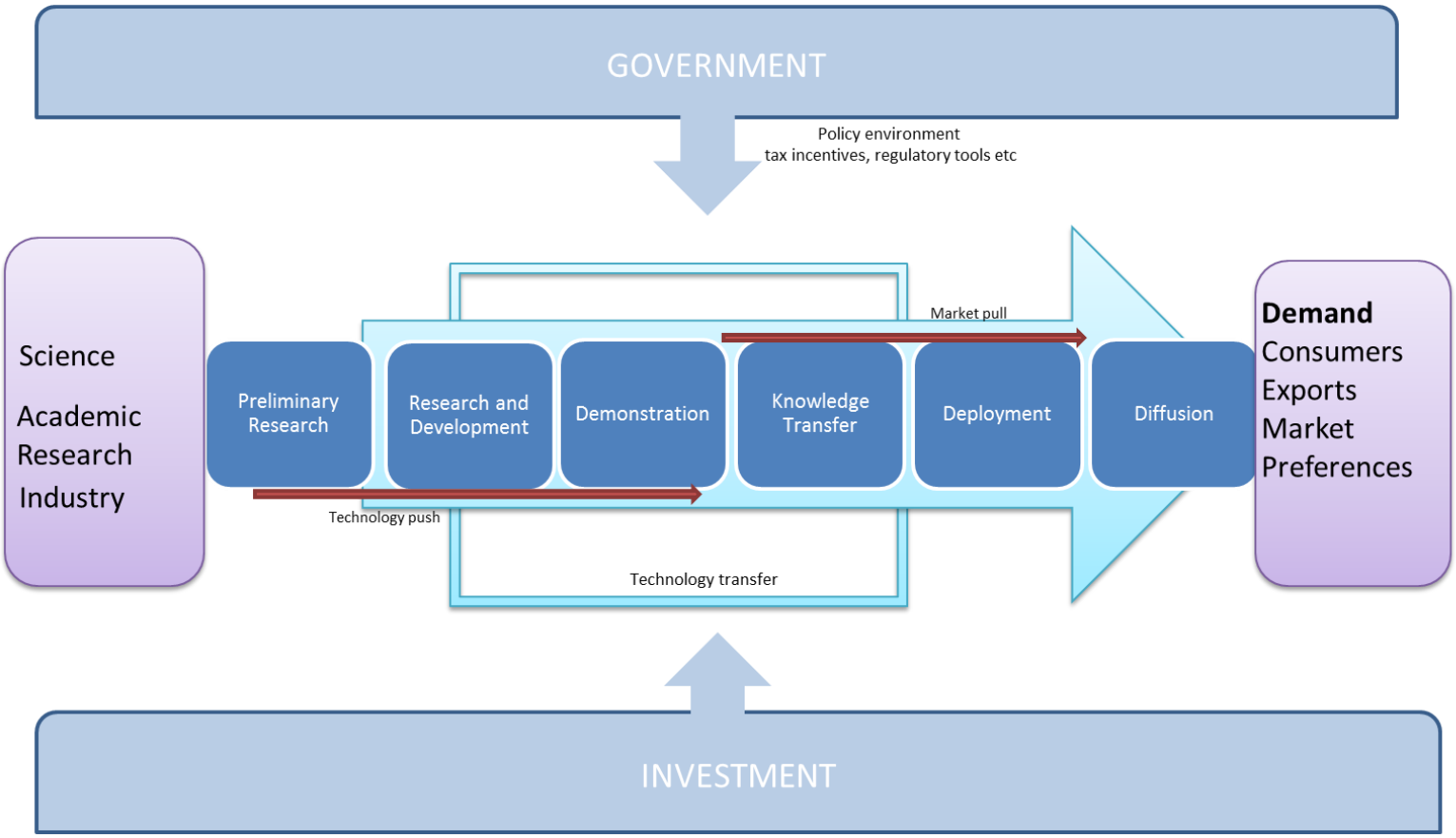


Figure 12: Technology Transfer as part of the innovation chain (Adapted from:(IEA, 2009)

Research and Demonstration Facilities

One way of increasing research on local green roofs while creating a working demonstration of green roof technology would be through the creation of a research facility for the development of green building techniques. This facility would showcase to the market and public that tropical green buildings are not just theoretical possibilities while informing future policies. The demonstration projects need to be highly visible and accessible to be effective

especially with the introduction of the green roofs to an unfamiliar public, as it is necessary to build interest and more importantly trust in the concept.

This combination is similar to what occurs at the Scandinavian Green Roof Institute at Augustenborg in Malmö, Sweden. The Institute serves as both a large scale research station and educational facility, with experimentation with different green roof applications.The SGRI continues to experiment with green roof technology including new developments in green roof food crop agriculture and PV cell incorporation (Personal Communication: E.P Lindström 2012). This continuous experimentation occurs despite the fact that green roofs are already well-established in Malmö and the Augustenborg housing development near the SGRI botanical garden incorporates green roofs with a network of streams, ponds, and drainage areas between buildings to deal with storm water run-off(Peter Stahre, 2003).

The benefits of green roofing in this area have been well documented and witnessed by citizens themselves, who have seen the area grow from an undesirable place to live to an in demand location (Personal Communication: E.P Elsa Lindström 2012). However the SGRI serves as an outlet for continuous experimentation and improvement through academic collaborations with research students, and knowledge sharing through international congresses, conferences and regular newsletters and open days for the public

Such a facility, if funded by the GORTT could utilize the state-owned universities: University of the West Indies at St. Augustine and the University of Trinidad and Tobago to build in house research databases and increase local knowledge capacities. Hosting local research also allows for the possibility of quantifying local opportunities and developing local innovations. The IPCCC notes that many islands, despite the increasing need for urban resilience continue to remove the traditional mechanisms of coping with environmental hazards(Nobuo Mimura, 2007).

Whichever route is taken for the establishment of this type of facility, it is important for the demonstration projects to have explicitlong term technology experimentation goals. There is a need for system innovation initiatives, to explore visions of sustainability through research and the real use of green roofs in society.(Saeed Parto, 2007). In order to determine the best path for sustainability forTrinidad and Tobago, experimentation within the local context needs to occur. Technology experimentation is an important element of system innovation to determine effects and best practice routes. In research analysing experiments in sustainable transport, it was found that the usefulness of the experiment programmewould be increased if the experiments had been set up with the explicit objective to generate knowledge. As the projects were largely isolated and did not inspire secondary research by other sectors nor contribute to development in other sectors (Rene Kemp, 2007) .

This is important in Trinidad and Tobago as it has been identified that not only is less research being done on a local context, but there is less and less collaboration between research bodies.Large scale experimentations at a local level can bring together stakeholder and provide opportunity to learn and improve on the interaction between systems within the local context. (Morsink et al., 2011)

5.4 Technology Needs Assessment

Baseline Data

Assessing local needs for technologies does not mean a total importation of foreign ideas and concepts and it is important to be able to adapt technological concepts to the local context

and customs. Technology needs assessment (TNA) refers to the system of country-specific activities to determine technologypriorities through widespread stakeholder consultations. The process of identification of barriers to green roof technology transfer, and finding measures to address those barriers are the focus of this step.

The lack of comprehensive local data on environmental issues makes it difficult to identify problems and justify corrective action. It was suggested by one TTGBC member that generally, there is less baseline research being done in Trinidad than there was being done 30 years ago and the research that is being done, is very segmented across agencies and organisations.In general, the building industry in Trinidad and Tobago tends to adopt US Standards due to the proximity (Newton, 2010)and there is also a history of using British building techniques due to the colonial past. It is important to develop locally specific design guidelines that incorporate the social, economic and environmental context of urban areas in Trinidad and Tobago to push a technology transition to more environmentally sustainable technologies.

Cultural Considerations

Prioritising local technology needs involves acknowledgement of the cultural landscape of Port of Spain. As identified in the PEST analysis, accessible green roofs may not be appealing to residents of Port of Spain, Trinidad due to safety and privacy concerns. However, Port of Spain has a vibrant social 'life' with many businesses such as clubs, restaurants, bars and general 'liming [10]areas. There is private sector opportunity for businesses to not just add to the public good but to increase their competitive advantages through the use of strategic accessible green roofs. Some evidence has already been seen with the Hyatt Regency Hotel in Port of Spain which uses a modular vegetated rooftop along with its rooftop pool and bar which has now become its hallmark. In the city of Port of Spain context, the private sector and business owners form an important stakeholder group that should be consulted during policy development.

The urban areas of Trinidad and Tobago are relatively close to natural vegetation and green space (Most notably, the central Queen's Park Savannah). Culturally, there is not much of the urban displacement from the environment that often motivates the desire to "green" urban environment. (Raymond) While the city of Port of Spain does have In this sense, the motivations behind introducing green roofs in Trinidad would differ from other countries and should be adapted to reflect this (more functional, less aesthetic)

Prioritizing Technology needs

Researching local technology needs at a national level may reprioritize the drivers of the use of green roof technology. To efficiently manage the technology transition to green roofing, whatever goals are set will need to be revisited and adapted using ongoing research and innovation breakthroughs. After thorough investigation, it may be discovered that the urban heat island effect may not be the most pressing issue in Port of Spain, but the availability of fresh local food is. In that case, policy that would have to be adapted to be able to maximize the potential for urban food agriculture through the use of intensive, accessible green roofs.

There is a current focus on the research and development of solar cell technology and policies in Trinidad and Tobago. This is supported by the Ministry of Energy's income tax reliefs regarding renewable energy technology.

Energy efficiency is a low hanging fruit that has not been prioritized in local energy policy and innovations could be geared towards this as well

[10] Local terminology for socializing leisurely.

5.5 Capacity Building

Technology transition is not solely a governmental responsibility, and all stakeholders should be involved in the process in some way. The empowerment of all stakeholders to adapt and be able to use the information made accessible through experimentation is directly associated with local capacity to adapt. Local capacity building is an important requirement of transition management.(Saeed Parto, 2007)

According to the IPCC, enhancing local adaptive capacities involves more than just the identification of local variations of the technology. Capacity building involves enabling of institutions to develop technical skills and relevant training regarding the technology.(Nobuo Mimura, 2007)

It has been suggested that the success of increasing local capacities for increased resilience to the effects of climate change is dependent on integration with other policies such as disaster preparedness, land-use planning, environmental conservation, coastal planning, and national plans for sustainable development(Nobuo Mimura, 2007)In much the same way, increasing the local capacity to adapt to green roofs as a tool for this increased resilience should involve similar multi-sector involvement.

Professional Capacities

The construction industry in Trinidad and Tobago is one that is traditionally risk-averse to trying new methods and materials. To encourage green building techniques, requirements for continuedprofessional development can be established. For the implementation of green roofs this can take place through workshops, conferences and short courses on green roof technology that facilitate knowledge transfers.

Architects, builders in the UK and the US, and Jamaica (Personal Communication, Raymond 2012) are required to keep their knowledge and skills relevant to their professionthrough regular training termed Continued Professional Development (CPD). This usually takes the form of a set amount of annual training hours that have to be completed to maintain their license. Green roofs are a popular topic for CPD Seminars worldwide (See Appendix: Figure 19An example of a continuing professional development seminar on green roofs (Source: ICOPAL)Figure 19)

CPD programs and seminars involving green roofs and green building techniques could be implemented as it will not only increase the standard of construction practices in Trinidad but it will also ensure that new innovations and technologies are explored first hand by those who are 'on the ground' thus supporting a bottom up approach. State owned and facilitated education centres offer a good opportunity for government involvement in the development of these CPD seminars. Strategies aimed at training and educating human capital are essential to the implementation and maintenance of innovative technologies.

Institutional capacities

Legislation is already in place to incentivize energy auditing, however there needs to be proper organization and use of the data when collected as it would inform how a local green roof policy would be developed. Innovative market mechanisms such as the issuing of certificates or awards for verified energy efficiency and energy auditing can be applied and introduced to encourage information distribution and knowledge sharing. The TTGBC has attempted to introduce this type of initiative, called the Green Star Award, partly to award businesses with environmentally sustainable practices, but to also contribute to the energy auditing data of the country for further research (TTGBC). The Green Star programme has suffered from a lack of 'high level' support and access.

Building local capacities also includes the development of a government agency with the responsibility to monitor facility maintenance to coordinate, oversee and monitor programme implementation and energy auditing (ECTT, 2011). Such an agency would ensure coordination among involved parties and be accountable for energy conservation initiatives (targets, guidelines and regulations, monitoring, regulatory compliance, and evaluation and review). Comprehensive, reliable data would be accessible and would allow energy data to be easily assessed and compared. This baseline database could justify the development of green roofs on buildings

As the success of a technology like green roofs depends also on significant public support, there is a need to address the ability of civil society to access sound scientific and technical information.

Civil Capacities

All the stakeholders, actors, decision-makers, policy makers, investors are framed within the wider political, cultural and economic background termed the socio-technical landscape. Changes occur in the landscape but much more slowly than regime level. Disasters cause changes in risk perceptions and create windows of opportunity to affect behavioral responses and a reallocation of resources to better mitigate and prevent future disasters(Kousky, 2012). One example is the recent flooding situation in Port of Spain leading to an overall increase in the awareness of poor stormwater drainage in Port of Spain due to increase in flash flooding.

This increasingly damaging circumstance is leads to pressure on authorities to adapt, providing openings for new adaptive technologies, like green roofs, to establish themselves.

In a newspaper report, Dr. Allen Sammy, head of the Land Settlement Agency (LSA)was quoted as saying "A lot of people have not been paying attention to the revegetating of slopes and preventing the clearing of additional slopes. "Revegetating of the entire hillsides is going to very important and it's the nature of the vegetation also...not merely planting bushes, but putting trees with canopies and vegetating the ground cover,". Dr. Sammy continued by explaining that the importance of this vegetation was to prevent the rapid run-off of water into the water bodies. (Kowlessar, 2011)

Those in civil society must be empowered to take advantage of these windows of opportunity and be able to support and demand new sustainable technology. Public outreach campaigns and educational facilities are important for increasing awareness but there is a need for public access to objective technical assistance to understand technical and legislative documentation.According to local environmental lawyer, Dr. RajendraRamlogan, it is difficult to attract technical and scientific assistance to support interested public (Ramlogan, 2010). Civil capacities can also be raised by increasing the accessibility to technical and administrative support.

5.6 Mechanisms for Technology Transfer

According to an IPCCC working group on small island states, there has been an increase in "ad hoc projects", rather than long term strategies for sustainable development.(Nobuo Mimura, 2007) Increasing urban resilience in small island states such as Trinidad and Tobago will depend on the combined support of relevant institutions, funding and technological support.

Facilitating Collaboration

There is a need for collaboration between stakeholders from all different areas as all will have different knowledge and abilities. However, it is important to acknowledge that interventions

are needed to ensure that the channels for collaboration exist and are inclusive and efficient.Environmentally sustainable technologies such as green roofs can benefit highly from the development of cross sector collaborations between state, investors, professionals and citizens (NGOs) where different actors play a role.(Morsink et al., 2011)Effective collaboration among all stakeholdershelps to overcome political obstacles, increasing the necessary capacity for using and maintaining the acquired technology(Ockwell, Watson, MacKerron, Pal, & Yamin, 2008).A critical factor in the diffusion of environmentally 'sound' technology is the creation of 'multi-stakeholder partnerships' with local stakeholders from different arenas that can better access to resources and local perspectives.(Morsink et al., 2011)

Collaborations also reduce financial pressure by sharing the costs of new technologies. Collaborations between international donor organizations with experts and local actors are valuable because of local knowledge of legal and regulatory framework, necessary stakeholders, as well as the cultural background(OECD, 2004)

Stakeholder Engagement and Awareness

It is very important to not simply concentrate on the "on the ground" urban development sector players when introducing green roofs. All stakeholders must be educated about the benefits of green roofs in order for any development to move to diffusion and deployment (Gail Lawlor, 2006). Lack of proper stakeholder engagement risks unequal influence by powerful and/or politically well-connected stakeholders ("Stakeholder Analysis," 2001).

Proper stakeholder engagement increases the perception of public trust in new technology as well as in the capacities of authorities. Public trust is a critical factor for the success of urban planning policy instruments, especially in Trinidad and Tobago, where perceptions of corruption are high (Julien, 2011). In the case of a green roof policy, there is a wide variety of stakeholders from different fields that should be involved in the planning process. Participation of all these groups is important in the development of comprehensive plans so they can meet the needs of as many stakeholders as possible and thereby attain maximum urban sustainability goals. According to Ramlall, despite attempts at inclusion that have proven successfully in other contexts (such as in Singapore) in (East) Port of Spain, implementation has failed mainly due to the lack of political support and inadequate resources (Ramlall, 2010)

In a discussion regarding the feasibility of Port of Spain as a sustainable city, Ramlall claims, "another critical success factor for urban sustainability is efficient allocation of resources which can generally be obtained only through strong political support." (Ramlall, 2010)This aligns with stakeholder perception that there is a high proportion of central government influence and political alignment.

The Caribbean Natural Resources Institute argues that 'co-management' should be used to help address environmental challenges and can be applied to the challenges faced by green roof implementation in Trinidad and Tobago. Encouraging this type of collaboration ensures that a program's success is not solely dependent on the knowledge, perspectives and experiences of one powerful stakeholder and it introduces resilience to administrative and political changes. Co-management refers to the coordination or collective efforts among a group with a shared goal. This co-management requires not only stakeholder engagement during the policy development phase but, but forums to actively involve them in the management and decision-making process.

Presently, non-governmental stakeholders serve consulting or informing roles to policy makers in urban development policies. Co-management would result in greater roles and

responsibilities for all stakeholders and a greater role in the success of the policy. (Adger & Tompkins, 2004)

Public-private partnerships are a mechanism by which knowledge transfer and financial support can be encouraged in the green building sector on the whole. Traditionally, infrastructure development and provision of public services was strictly under government's domain. Infrastructure services for water, electricity, telephone, transport, roads, still provided by the government and or its state-owned companies (SOEs). However relying on the government to cover the costs of infrastructure development results in the issues of project stagnation, insufficient power distribution and funding issues that were commonly cited amongst interviewees as major challenges to green building in general. When infrastructure providers entered into contracts with private sector actors to increase the level of investment to meet demand, there was a general concern that directly negotiated contracts with politically well-connected parties lacked of transparency, competitive prices and even encouraged corruption and incompetence. "

Financial Mechanisms

The Trinidad and Tobago Green Fund, established in 2000 introduced a 0.1% tax (the Green Fund Levy) on gross income of all firms doing business in Trinidad and Tobago. The Green Fund is a mechanism through which financial support can be obtained for environmentally sustainableprogrammes and projects. Despite its implementation for over a decade, the Green Fund has only funded 3 projects. Barriers to accessing Green Fund support should be investigated as the Green Fund represents an opportunity for innovation and entrepreneurship (UNEP, 2012).

Financial resources that may not be available to the GORTT currently may come from international bodies or donors. International partnership and support for technology transfer is especially important to assist with the local capacity building indeveloping countries (Stern2007)

National Innovation System

National systems of innovation and international collaboration with agencies for research and knowledge sharing play a central role in technology transfer.(Ockwell et al., 2008)A major player in promoting technology transfer is the National Innovation System of Trinidad and Tobago (NSITT). The goal of the NSITT is to develop and implement innovation policy to diversify the economy away from hydrocarbons. The National Innovation System of Trinidad and Tobago (NISTT) provides a good forum to push innovation into green technologies/ infrastructure such as green roofs by pooling the correct resources

The NISTT aims to facilitate economic diversification through encouraging research driven innovations of individuals and companies. It also aims to increase awareness of innovation and international competitiveness.(Economy, 2011)

This will improve T&T's Global Competitiveness and Innovation Rank which is a critical indicator of development. The country's ranking in competitiveness by 20 points by 2014 (Trinidad and Tobago is currently ranked 84 out of 142 countries(Organization, 2012)

The NISTT will feature an interconnected network of institutions and of additional revenue streams, which makes it an important mechanism for the transfer of innovative technology like green roofs

Effective public interest hinges on the ability of civil society to present from a sound scientific and technical standpoint (Ramlogan) Additionally there is a need for access to technical assistance to understand technical and legislative documentation. According to local environmental lawyer, Dr. RajendraRamlogan, it is difficult to attract technical and scientific assistance to support public interest environmental litigation. This building of civil capacities should be focused on when developing collaborations and a participatory process for policy implementation.

Recently, public environmental awareness and campaigning has benefitted positively from the surge in social media and the dissemination of information through NGOs with a high internet presence. However, environmental NGOs struggle financially and with limited resources, and while major NGOs accept funding from the private sector, this can lead to conflict with environmental advocacy activities. Accepting corporate funding may undermine of the abilities of NGOs to pursue transparent environmental advocacy and lobbying which is necessary to push green roof innovation from the niche level to the regime level. (Ramlogan)

5.7 Enabling Environment

Creating a viable environment for the diffusion of new technologies definitely impacts the uptake of the new technology. Understanding and analyzing how to create this enabling environment is a lengthy process and requires local knowledge to understand how things need to be changed to achieve this(Morsink et al., 2011)

Fostering Bottom-Up Approaches

A bottom up approach to sustainable development could help Port of Spain secure a more sustainable path. Improving technology, more data, more knowledge and experience and greater awareness should empower people to make the necessary changes at the local level and(Gabriel Nagy & Ramsumair, 2012)

Experiences with urban resilience in Trinidad and Tobago suggests that there is an incompatibility of current government structures with those suggested as necessary for promoting social and ecological resilience. Inclusive institutions and the sharing of responsibility for natural resources go against the dominant hierarchical institutional forms of most governments throughout the world(Adger & Tompkins, 2004).

Top Level Support

However, in the case of Trinidad and Tobago, there are several factors that suggest a top down approach is also necessary to support bottom up efforts.According to Ramlall, there are several inefficiencies inherent within government produced Port of Spain development plans that make the goal of a sustainable city almost impossible without intervention.The plans lacks the specific strategies and standards necessary to develop and maintain a 'sustainable city'(Ramlall, 2010).

While development standards guide development in the city towards a sustainable city goal, this guidance is functionally absent. Building codes are inefficient and unenforced with little visible incentives to encourage developers to build with environmental sustainability goals. (Ramlall, 2010)

One of the strengths of having a government based green roof policy lies in the fact The State is the major landlord in Trinidad and Tobago, owning over fifty-two (52%) of all lands and multiple municipal buildings concentrated in Port of Spain (Wijetunga, 2000)

The government has a large stake in the effectiveness of the policy. The high number of government buildings ensures that any strategies for green roofing undertaken by the government would be highly visible and set a benchmark.

Any central government based policy has a level of risk attached to it due to the nature of administration in Trinidad and Tobago. The current government structure, results in a high proportion of administrative power being held by a few elected officials, mainly the Prime Minister and the Cabinet of Ministers. Initiatives that have been in the interest of sustainable development and environmentally benefits have been consequently 'scrapped' with the introduction of new government administrations in the interest of change, many have gotten 'lost' in the handing over of portfolios and new administrations and visions.

The political landscape has a direct effect on what policies are implemented or not implemented as there is a high amount of central government control on national strategies. It is not uncommon that political parties in electoral bids construct facilities and infrastructure quickly for quick political mileage and this contradicts the long term payback periods that green roofs involve.

This can be counteracted through attempts to decentralize the government's policy making power. Decentralization of power through the empowerment of the regional corporations would be ideal to ensure decisions relevant to their regions. Regional corporations would have the autonomy to decide which policies are most valid and beneficial for their regions. For example, green roofs serve a different purpose in Port of Spain as they would serve in Chaguanas due to geography, economic activity and other motivations e.g. commercial opportunities.

Due to a lack of awareness of payback periods and life cycle costs among high power decision makers, it is not seen as prudent decision making and procurement to choose a more expensive upfront technology.The entire process of procurement needs review and standardization. The use of 'lowest cost' as the main determining factor in contracts encourages using cheaper, lower quality materials and less innovative technologies. This is especially true of green roofs as some studies have in fact shown, that from a monetary cost benefit analysis, green roofs over their life cycle may in fact cost more than traditional roofs, however there are positive externalities.

Using the lowest price as the determining factor in procurement disguises the environmental externalities of the construction industry that could be mitigated through the use of green roofs. Adding to this inertia to encourage new technologies is the perception that many key actors have a vested interest in keeping the system as is.
As the socio-technical regime acts as a filter for successful and unsuccessful innovations, with worthy innovations are incorporated into the current regime, if there are conflicting interests at this level, change can be viewed as potentially threatening to the vested interests of the established players within that sector.

There is a need to create proper tendering legislation for the construction industry. This is a major problem when it comes to promoting sustainable technologies in the construction sector in Port of Spain and unless this legislation is enforced investors and donors organizations may seek opportunity elsewhere or adopt a 'wait and see' attitude, stagnating investment.
Green roof policy needs to exist as part of a larger green building legislation and enforcement in Trinidad and Tobago in order to ensure its deployment and diffusion.

There is a lack of understanding about direct tangible and long-term economic benefits of extensive green roofs. Green roof structural loading requirements require additional capital expenditure. This lack of awareness is not unique to green roofs however, and is indicative of

a larger social characteristic of Trinidad and Tobago. There is a tendency in Trinidad and Tobago, as in many developing countries, to view the environment from a utilitarian point of view. The environment is valued based on what marketable resources it possesses, not for any intrinsic value or services provided to the people as evidenced by the exploitation of hydrocarbon industry at the expense of environmental protection.

All persons who were interviewed agreed that a nationwide government policy to incentivize the development of green roofs is not only important but necessary to the deployment of the technology. Equally important is the enforcement of such a policy.

Currently, there are tax waivers for the importation of energy efficient products and solar PV technology. These technologies have still not seen a push in development, indicating that monetary incentive is not enough to encourage the development of green roof technology. The encouragement of green roofs through policy will influence the overall economic activity within the region it is implemented in by encouraging "first mover" opportunities for businesses, developers and architects to develop expertise and competitive advantages in a new field.

Most stakeholders were of the opinion that punitive measures would not be the best for encouraging the development of this technology as it needs to be a stakeholder based process (bottom up approach) and all the stakeholders need to have access to proper information and be made aware of the costs and benefits of the technology. The Government of Trinidad and Tobago has made steps to include representative of all stakeholders when developing new development strategies and plans (NSDS, TTBS Building code) and should continue this stakeholder based approach.

It is also acknowledged that small island states have unique pressures and many critical development priorities for example, attracting foreign investment and risks associated with climate change and sea-level rise. They conclude, following a case study of Barbados, that efforts to enhance island resilience must be mainstreamed into general development policy formulation, and that adaptations should not be seen as confined to engineering or urban planning-based realms (Nobuo Mimura, 2007)

Green Roof Policy Instruments and Non Policy Measures

"The Carrot or the Stick"

As is the case in many developing countries, civil society in Trinidad and Tobago is not very involved in the decision making process and the state is as a result responsible for making decisions regarding economic development, allocating financial resources and ensuring environmental protection(Persadie, 2005) . While the state acts as the guardian of the environment, as a public good, there is a conflict as environmental degradation is largely the result of economic activities which the state actively encourages. By definition, the private sector prioritizes profit and private benefits over public benefit and therefore cannot be expected to act in a way that will seemingly reduce profit by implementing new sustainable technology. The GORTT must therefore assume direct responsibility through command or control or incentivize 'green' behavior in private sector bodies.

An integral part of successful technological transition management is the empowering 'frontrunners' (R. Kemp et al., 2007). This requires the provision of financial and human resources to push a technology. In an investigation of 'roof transition' in the Netherlands, it was concluded that the development of new regulations and changes to funding schemes

created necessary space for more innovation and research that created practical paths to the abstract vision of 'sustainable development' (R. Kemp et al., 2007).

The encouragement of green roofs through policy will influence the overall economic activity within the region it is implemented in by encouraging "first mover" opportunities for businesses, developers and architects to develop expertise and competitive advantages in a new field.

Policy instruments refer to the measures that can be designed and implemented by the GORTTencourage the diffusion of green roofs. Policy instruments should be implemented as key drivers to facilitate green roof diffusion and deployment. Policy instruments can be designed to encourage research and developmenthelping to create the enabling environment for public and private investors to engagein innovation and experimentation (IEA, 2009).To maximize the chances of success, policy instruments can be combined to generate synergistic effects (OECD, 2004). Policy instruments can be designed and implemented by GORTT to create incentives for encouraging the diffusion and commercialization of green roof technology.

There are a number of instruments that can be used encourage implementation of green roofs.

Successful green roof policies fall into four general categories:

• Direct financial incentives;

• Indirect financial incentives;

• Compensation measures

• Collaborative support mechanisms

Encouraging green roofs in Port of Spain (and green building concepts in general) will require investments within all levels in many forms including financial incentives from government; loans and capital investment from banks, such as the IDB and private agencies. These instruments will help overcome challenges identified by stakeholders and push innovation in green roof technology.

In the preliminary absence of a strong market pull encouraging deployment of such a technology, it is up to government actors to push the technology and innovation process. Past experiences with green building initiatives in Trinidad and Tobago, indicate that it is not sufficient to expect building owners to volunteer to install green roofs, but it is necessary for the governing authorities to introduce green roof policy. Policies that are aimed at private sector companies must encourage innovation and emphasize economic and environmental, goals and help reduce perceived trade-offs between economic development and environmental quality.

Indirect financial incentives

Indirect incentives in the Trinidad and Tobago context could take the form of improving the energy efficiency of a building, leading to a reduction in the energy costs to the end users. In Trinidad and Tobago however, this is usually not of high priority due to low energy costs (due to the fuel subsidy) and lack of comprehensive data on energy usage. However, in efforts to cut operational costs, businesses should look into installing green roofs as a long term investment.

In Trinidad and Tobago, The Town and Country Planning Division of the Ministry of Planning and Sustainable Development currently offers indirect financial incentive for vegetation through a policy similar to Singapore's GFA programme. This is done on a case

by case basis and is not enforced using any legislation, simply encouraged A trade-off policy such as Singapore's GFA plan should be legitimized and enforced to incentivize the inclusion of green roofs in building plans.

Direct financial incentives

Direct financial incentives include covering some of the costs of installing a green roof. This would need to be implemented by the GORTT and developed by the relevant ministries. Specific conditions would need to be settled on through background research and then verified in an application process to qualify for the funding. The conditions can include minimum water-retention capacity, growing-medium thickness and a contract that would encourage a turnkey solution to encourage accountability in the project. Additional contracts for maintenance of the green roof could also be established here to reduce the costs of maintenance using government offices.

This financial investment requires significant capital investment that may be seen as a deterrent to this instrument in Trinidad and Tobago, where the technology is new and therefore may be seen as a risky investment. Often governments choose to reserve funding for projects that are close to market as they are low risk. This however puts innovative environmental technology, such as green roofs, at a disadvantage.

Compensation Measure

Density bonuses are another tool that may be a viable possibility in Trinidad, especially in Port of Spain, where urban density is highest. In this case, the floor space or building height is allowed to be beyond regular regulations if there are proven community benefits, such as the ones provided by a green roof or terrace. A similar bonus is used in targeted areas in Portland Oregon where from three square feet of additional development are allowed for one square foot of green roof.

Research and development into green roof technology could be encouraged through direct financial incentives through grants for pilot retrofit programs among state owned Government buildings for maximum visibility.

For these instruments, it is especially important that all stakeholders be made aware of the financial incentives and applications be made accessible to the appropriate parties.

Regulatory measures

Compulsory green roof installation can ensure that a specific space is 'greened'. Regulatory measures can achieve specific and sustainable urban goals such as improvements in air quality, urban heat island effect, stormwater management and amenity space. Regulatory measures can also set minimum properties for the green roof, such as growing medium thickness or types of plants used. This approach has been widely used in Germany and Copenhagen. This approach may not be the best approach for Trinidad and Tobago in the short term due to the novelty of green roof technology and need to build a substantial database of site specific information. The potential however exists for the GORTT to mandate compulsory green roofing for all municipal buildings in Port of Spain as the Government has a high level of building ownership in the city and would make a visible impact and show high level commitment. It can be mandated that a portion of all government buildings have green roofing or vegetation on the rooftops where appropriate. Retro-fittings of older government buildings being renovated would be ideal targets for this type of policy.

Other regulatory policies include implementing or enforcing existing regulations that may not be directly related to construction and planning. For example, enforcing drainage laws that a building is not allowed to increase stormwater flow from a site.Laws that govern worker's

rights could regulate the intangible benefits of green roofs to worker's health as well as tangible benefits such as improvement in air quality.

Collaborative Support

Important steps that should be undertaken in the short term are initiating broad stakeholder engagement programmes that do not require government intervention. Collaborations between different sectors such as professional and academic could result in low cost, low risk development of efficient knowledge databases Collaborations between professionals, such as Engineers, Architects, Planners, Architects etc. and clarification of goals, roles and responsibilities in the predevelopment and development stages are necessary to promote and lobby for a green roof policy.

Academic research institutions can adopt campaigns and competitions to encourage public engagement and education the public on green roof benefits and raise environmental awareness in society.

In the short term, government intervention could take place by capitalizing on existing policies and opportunities that would provide subsidies or grants to company startups that specialize in green roofing. This could be done through the Green Fund.

Continuing professional development asa license requirement for relevant professionals is ideal in stimulating a bottom up approach to policy development and should be incorporated into law.

Improving approval procedures (and enforcing penalties) and engaging the EMA more in the approval process for buildings rather than interventions for 'designated activities' which do not occur in the urban areas.

Lobbying to amend the forthcoming Building Code to explicitly facilitate "green technologies like green roofs and Include green roofs as a stormwater best management practice in the Urban Design guidelines distributed by the Ministry of Local Government.

Programmes for system innovation offer environmental benefits alongside other types of benefits. Such programmes should be time-limited and flexible

6 Chapter 5: Steering the Transition

6.1 Transition Management

As discussed previously, The UNFCCC framework identifies areas of action for the effective management and guidance of a technology transfer. Through data analysis, it becomes clear that if long term technology transfer is to be effective in Trinidad and Tobago, the process needs to be a step in a wider technological shift. Technological change can occurs through either incremental or radical innovations or combinations thereof through deliberate research and development into the field.(Ockwell et al., 2008). For the newly acquired technology to be efficiently utilized and maintained there needs to be a broader transition of the existing administrative and legislative systems to one that complements a vision of sustainability.

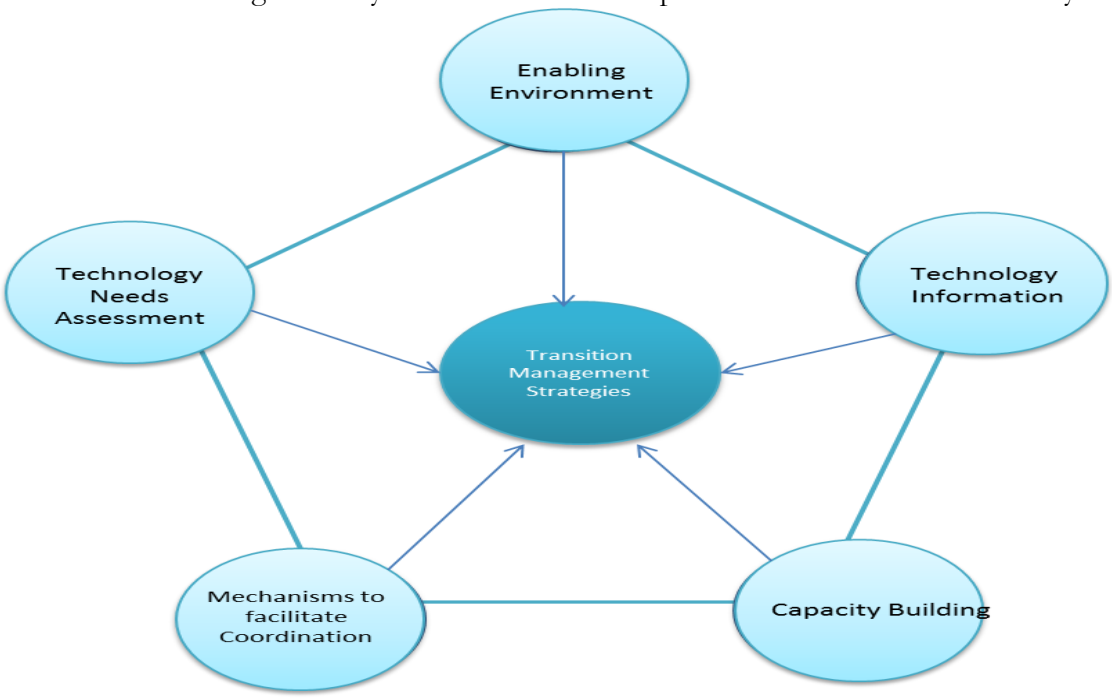


Figure 13: Transition Management Strategies formed from information from technology transfer process (Author's interpretation)

Taking a 'business as usual' approach to the present urban development situation in Port of Spain leaves unsustainable practices unquestioned and has resulted in increasing negative impacts. The legislative landscape does not foster improvement in technology and stunts the development of innovative solutions to sustainability challenges because of higher upfront costs.

Frustration amongst actors in the sector is worsened by a high reputation of public sector corruption in Trinidad and Tobago. The 2011 Corruption Perceptions Index[11] (CPI) places Trinidad and Tobago at 91 out of 183 countries with a score of 3.2 out of ten. This is the lowest ranking ever attained since being included in the CPI for the first time in 2001.(Julien, 2011). In 2010 , Trinidad and Tobago was ranked 72 out of 180 countries in the annual Global Corruption Report of Transparency International (Bruzual, 2010; Kirton, 2010). The

[11]The CPI ranks countries based on how corrupt their public sector is perceived to be.

report highlighted corruption regarding legal and institutional changes and 'overlapping directorships' leading to conflicts of interest(Kirton, 2010). Within the urban development sector, the perception of corruption is especially high following high profile corruption controversies involving UDECOTT (Urban Development Corporation of Trinidad and Tobago) in 2009-2010. Attempts to achieve sustainable development have been actively thwarted by persons with vested interests in leaving the current regime as is. According to (Bissessar, 2010) it can be argued, that in the case of Trinidad and Tobago, the 'political directorate' shows reluctance to empower local bodies, not simply because of a lack of capacity, but because of the resultant loss of power and control.
Review of the data collected and presented in Data Analysis, indicates that the challenges facing the integration and development of a potential green roof policy in Port of Spain, Trinidad are not limited to green roof technology, however they are the same issues faced by most attempts to develop environmentally sustainable projects/initiatives such as a green building code. A difficult challenge liesin trying to encourage stakeholders to look beyond private self-interests and work with a broader long term vision of sustainability through collaboration and participatory decision making.(Morsink et al., 2011)

Traditional approaches have resulted in many 'paper plans', while inefficient or inappropriate policies and poor enforcement allow unsustainable development to occur unchecked (Rakodi, 2001). Rakodi makes a strong statement when discussing urban development policy in developing countries, "*Without increased legitimacy, the vicious circle of inefficiency and ineffectiveness will continue.*"

Resources must be provided for the improvement of policy making abilities of authorities and attention must be paid to the overall systems of governance and politics if new policy is to be useful.

The most effective approach in ensuring an effective implementation of green roofs is a strategy which is integrated into an overall transition of the current sociopolitical macroenvironment to one with a vision of sustainable development.

The concept of Transition Management seeks to steer sustainable development through the identification of the unsustainable systems that exist and restructuring them. is geared towards enabling, facilitating and guiding the social, technical and political transformations required by embedded societal systems to bring about sustainability(Jan Rotmans, 2001).According to advocates of this form of governance, persistent problems involving multiple domains, actors and sectors in society motivates the shift to a form of governance that addresses the multiple levels and dimensions in which these problems manifest (René Kemp, 2006). The approach involves increasing participation by encouraging bottom-up approaches that are supported through top-down initiatives.

It is useful to note that a green roof policy is not necessary to deploy green roofs successfully and benefit from some of the benefits, as many countries have seen increases in green roofing without policy interventions. However, the countries that have established green roof policies do so due to the understanding that green roofs, and green infrastructure in general work as a system, with cumulative public benefits. Relatively large areas of green roofs are necessary to maximize the full benefits (Ngan, 2004), governments at all levels must encourage more extensive green roof implementation. There are also major obstacles that in the short term must be overcome through the direct intervention of municipal policy makers

According to Loorbach, the concept of transition management stems from the increasing agreement that both top-down approaches by government and the free market approaches to

generating sustainable solutions are inefficient management mechanisms, but it is however, "impossible to govern societal change without them"(Loorbach, 2010).

In Trinidad and Tobago, there seems to be a perpetual gap between what society desires and the strategies that are implemented to attain those goals. In the field of green urban development, this has led to frustration and learned helplessness[12] among key stakeholders. Transition management attempts to link what is societally desirable and envisions how best to attain those goals. (Jan Rotmans, 2001)

Urban development policy requires reform and development to better achieve urban sustainability, the cooperation of other political, economic, social and technical factors is vital to ensure successful implementation and enforcement of any policy. These factors are often overlooked as emphasis is placed on the development of the urban planning instruments themselves, not acknowledging that in the absence of efficient facilitating factors, success will not be achieved (Ramlall, 2010).

Supportive legislative and administrative framework must be in place. There are several policies under which the development of green roof technology could be developed for the city of Port-of-Spain, however, as is the case with many developing countries "legitimacy is not derived automatically from the enactment of legislation" (Rakodi, 2001). Legitimacy is only attained when those with authority are empowered to enforce legislation to be effective in upholding the rules and regulations within legislation without any obstacles such as acts of bias against certain groups (Rakodi, 2001.

Transition management implies that explicit attempts to change the socio-technical landscapeare necessary to resolve persistent societal problems and is geared towards existing system improvement and system innovation(Loorbach, 2010).The adoption of green roofs in Trinidad can be classified as a technological transition and in this way, the concept is ideally suited to the local situation in Trinidad and Tobago as it emphasises short term current system improvement that will increase the enabling environment for the acceptance of green roofs while envisioning long term results through innovation and research of the technology itself. The increasing call for green building techniques due to increased flooding impacts can be used as an entry point for beginning the process of transition management in Trinidad and Tobago.

Transition management strategies encourage'myopic powerful actors' to work towards sustainability goals while simultaneously buildingpublic support for the transition (empowering them to lobby for desired changes)(Saeed Parto, 2007). It is essential that these strategies display strong commitment to the goals, regular assessment and adjustment of goals and policies as necessary. This emphasis on long term visioning is important in the context of Trinidad and Tobago as the high level of state administration on environmental sustainability projects results in a high reliance on general election outcomes which have changed multiple times in relatively short timespans.

Transition management places focus on the coordination of public and private actions, combining top down and bottom up approaches in an effective way, with great importance placed on fostering learning and innovation.Transition management strategies have been developed in various governmental sectors worldwide and have been designed to encourage

[12] Learned helplessness refers to the condition where one fails to respond in a way to help oneself in order avoid unpleasant circumstances resulting from a perceived absence of control over the outcome of a situation.

short-term innovation and connect them to long-term sustainability visions.((René Kemp, 2006)

The main goal of implementing a green roof policy within a more collaborative governance (such as is proposed by transition management) is to influence and guide the choices of key actors in the system to break out of the "technology lock in" through the fostering of a broad network of actors and encouraging innovation.This network will be empowered to change the reluctance to alter the current unsustainable systems that have unfortunately which have been systematically reinforced by powerful (landscape and regime) influences (UNPAN, 1998). (Saeed Parto, 2007).

Chapter 6: CONCLUSIONS

The purpose of this research was to answer the questions of relevance of a green roof policy to Trinidad and Tobago; consult with key stakeholders to gain their perspectives on the characteristics of an efficient green roof policy and then prescribe accordingly.

Green roofs can play an important and effective role in the sustainable development of Port of Spain, Trinidad and Tobago, not only for the quantifiable benefits, but as a visible, vehicle for initiating necessary discussion on how greenbuilding and design can be used as a tool for urban resilience.

Multifunctional green roofs, whether that function is for biodiversity, storm water management or public services, provide arelatively easy to understand, visible 'catalyst' for a transition towards more sustainable development.

All agencies and statutory bodies need to act to ensure that developers and innovators are encouraged and empowered to embrace the novel technology. The responsibility to build the local adaptive capacities of relevant agencies lies ultimately with the state (GORTT) to support and encourage bottom up initiatives and innovation.

The major challenges that were identified that needed to be overcome were numerous, but were most frequently stated as:

- Lack of knowledge and awareness of green roof technology among stakeholders

There is generally a lack of knowledge about green roofs and comprehensive local benefits. Green spaces in Port of Spain are most often viewed from a recreational and aesthetic point of view only.

- Lack of incentive to buy in to new technology

Green roofs require additional capital expenditure. Without incentivizing their development, most businesses would not change to using a green roof for public benefit.

- Economic concerns or lack of information regarding payback periods

There is a lack of understanding about the short term, life cycle and long-term economic benefits of green roofs, and green building on the whole.Lack of local research only adds to the lack of understanding and contributes to perceptions of risks associated with new technology such as green roofs.

- Construction sector immaturity and low levels of accountability

The construction sector in Trinidad and Tobago is relatively risk averse and sustainable design is not well known amongst practitioners. The construction sector also suffers from high perceptions of corruption which make gaining public trust difficult.

An effective green roof policy would need to overcome these challenges through intercepting to incentivize the desired behaviours to transition towards more sustainable development. Punitive measures that are seen in other countries where green roofs are more developed are not ideal for the context of Trinidad and Tobago as the technology is still new and immature in this context.

Policy routes that have been taken globally have been investigated for analysis of motivations for implementing green roof policy as well as the instruments and initiatives that have been used. These policies can be summarized into Financial Incentives (Direct and Indirect), Regulations (mandates). There have also been successes in non-policy measures that serve to build the strength of bottom up approaches.

Table 3 Summary of types of Green Roof Policies in chosen cases (Adapted from:(Shepherd, 2010)

POLICIES	
Financial Incentive Programs	Germany, Toronto, Tokyo, Singapore
Regulations	Germany, Toronto, Tokyo, Singapore
NON POLICY MEASURES	
Educational Campaigns	Toronto, Singapore, Tokyo
(Professional Competitions and Awards)	Singapore
Established mechanisms for collaboration	Singapore

Urban development policy in Trinidad and Tobago requires reform and development to better achieve urban sustainability goals. The alignment of other political, economic, social and technical factors is vital to ensure the successful implementation and enforcement of any green roof policy that may be developed in future.

Administrative and legislative support must be encouraged and in place for any policy to achieve success. Though there is legislation governing urban planning in the city of Port-of-Spain, it is important to raise the capacities of all stakeholders and increase legitimacy within development strategies. Legitimacy is attained when the enforcement capability of those with the authority is effective in fulfilling its mandate, that is, they are able to uphold the rules and regulations as stipulated by the legislative framework without any obstacles(Rakodi, 2001)..

The novel nature of green roof technology in the region, and specifically in Trinidadunfortunately only contributes to the paradoxical situation that is seen in most green building attempts. The lack of official guidelines prevents those in the urban development industry from recommending green roofs for their projects, but without a substantial number of projects, establishing the standards is not high priority.

Many of the issues raised in this research point to a wider issue of the structure of governance and policy making systems in Trinidad and Tobago. In order to succeed in the vision of sustainable development, Trinidad and Tobago requires innovative, multidisciplinary and participative forms of governance such as that is proposed by the concept of transition management.

This 'transition management' approach seeks to encourage bottom-up approaches through expanded stakeholder participation, that are then supported in a top-down manner.

A major change to Trinidad and Tobago's current top-down dependent approach to policy making and implementation is needed.This requires a more participatory and stakeholder empowering strategy for the way forward. (Alonge, 2006)

Trinidad and Tobago is far from realizing a sustainable society with the current status quo and modus operandi, and there are real future challenges to be overcome at all levels in the system.

It is likely that the existing structures and interests actively prevent the changes from diffusing, or that the civil support is not well organized, capable and mobilized. Or that the transitional change leads us into an undesired direction of unsustainability, be it in economic, ecological or social sense. The crucial challenge for transition management will therefore be for the coming years to engage actors in the process and develop sustainable green roof technology and promote its use.

6.2 6.1 Recommendations for Further Research

This research is meant to act as part of a predevelopment phase for green roof policy in the urban area of Port of Spain. However, it has been found through the research process that Trinidad and Tobago does not possess the fundamental legislative and policy background that would guarantee the success of such a policy.

Research into other global green roof policies has shown that each case has its own dynamic motivations that have influenced how the policies have been manifested (social, cultural, economic, political etc.). The most urgent need for Trinidad and Tobago to begin to develop local policies is to increase the level of comprehensive data and quantify and justify new technologies. It is therefore recommended that research be done into the quantifying benefits and costs of green building techniques, which would require the use of energy auditing data.

The development of a fundamental building code with green building standards would be ideal mechanisms to implement green roofs. Further research should be done by those involved closely with the urban development sector into specific green roofing policies and their dynamics.

Further research would also include more in depth consultation with decision makers within the Government with the power to affect changes not just the affected stakeholders.

Research is also recommended into the potential for green infrastructure and green building techniques to be implemented on a large scale in Tobago. Due to differing motivations (eco tourism from European tourists), it would show vastly different perceptions among stakeholders. Tobago also has a level of autonomy through the Tobago House of Assembly that would need to be analysed separately.

7 Bibliography

Adger, W. N., & Tompkins, E. L. (2004). Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society, 9*(2), 10-10.

Agard, J., & Gowrie, M. (2002). Environmental Vulnerability Index (EVI): Provisional indices and profiles for Trinidad and Tobago: Environmental Management Authority, University of the West Indies.

Alonge, A. J. (2006). *Bringing Stakeholders into Agricultural Extension Reform*

Agenda: A Participatory SWOT Analysis of the Trinidad

National Agricultural Extension Service Paper presented at the AIAEE 22nd Annual Conference, Clearwater Beach, Florida.

Archer, M. (2010, 14th October). "A GBC to Call Our Own" Retrieved August, 2012, from http://www.aclaworks.com/news/a_gbc_to_call_our_own/).

Beard, T. (2012). *"Sustainable Cities: The Case of Greater Port of Spain, Trinidad"*. Paper presented at the 46th ISOCARP Congress 2012 Nairobi.

Bergman, M. M. (2008). *Advances in mixed methods research : theories and applications*: Sage Publications Ltd.

Bissessar, A. M. (2010). Local Governance Structures in Trinidad and Tobago: Muddling Through. [Article]. *Las Estructuras de Gobernación Local en Trinidad-Tobago: Desembrollando., 59*(4), 127-144.

Bruzual, A. (2010, March 20). "Society of corruption", *The Newsday*.

CARICOM. (July- September 2010). "Trinidad and Tobago pushes for Sustainable Energy", *CARICOM Energy Programme Quarterly Newsletter,* p. 10.

CARICOM. (2007). Caricom Energy Policy.

Carter, T., & Fowler, L. (2008). Establishing Green Roof Infrastructure Through Environmental Policy Instruments. *Environmental Management, 42*(1), 151-164. doi: 10.1007/s00267-008-9095-5

Carter, T., & Jackson, C. R. (2007). Vegetated roofs for stormwater management at multiple spatial scales. *Landscape and Urban Planning, 80*(1–2), 84-94. doi: 10.1016/j.landurbplan.2006.06.005

Carter, T., & Keeler, A. (2008). Life-cycle cost–benefit analysis of extensive vegetated roof systems. *Journal of Environmental Management, 87*(3), 350-363. doi: 10.1016/j.jenvman.2007.01.024

CDERA. (2003). Status of Hazard Maps Vulnerability Assessments and Digital Maps: Trinidad and Tobago Country Report: The Caribbean Disaster Emergency Response Agency (CDERA).

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning, 68*(1), 129-138. doi: 10.1016/j.landurbplan.2003.08.003

Coaffee, J. (2008). Risk, resilience, and environmentally sustainable cities. *Energy Policy, 36*(12), 4633-4638. doi: 10.1016/j.enpol.2008.09.048

Comission Staff Working Document of Regional Policy contributing to sustainable growth in Europe 2020

(2011).

Commission, U. S. I. T. (2009). The Impact of the Caribbean Basin Economic Recovery Act *Nineteenth Report*

D. Banting, H. Doshi, J. Li, & Missios, P. (2005). Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto: Dept. of Architectural Science, Ryerson University.

Economy, M. M. o. P. a. t. (2011). Medium-Term Policy Framework 2011-14

ECTT, T. E. C. o. T. a. T. (2011, April 8th). "Green buildings and energy efficiency", *The Trinidad Guardian*.

EMA. (2012). History Retrieved 2012, from www.ema.co.tt

Forbes, D. J. (2010). *An analysis of municipal tools for promoting green roof technology into dense urban development*. M.A. 1480905, Tufts University, United States -- Massachusetts. Retrieved from http://search.proquest.com/docview/756893724?accountid=12187

http://XU2LA7UD9L.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQuest+Dissertations+%26+Theses+A%26I&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&rft.genre=dissertations+%26+theses&rft.jtitle=&rft.atitle=&rft.au=Forbes%2C+David+John&rft.aulast=Forbes&rft.aufirst=David&rft.date=2010-01-01&rft.volume=&rft.issue=&rft.spage=&rft.isbn=9781124205175&rft.btitle=&rft.title=An+analysis+of+municipal+tools+for+promoting+green+roof+technology+into+dense+urban+development&rft.issn= ProQuest Dissertations & Theses A&I database.

Gabriel Nagy, & Ramsumair, P. (2012). *Evolution and the Path Towards Sustainable Cities*.

Gail Lawlor, B. A. C., Hitesh Doshi, Ireen Wieditz. (2006). *Green roofs : a resource manual for municipal policy makers*. Canada Mortgage and Housing Corporation

GORTT. (2012). *Request for Proposals for the National Physical Development Plan for Trinidad and Tobago*. Port of Spain, Trinidad: GORTT Retrieved from https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0BxxNxhCiqznENzliNDliNzUtZGEyOC00ZTY2LThlN2UtYjM0M2MwZGRiMTkz.

Gowrie, M. N. (2003). . Environmental vulnerability index for the island of Tobago, West Indies. *Conservation Ecology, 7(2): 11*. .

IDB. (2011). Urban Sustainability in Latin America and the Caribbean

In I. O. o. E. Relations (Ed.): Interamerican Development Bank.

IDB. (2012). Port of Spain, Trinidad and Tobago Action Plan Inter-American Development Bank: Trinidad Sector.

IEA. (2009). *"Ensuring Green Growth in a Time of Economic Crisis: The Role of Energy Technology"*. Paper presented at the G8 2009, Siracusa.

IEA. (2011). CO2 emissions from fuel combustion: highlights. : IEA statistics, International Energy Agency.

Jan Rotmans, R. K., Marjolein van Asselt, . (2001). "More evolution than revolution: transition management in public policy". *foresight, 3*(1).

Julien, J. (2011, December 2nd). A 'precipitous drop', *Trinidad Express*.

Kemp, R. (2007). "Integrating innovation and environmental poicies". In B. H.-C. Saeed Parto (Ed.), Industrial innovation and environmental regulation: developing workable solutions.

.

Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. *International Journal of Sustainable Development and World Ecology, 14*(1), 78-91. doi: citeulike-article-id:4228049

Kirton, D. R. M. (2010). The Political Culture of Democracy of Trinidad & Tobago: 2010: Institute of International Relations, University of the West Indies.

Kousky, C. (2012). Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters, Their Determinants, and Risk Reduction Options.

Kowlessar, G. (2011). Tackling flooding in PoS - Agency to focus on squatters, *Trinidad Guardian*.

Lazzarin, R. M., Castellotti, F., & Busato, F. (2005). Experimental measurements and numerical modelling of a green roof. *Energy and Buildings, 37*(12), 1260-1267. doi: 10.1016/j.enbuild.2005.02.001

Lin, Y.-J., & Lin, H.-T. (2011). Thermal performance of different planting substrates and irrigation frequencies in extensive tropical rooftop greeneries. *Building and Environment, 46*(2), 345-355. doi: 10.1016/j.buildenv.2010.07.027

LLP, L. P. (2008). Urban Design Principles: Generic Urban Design Framework for Trinidad and Tobago.

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance, 23*(1), 161-183. doi: 10.1111/j.1468-0491.2009.01471.x

Miller, L. J. (2008). *Green roof policy: A sustainable space to grow?* M.A. 1454918, Tufts University, United States -- Massachusetts. Retrieved from http://search.proquest.com/docview/304429702?accountid=12187

http://XU2LA7UD9L.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQuest+Dissertations+%26+Theses+A%26I&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&rft.genre=dissertations+%26+theses&rft.jtitle=&rft.atitle=&rft.au=Miller%2C+Lauren+Jessica&rft.aulast=Miller&rft.aufirst=Lauren&rft.date=2008-01-01&rft.volume=&rft.issue=&rft.spage=&rft.isbn=9780549560104&rft.btitle=&rft.title=Green+roof+policy%3A+A+sustainable+space+to+grow%3F&rft.issn= ProQuest Dissertations & Theses A&I database.

CHAPTER 35:01 ACT NO. 29 OF 1960, TOWN AND COUNTRY PLANNING ACT Stat. (1960).

Ministry of Planning and the Economy, G. (Producer). (2011). Trinidad and Tobago's Status on Sustainable Development.

Morsink, K., Hofman, P. S., & Lovett, J. C. (2011). Multi-stakeholder partnerships for transfer of environmentally soundtechnologies. *Energy Policy, 39*(1), 1-5. doi: 10.1016/j.enpol.2010.09.043

Mui, T. (2007). Application of Green Roof to Green Architecture from Designer's Perspective.

Nagy, G. (2011). Urban Development and Housing Trinidad and Tobago: Input to Country Strategy 2011- 2015: Inter American Development Bank.

Newman, P. (2010). Green Urbanism and its Application to Singapore. *Environment and Urbanization Asia, 1*(2), 149-170. doi: 10.1177/097542531000100204

Newton, M. (2010). *LEED – A Caribbean Architect's Perspective* acla works.

Ngan, G. (2004). "Green Roof Policies: Tools for Encouraging Sustainable Design".

Nobuo Mimura, L. N., Roger McLean, John Agard, Lino Briguglio, Penehuro Lefale, Rolph Payet,Graham Sem. (2007). Small islands. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental

Panel on Climate Change, . In O. F. C. M.L. Parry, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., (Ed.). Cambridge University Press, Cambridge, UK, 687-716.

Nyuk Hien, W., Puay Yok, T., & Yu, C. (2007). Study of thermal performance of extensive rooftop greenery systems in the tropical climate. *Building and Environment, 42*(1), 25-54. doi: 10.1016/j.buildenv.2005.07.030

Oberndorfer, E., Lundholm, J., Bass, B., Coffman, R. R., Doshi, H., Dunnett, N., . . . Rowe, B. (2007). Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. *BioScience, 57*(10), 823-833.

Ockwell, D. G., Watson, J., MacKerron, G., Pal, P., & Yamin, F. (2008). Key policy considerations for facilitating low carbon technology transfer to developing countries. *Energy Policy, 36*(11), 4104-4115. doi: 10.1016/j.enpol.2008.06.019

OECD. (2004). International Energy Technology Collaboration and Climate Change Mitigation.

OECD. (2009). DAC List of ODA Recipients.

Organization, W. W. I. P. (2012). The Global Innovation Index 2012. Retrieved from http://www.globalinnovationindex.org/gii/main/fullreport/files/Chap3/Trinidad%20and%20Tobago.pdf.

Development and transfer of technologies: Framework for meaningful and effective actions to enhance the implementation

of Article 4, paragraph 5, of the Convention (2001).

Persadie, N. R., Rajendra. (2005). Pursuing Development and Protecting the Environment: Dilemma of the Developing World. . *Electronic Green Journal*(22).

Peter Stahre, G. D. G. (2003). New Approach to Sustainable Stormwater Planning. Augustenborg, Sweden: International Green Roof Institute.

Rakodi, C. (2001). Forget planning, put politics first? Priorities for urban management in developing countries. *International Journal of Applied Earth Observation and Geoinformation, 3*(3), 209-223. doi: 10.1016/s0303-2434(01)85029-7

Ramlall, J. D. (2010). *"Sustainable City of Port-of-Spain: Myth or Reality?"*. Paper presented at the 46th ISOCARP Congress 2010, Nairobi.

Ramlogan, R. (2010). Using the Law to Achieve Environmental Democracy and Sustainable Development: an Elusive Dream for Trinidad and Tobago. *Electronic Green Journal, 1*(30).

Rawlins, M. A.-K., M. (2009). Case Study Guide: for CAPE Geography, Environmental Science and Biology.Port-of-Spain

René Kemp, D. L. (2006). Transition management: a reflexive governance approach. In D. B. Jan-Peter Voß, René Kemp (Ed.), *Reflexive Governance for Sustainable Development*.

Renwick, D. (2012, July 17th). T&T's wasted energy, *The Trinidad Express*.

Rowe, D. B. (2011). Green roofs as a means of pollution abatement. *Environmental Pollution, 159*(8–9), 2100-2110. doi: 10.1016/j.envpol.2010.10.029

Rudo Udika. (2010). *Flood Management: an examination of mitigation measures for flooding in urban areas in*

Trinidad

Paper presented at the 46th ISOCARP Congress 2010, Nairobi.

S Peck, C. C., M Kuhn, B Bass. (1999). Greenbacks from Green Roofs: Forging a New Industry in Canada. Ottowa: Canada Mortgage and Housing Corporation.

Saeed Parto, B. H.-C. (2007). *Industrial innovation and environmental regulation developing workable solutions*.

Sam C. M. Hui, S. C. C. (2011). *Integration of green roof and solar photovoltaic systems*. Paper presented at the Joint Symposium 2011: Integrated Building Design in the New Era of Sustainability.

Shen, L.-Y., Jorge Ochoa, J., Shah, M. N., & Zhang, X. (2011). The application of urban sustainability indicators – A comparison between various practices. *Habitat International, 35*(1), 17-29. doi: 10.1016/j.habitatint.2010.03.006

Shepherd, N. (2010). Green Roof Incentives : A 2010 Resource Guide: DC Greenworks.

. Skyrise Greenery Incentive Scheme. (2012, May 2012), 2012, from http://www.skyrisegreenery.com/index.php/home/incentive_scheme

Soma, K. (2003). How to involve stakeholders in fisheries management—a country case study in Trinidad and Tobago. *Marine Policy, 27*(1), 47-58. doi: 10.1016/s0308-597x(02)00050-7

Staff, T. G. (2012a, August 9th 2012). "Government moves towards CNG to reduce fuel subsidy", *The Trinidad Guardian*.

Staff, T. G. (2012b). "IDB includes PoS in emerging sustainable cities initiative", *The Trinidad Guardian*.

Staff, T. G. (2012c, August 15 2012). "Over $100m in losses in Diego Martin floods", *The Trinidad Guardian*.

. Stakeholder Analysis. (2001). *Anticorruption*, from http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/stakeholderanalysis.htm

The International Bank for Reconstruction and Development, T. W. B. (2012). Doing Business 2012. Washington DC, USA.

Tian, Y., Jim, C., & Tao, Y. (2012). Challenges and Strategies for Greening the Compact City of Hong Kong. *Journal of Urban Planning and Development, 138*(2), 101-109. doi: doi:10.1061/(ASCE)UP.1943-5444.0000076

Townshend, D. (2007). Study on Green Roof Application in Hong Kong: Final report: Ubris Limited: ARCHITECTURAL SERVICES DEPARTMENT.

UNEP, R. O. f. L. A. a. t. C. (2012). *Green Economy in the Context of Sustainable Development and Poverty Eradication: A Latin American and Caribbean Perspective*

Paper presented at the Eighteenth Meeting of the Forum of Ministers of Environment of Latin America and the Caribbean

Quito, Ecuador.

UNPAN. (1998). *Rethinking public administration : an overview*. New York United Nations.

Urban Redevelopment Authority, U. (2010). Handbook on Gross Floor Area.

USEPA. (2008). Reducing Urban Heat Islands: Compendium of Strategies

Climate Protection Partnership Division in the U.S.

Environmental Protection Agency's Ofice of Atmospheric Programs.

Wijetunga, A. A. (2000). Policy for the Management of State Lands *Land Use Policy and Administration Project (LUPAP)*: Land Tenure Center: University of Wisconsin - Madison

Wong, N. H., Chen, Y., Ong, C. L., & Sia, A. (2003). Investigation of thermal benefits of rooftop garden in the tropical environment. *Building and Environment, 38*(2), 261-270. doi: 10.1016/s0360-1323(02)00066-5

Wong, N. H., Cheong, D. K. W., Yan, H., Soh, J., Ong, C. L., & Sia, A. (2003). The effects of rooftop garden on energy consumption of a commercial building in Singapore. *Energy and Buildings, 35*(4), 353-364. doi: 10.1016/s0378-7788(02)00108-1

Wong, N. H., Tay, S. F., Wong, R., Ong, C. L., & Sia, A. (2003). Life cycle cost analysis of rooftop gardens in Singapore. *Building and Environment, 38*(3), 499-509. doi: 10.1016/s0360-1323(02)00131-2

Yin, R. K. (2003). *Case study research : design and methods* Thousand Oaks, Calif.: Sage Publications.

Youngquist, T. D. (2009). *What is green infrastructure? An evaluation of green infrastructure plans from across the United States.* M.C.P. 1464412, Iowa State University, United States -- Iowa. Retrieved from http://search.proquest.com/docview/304907981?accountid=12187

http://XU2LA7UD9L.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQuest+Dissertations+%26+Theses+A%26I&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&rft.genre=dissertations+%26+theses&rft.jtitle=&rft.atitle=&rft.au=Youngquist%2C+Timothy+Dennis&rft.aulast=Youngquist&rft.aufirst=Timothy&rft.date=2009-01-01&rft.volume=&rft.issue=&rft.spage=&rft.isbn=9781109144499&rft.btitle=&rft.title=What+is+green+infrastructure%3F+An+evaluation+of+green+infrastructure+plans+from+across+the+United+States&rft.issn= ProQuest Dissertations & Theses A&I database.

Cited Personal Communication

Lindström E.P May 2nd 2012

Newton, M (2012), June 28th 2012

Raymond M. (2012), August 3rd 2012

Appendix 1

STAKEHOLDER Categories

Private Sector	Public Sector	Civil Society Stakeholders
Corporations and Businesses (e.g. Contractors, Design firms, Architectural Firms, Roofing specialists)	Ministries (e.g. Ministry of the Environment and Water Resources, Ministry of Planning and Sustainable Development, Ministry of Finance, Ministry of Legal Affairs)	Media (Newspapers Radio, Television)
Local Academic Institutions (e.g. COSTAAT, UWI, UTT, SBCS)		Community based organisations
Business Associations	Elected Representatives (Constituency Parliamentary representatives)	Advocacy Groups (e.g. Caribbean Institute of Sustainability, Trini Eco Warriors, SustainTT)
Professional Bodies (e.g. TTGBC, TTIA, TTCA)	Courts (Environmental Commission)	National NGOs
Financial Institutions (e.g. Banks, Credit Unions)	Local Government (Regional Corporations, Mayors, Councillors, ODPM)	International NGOs

Appendix 2

Communication List

Name	Role	Type of Communication	Date
Chantal B. Philip	Public Education and Training Specialist, ODPM	Personal communication	August 26th 2012
Dr. April Baptiste	PhD. Environmental and Natural Resource Management, Director of Environment for The Community HUB (a social NGO), based in Trinidad and founder of YEDCo (Youth Environmental and Development Coalition	Personal communication	May 15th (email) August 28th (telephone)
Dr. Gabriel Nagy	IDB Team Leader,ECSI, Port of Spain, Interamerican Development Bank	Personal communication	April 24th 2012 (email)
Dr. Marissa Gowrie	Deputy Environmental Manager, Environmental Policy and Planning Division of the Ministry of Housing and the Environment (now changed)	In person interview	June 26th 2012
Gillian Fraser	Architect, Director at Carbon/green International Sustainability Consultants,Director of the Trinidad & Tobago Green Building Council, (TTGBC), member of the USGBC	In person Interview, TTGBC Meeting	July 1st 2012 June 27th 2012
Gizel Berkeley	Architect, GreenSpring Design Ltd, Member of TTIA	Telephone Interview	June 28th 2012 (telephone)
Gregory Salandy	Architect and Director GSAL Designs Ltd, design firm with "heavy bias to green/smart architecture and engineering technology"	In person interview	July 5th 2012

Hugh Schamber	Managing director Weathershield Systems Caribbean Limited and Trinidad Mastic Asphalt & Contracting Co. Ltd:, also a past president of Trinidad and Tobago Contractors Association (TTCA)	In person interview	11th July 2012
Mandilee Newton	Architect, Director of TTGBC and LEED Green Associate at Aclaworks	In person Interview, TTGBC Meeting	June 28th 2012 June 27th 2012
Mark Raymond	Architect and lecturer on urban planning and sustainable design	In person interview	August 3rd 2012
Rodney Ramlogan,	Manager, Regional Planning , Ministry of Local Government LocalArea and Regional Planning and Development Unit	In person interview	August 9th 2012
Petal Joseph	Regional Planner, Ministry of Local Government LocalArea and Regional Planning and Development Unit	In-person Interview	August 9th 2012
Stephen Greenleaf	Founder Caribbean Institute of Sustainability, Sustainability consultant and Greenleaf Sustainability Consulting	Personal communication, TTGBC meeting	June 27th 2012

Appendix 3:

INTERVIEW QUESTIONS:

QUESTIONS:

Briefly describe your background.

In your line of work, do you work with the concepts of urban resilience and sustainability?

If so, What indicators are used to asses urban resilience and sustainability?

To your knowledge, have any recent comprehensive studies been done to assess a baseline for the (drainage) situation in Trinidad and Tobago?

Are there any active government policies or initiatives, that you know of, that are in place to increase urban resilience and sustainability?

To your knowledge, have urban green roofing projects been attempted beforehand in Trinidad and Tobago?

Where would I be able to find more information on these projects?

Do any policies regarding green building in urban areas exist in Trinidad and Tobago?

To your knowledge, have any green building/urban greening policies been attempted before?

Can green roof initiatives be incorporated into any existing development policies?

What do you see as potential barriers to green roofs and green roof policy in Trinidad and Tobago? (technical, cultural, academic, political etc)

What do you see as potential drivers of green roofs and green roof policy in Trinidad and Tobago? (technical, cultural, academic, political etc)

What are some key agencies that should be involved in this type of development policy?

Any Other Comments/ Information?

Appendix 4

Generic Green Roof Policy Phases (Source: (Gail Lawlor, 2006)

Phase 1: Introduction and awareness

In this phase, the benefits and costs of green roofs are assessed. This phase can include knowledge sharing activities such as workshops, congresses and international conventions. Many green roof advocate organisations hold regular conferences Wworld Green Roof Congress, Green Roofs for Healthy Cities etc) and on a local level, workshops can be conducted to bring interested stakeholders together.

Phase 2: Community engagement

This phase attempts to raise the profile of green roofs within the local context. This includes meetings with local stakeholders e.g. community leaders, mayors, architects, landscaping professionals, building owners and environmental groups to gain support for green roofs. Through dialogue with stakeholders sources of funding may be explored and identified.

Phase 3:Action plan development and planning.

This involves the creation of a working committee made up of key stakeholders. A green roof demonstration project may be launched with or without scientific monitoring equipment, depending on the need for local research data

Phase 4: Technical research

This phase involves the establishment of public-private partnerships set up a research site. In some cases, the technical research can take the form of demonstration projects or green roof installations on prominent site, such as the green roofs on the Toronto and Chicago city halls. This step is very important for areas where the technology is novel as setting green roof policy needs local research data with outcomes that can be applied to any or all of the key motivators that have been prioritized.

In the technical phase, researchers investigate and quantify the benefits of green roofs in local contexts, which will become part of green roof policy and design guidelines. Research typically involves assessing the ability of green roofsto manage stormwater, mitigate the urban heat island, or provide other necessary environmental benefits.

Phase 5: Program and policy development

The green roof advisory committee may expand to include more professionals, such as landscape designers, horticulturalists, designers and municipal urban planners. This phase translates local and regional research into policy options and tools. This involves establishing ways of offering incentives to contractors, developers and building owners to retrofit or plan new buildings with green roofs. This can include financial incentives, tax credits or density bonuses. Chicago, Portland and Singapore are in this phase.

Phase 6: Continuous improvement

At this phase, a jurisdiction has achieved maturity and familiarity withgreen roof technology. Now, the jurisdiction assesses the effectiveness of policies and programs and decides whether to continue on the same path or explore other policy options. To gather information and assess program success, there must be a mechanism to collect and analyze constructive feedback from users, professionals and the building community. Phase 6 typically involves exploring other policy options or further research to fine-tune existing programs.

(Gail Lawlor, 2006)

Appendix 5

SITE VISIT TO SCANDINAVIAN GREEN ROOF INSTITUTE, AUGUSTENBORG SWEDEN

Figure 14: Different experimental vegetation plots at Augustenborg Rooftop Garden

Figure 15 PV cell and extensive green roof integration at Augustenborg, Sweden

Appendix 6

Examples of Green Roofs in Port of Spain, Trinidad

(Source: Hugh Schamber, Director, Weathershield Systems)

Figure 16 The National Library, Port of Spain, Trinidad and Tobago features green roof terraces.

Figure 17 The Hyatt Regency Hotel in Port of Spain with an accessible, modular rooftop terrace

Figure 18 RBC TT Bank in Port of Spain Trinidad, with an accessible elevated green terrace

Appendix 7

ADVERTISED CONTINUING PROFESSIONAL DEVELOPMENT SEMINAR ON GREEN ROOFS

April 2010
ICO2074

Anderson Monarflex | icopal

ICOPAL CPD SEMINAR OVERVIEW

Lightweight Green Roof Systems

CPD Seminar Content

- **Green Roofs globally**
- **Green Roof legislation**
- **What is a Green Roof?**
- **Extensive Green Roofs**
- **Intensive Green Roofs**
- **Benefits of a Green Roof**
- **Designing the right Green Roof: Key considerations**
- **Green Roof case study**

The Seminar provides an in-depth understanding of Green Roof systems and the various types available today. It provides an informative view on the global Green Roof market and the relevant legislation involved when planning and installing.

The Seminar highlights the key features and benefits of Green Roofs in terms of their environmental impact and details the key design considerations when selecting the right system along with the subsequent installation and maintenance involved.

A relevant case study will then be discussed to illustrate the key considerations in practice.

Additional Icopal CPD Seminars
It is essential to stay ahead in the fast-changing field of waterproofing. Who better than Icopal, the world leaders in construction membranes, to give you and your colleagues the edge.

We are happy to arrange seminars at convenient times, including lunchtimes and early evenings, with free refreshments provided. Every attendee to each seminar will also receive CPD certification.

CPD Seminars Also Available:

- Development of TPO Single Ply Roofing Membranes
- Structural Waterproofing – DPC Design & Detailing
- Development of Bituminous Waterproofing Membranes Including FireSmart & Flame Free Application
- Pitched Roofing Design & Detailing
- Geomembranes – Structural Gas & Water Protection

For more information on Icopal CPD Seminars simply complete and return the Fax-Back Form overleaf or email **cpd.uk@icopal.com**

Icopal Ltd
Barton Dock Road • Stretford • Manchester • M32 0YL • Tel: 0161 865 4444 • Fax: 0161 866 9859 • web: www.icopal.co.uk • email: cpd.uk@icopal.com

Figure 19 An example of a continuing professional development seminar on green roofs (Source: ICOPAL)

Appendix 8

Flood Event in Port of Spain AUGUST 11th 2012

Source: TRINIDAD EXPRESS ONLINE

http://www.trinidadexpress.com/photos/Torrential-rain-winds-and-flooding-linked-to-Tropical-Storm-Isaac-Thursday-August-23rd-2012

Figure 20: Flooding at the Brian Lara Promenade, Downtown Port of Spain

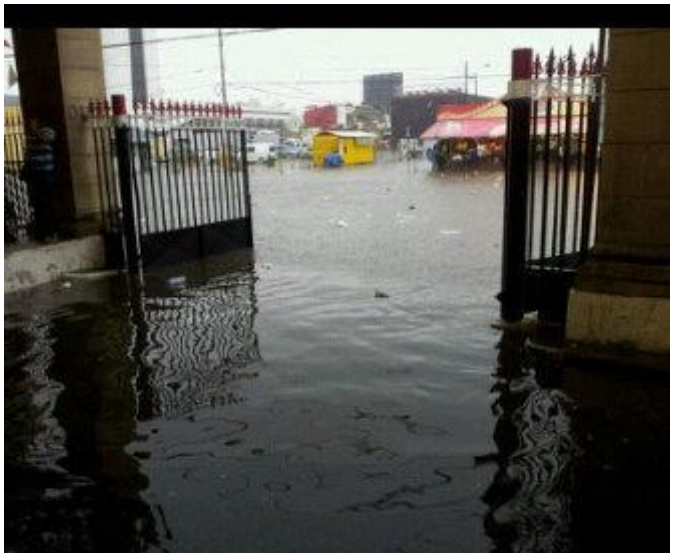


Figure 21: Flooding at City Gate, (Main Bus Terminal) Port of Spain

Figure 22: Flooding at Barataria, Greater Port of Spain Area

Figure 23 Effects of flash flooding in Diego Martin, Greater Port of Spain area

Figure 24 Rapid flow of floodwater downhill in Glencoe, Greater Port of Spain Are