BEYOND CLIMATE CHANGE THEORY: WHAT CONTRIBUTES TO THE ADAPTIVE CAPACITY OF CARIBBEAN SMALL ISLAND COMMUNITIES?

Jessica Jaja

Thesis submitted to
The Faculty of Graduate and Postdoctoral Studies
In partial fulfillment of the requirements for the degree of
Master of Arts in Geography with Specialization in Environmental Sustainability

Department of Geography
Faculty of Arts
University of Ottawa

ABSTRACT

The focus of this research is on identifying the determinants of local-level climate change adaptive capacity in Caribbean small island communities. A single case study approach was employed to assess retrospectively both internal and external factors that contributed to the adaptive capacity of Paget Farm, Saint Vincent and the Grenadines. The Caribbean region's first solar-powered desalination plant was implemented in the community specifically as a climate change adaptation strategy and thus provides an ideal case for retrospective analysis. A series of semi-structured interviews with local residents and key stakeholders revealed a number of interacting social and institutional factors that contribute to community-based adaptive capacity. Further analysis of institutional factors was undertaken using Social Network Analysis, which enabled visualization and quantification of vertical and horizontal institutional integration of the networks formed during different phases of project implementation. The research extends scholarly understanding of the determinants that influence local-level climate change adaptive capacity and provides practical evidence that can assist small island communities to respond to a changing climate.

RÉSUMÉ

Cette thèse vise principalement à identifier les déterminants liés à la capacité d'adaptation aux changements climatiques dans les petites communautés insulaires des Caraïbes. Une étude de cas unique a été utilisée afin d'évaluer, de façon rétrospective, les facteurs internes et externes qui contribuent à la capacité d'adaptation de la communauté de Paget Farm, à Saint-Vincent-et-les-Grenadines. Cette communauté est en fait le site de la première usine de dessalement de l'eau à énergie solaire dans les Caraïbes. L'usine de dessalement a spécifiquement été mise en place au sein de cette communauté comme stratégie d'adaptation face aux changements climatiques et, par le fait même, constitue un cas idéal pour une analyse rétrospective. Une série d'entrevues semi-structurées avec des résidents locaux et des intervenants clés a révélé qu'un nombre de facteurs sociaux et institutionnels interagissent et influencent la capacité d'adaptation de la communauté. Un examen plus approfondi des facteurs institutionnels a été mené par l'entremise d'une « analyse des réseaux sociaux ». Ceci a permis la visualisation et la quantification des niveaux d'intégration verticale et horizontale des réseaux institutionnels formés durant les différentes phases de la mise en œuvre du projet d'usine de dessalement de l'eau. Cette recherche améliore la compréhension académique des déterminants qui influencent la capacité d'adaptation au niveau local et offre des exemples pratiques qui pourraient permettre aux petites communautés insulaires de s'adapter aux changements climatiques.

ACKOWLEDGEMENTS

This thesis would not be possible without the support of many individuals. First, I would like to acknowledge my supervisor, Dr. Jackie Dawson, for giving me the assistance and guidance needed to accomplish the overwhelming task of a Master's degree. Thank you, Jackie, for your guidance throughout my social sciences adaptation process (I could not study adaptive capacity without some adaptation of my own!). I much respect you and your work, and I am very grateful for the opportunities you have given me.

I would also like to thank my committee members, Dr. Daniel Lane and Dr. Eric Crighton, for their involvement. Dan, I appreciate all your assistance and support. I was honoured to be involved in the Coastal Change project and I thank you for the opportunity. The experience led me to connecting with community leaders, researchers and students—but really I should say friends—working on climate change adaptation in Canada and the Caribbean. Eric, thank you for your support and encouragement, and for my introduction to Human Geography and Environmental Studies during my undergraduate degree (although you may not remember!). Also, a very special thank you to Joanne Gaudet for the many times we met over coffee and for offering your insights into the world of Social Networks. I am very appreciative of your unwavering support and optimism.

I would like to express my sincere gratitude to those in Saint Vincent and the Grenadines who made my stay so enjoyable and enriching, and specifically to all the research participants who contributed to my Master's study. Your willingness to open the doors to your homes and offices, to take time out of your lives to assist me, and to trust me enough to share your experiences are truly appreciated and valued. A special mention must be made to the community of Paget Farm and all the residents of Bequia. I have made many friends, shared many laughs,

and always felt welcome on your Island of Cloud. I must acknowledge the wonderful Mrs. Clerise Derrick for your help and support during my time on Bequia. Thank you for offering me a home, the delicious meals we shared and most importantly, your friendship. A most sincere thank you to Mr. Herman Belmar and his family, Leah, Yasa, Jay, and Jose. Herman, not only did you accept to facilitate my project openly and willingly, but you taught me many invaluable lessons through your wisdom, perseverance and local knowledge. Leah, thank you for the many dinners and conversations… and all the cassava and avocados! Yasa and Jay, thank you for your hospitality while on mainland and for the karaoke nights (Jay—you've got skills!). Jose, thank you for all the laughs and teaching me to sail. Let's just say you have more patience than most!

Thank you to all my Ottawa friends who endured me over the past two years. Shany and Renée, thanks for always being by my side and forgiving me for not being as present as I should have been. Reiko, you have been an incredibly supportive, loving friend and roommate. I close this chapter of my life with many memories, many shared with you. LARC, I have learnt and continue to learn so much from you. Thank you for believing in me and always pushing me to strive for the best. Tarek and Hanna, I don't think I would have finished this thesis without our many writing sessions in coffee shops! And of course to all my Geography friends and colleagues—I know I was often late for Friday Drinks but I always loved them, and your company.

Lastly, my roots. Dad, Mom, Fred, Chris, Marie, and Kristen—you inspire me every day and I am so lucky to call you my family. I would not be where I am today without your continued support. Et ne pensez pas que je vous ai oublié: Jasmine et Dalia, mes nièces que j'adore, vous êtes une joie incroyable dans ma vie, et une source d'amour et d'énergie incontournable. Bisous xo

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

This thesis adheres to an article-based thesis format and consists of an introductory chapter, two research papers in preparation for submission to peer-reviewed journals, and a concluding chapter. The introductory chapter outlines the research objectives and a literature review, while the concluding chapter provides a summary of the findings, research contributions, limitations, and suggestions for future research. The research also resulted in the publication of a book chapter that presents a preliminary analysis and theoretical discussion of the usefulness of engaging in retrospective case studies to better understand climate change adaptive capacity at a local level (see Jaja & Dawson 2014)[1]. The interview guides, survey questionnaires, list of institutions involved in the research, recruitment poster and research ethics approval are provided in Appendices A through F.

As a Master's candidate, I took primary responsibility for the entire research process. In consultation with my advisor I conceptualized the project; developed the interview guides and survey questionnaires; conducted, transcribed and coded the qualitative data; collected and analyzed the quantitative data; and wrote the manuscripts. The thesis project received approval from the University of Ottawa's Research Ethics Board (File number #05-13-19; Appendix F), and all interviews were conducted with the prior and informed consent of participants. The research was funded by the Social Sciences and Humanities Research Council (SSHRC) Joseph-Armand Bombardier Canada Graduate Scholarship (766-2013-0855), the Ontario Graduate Scholarship (OGS) program, and the Laboratory for Environment, Society, and Policy (www.espg.ca).

[1] Note that the book chapter is not included as part of this thesis submission.

CHAPTER ONE

INTRODUCTION

> From now on, we will no longer be content to shout about the perils of climate change. Instead, we believe our acute vulnerability provides us with the clarity of vision to understand how the problem can be solved; the objectivity to say that it is in all of our interests to aggressively pursue that solution; and the courage and determination to lead by example by walking the path ourselves.
>
> - Mohamed Nasheed, Former President of the Maldives (UNFCCC 2009)

1.1 Project overview

This study investigates the internal (i.e. local) and external (i.e. non-local) factors that contribute to the ability of Caribbean small island communities to adapt successfully to climate change. The research draws on mixed-methods and is undertaken in the coastal community of Paget Farm located in Saint Vincent and the Grenadines. The case study was selected since it is the site of the first solar-powered desalination plant in the Caribbean region, which was implemented specifically as a climate change adaptation strategy in the community. This provides an ideal analogue to assess the factors that facilitated and enhanced local-level adaptive capacity in a retrospective manner. Past research on the topic of community-based adaptive capacity have utilized community case studies to speculate effective climate change adaptation strategies (e.g. Ford et al. 2006; Ford & Goldhar 2012—also see section below on 'Research gaps'). Therefore this study advances understanding of the determinants of adaptive capacity through its focused analysis of a community that is known to have already adapted to climate change. Thus, the overarching aim of the study was to identify and assess the interacting factors (i.e. determinants) that have facilitated and enhanced local-level adaptive capacity in Paget Farm. The specific objectives of the study include to:

1. Trace the development and implementation of the climate change adaptation project in Paget Farm (historical context);
2. Generate an inventory of institutions and project stakeholders involved in the Paget Farm project implementation;
3. Identify the relative importance of internal and external factors contributing to project development and process;
4. Assess the role of institutional networks in influencing project implementation.

Data collection included the use of qualitative and quantitative methods employed between May and September 2013. In-person semi-structured interviews were conducted with local residents of Paget Farm and key informants representing institutions involved in the implementation of the desalination plant, including: national government ministries, private companies, not-for-profits, regional organizations (i.e. supranational in the context of the Caribbean region), and international funding agencies (see Appendix D). Qualitative data were analyzed to identify and assess the factors perceived as critical to the completion of the desalination plant and to the enhancement of local-level adaptive capacity. An institutional network survey was also undertaken with key informants to examine quantitatively the relative importance of relationships that exist between institutions involved in the different phases of the desalination plant project (i.e. pre-project, planning, development, operational and post-project). Using Social Network Analysis, a powerful and relatively new technique in social science research, the levels of vertical (i.e. cross-scale) and horizontal (i.e. cross-sector) integration of the networks of institutions were visualized and examined including an analysis of how institutional relationships changed over time. This analysis allowed for conclusions to be made

about the importance of institutional factors in contributing to community-based adaptive capacity.

The study contributes to a limited but growing body of literature on the social and institutional determinants of local-level climate change adaptive capacity, with an emphasis on small island communities of the Caribbean region. The study is among the first to use a retrospective, versus speculative, case study approach to examining factors that can enhance climate change adaptive capacity. The research also sought to embed external (i.e. non-local) forces, drivers and processes that influence local-level adaptive capacity directly within its methodological framework. The community of Paget Farm was particularly ideal to assess these multi-scalar dynamics since a range of actors and institutions operating at different scales were involved in the implementation of the solar-powered desalination plant—a project specifically implemented to address a locally identified impact of climate change. Finally, the research contributes to a growing consensus on the usefulness of applying a SNA lens to understanding how institutional networks influence adaptive capacity. It further provides a more detailed, fine-grained analysis and understanding of the dynamic nature of institutional networks through the incorporation of temporality.

1.2 Justification of the research approach: defining successful climate change adaptation

Considering that the premise of this retrospective case-study based research is founded on the distinction that Paget Farm's desalination plant is indeed representative of a "successful" adaptation process, it is important to clarify the meaning of "success". Doria et al. (2009) used a variant of the Delphi technique to elicit expert opinion, and defined "successful" climate change adaptation as "any adjustment that reduces the risks associated with climate change, or

vulnerability to climate change impacts, to a predetermined level, without compromising economic, social, and environmental sustainability" (p. 815). Nonetheless, they stress the following three caveats: (1) Success is a subjective concept; (2) the predetermined level will vary for every adaptation strategy; and (3) sustainability is deliberately undefined, referring to either weak or strong sustainability.

The United Nations Framework Convention on Climate Change (UNFCCC 2010) specifies that an adaptation strategy is considered successful if outcomes and outputs meet expressed objectives. Accordingly, success could be determined by how well a strategy contributes to reducing the vulnerability of a system to a given climate change stressor. However, Adger et al. (2005) argue that it is not sufficient to determine success based solely on effectiveness for two reasons: it may not take into account externalities at other spatio-temporal scales, and benefits for the targeted agents may produce negative impacts for other systems, therefore reducing the latter's adaptive capacity. They maintain that success should thus be evaluated on: (1) effectiveness; (2) efficiency; (3) equity; and (4) legitimacy.

The efficiency of an adaptation strategy takes into account the costs of adapting relative to the benefits obtained, requiring an assessment of the distribution of market and non-market costs and benefits, and the temporal scope of the strategy. Assessing adaptation equity includes an evaluation of the perceptions of the outcome and the decision-making process, while legitimacy refers to the social acceptability of the adaptation strategy by those affected by the outcome, both at the community and decision-making levels (Adger et al. 2005). Failing to consider effectiveness, efficiency, legitimacy and equity when implementing an adaptation strategy can lead to maladaptation, in which case the strategy may inadvertently increase the vulnerability of target and/or non-target systems (McCarthy et al. 2001).

While a full assessment of the level of success of the solar-powered desalination plant in Paget Farm is not included within this thesis, it informed a book chapter on climate change management in Latin America and the Caribbean (see Jaja & Dawson 2014). This assessment was undertaken using the four criteria of successful adaptation outlined above by Adger et al. (2005). With regards to effectiveness, the majority of research participants perceived the plant as providing a safe, reliable and adequate supply of water to the community during subsequent periods of drought. Efficiency was determined through the review of an in-depth study examining a range of non-conventional water sources for the Paget Farm community. The study concluded that a desalination system was the most suitable option on the basis of financial viability, social acceptance, environmental integrity and technical abilities (Greaves 2012). Also in terms of effectiveness, the photovoltaic system produces more energy than the desalination plant requires operating at full capacity and although better measures could be put in place, there did not seem to be a significant overconsumption of the water.

As for the legitimacy of the desalination plant, local residents and key informants almost unanimously approved of the project and saw its value in terms of addressing water scarcity on the island. However it is important to highlight that although local residents interviewed accepted the project as a source of water for general domestic use, over half of the participants did not view the water produced as a legitimate source of drinking water. Lastly, the adaptation strategy appears to be equitable. At the time of study the water was being provided at no cost to local residents and appeared to be accessible to all members of the community. Despite the local-level perception and skepticism that exists with respect to consumption, the project was determined to be successful overall since it provides an alternative source of water for local residents and dramatically increases freshwater availability in a community previously reliant

almost exclusively on rainwater collection. It is difficult to determine if perceptions will change over time, but this examination of project legitimacy highlighted the importance of considering values, customs and traditions, and the appropriateness of adaptation strategies in any local community.

1.3. Research context and overview of relevant literature

Climate change is arguably the most complex, severe threat that our global society faces in the 21st century (IPCC 2014a). While the impacts increasingly permeate all social systems, they are not distributed evenly nor do all systems have an equal ability to adapt to the changes (Adger et al. 2003; Brooks & Adger 2005). Although remote small island communities of the Caribbean region have contributed only a small amount of the global greenhouse gas emissions that cause anthropogenic climate change, they are disproportionately vulnerable to the associated impacts (IPCC 2014b). This vulnerability stems from complex interactions between physical, economic, and socio-institutional factors that can result in acute exposure to climate change stressors, high sensitivity to the impacts, and a low ability to adapt to the changes (Smit & Pilifosova 2003; Füssel & Klein 2006). The following subsections provide an overview of climate change vulnerability in the Caribbean region; climate change adaptation; and the social and institutional determinants of adaptive capacity.

1.3.1. Climate change vulnerability in the Caribbean region

Caribbean small island communities are among the most exposed to the impacts of climate change globally (IPCC 2014b). Sea-level rise is one of the most widely recognized threats and has increased over much of the 20th century at a rate between 1.3 to 1.7 mm per year and since

1993, between 2.8 and 3.6 mm per year (Merrifield et al. 2009; Church and White 2011). In small islands, this increase is linked to the erosion of beaches and the destruction of coastal infrastructure as well as the intrusion of saltwater into freshwater aquifers and the bleaching of coral reefs (Nicholls & Cazenave 2010). In addition, ocean acidification caused by climate change is further contributing to the loss of coral reef systems; the natural barriers of local communities from hurricanes and tropical storms (Manzello et al. 2010). These extreme weather events, among others, are themselves expected change in frequency and intensity, and shift to areas previously less exposed to the associated impacts (IPCC 2012). Hurricane Ivan, which hit the Caribbean region in 2004, exemplifies the potential impacts of climate change as it relates to extreme weather events. Hurricane Ivan was the 10th most intense Atlantic hurricane ever recorded and left US$800 million (200% of GDP) in damages in Grenada alone. While Grenada was previously considered outside the Caribbean's Hurricane Belt, a second hurricane hit the country only 10 months later (AOSIS 2008).

In many small island communities of the Caribbean however, the most pressing issues resulting from climate change is the availability of freshwater (Mimura et al. 2007; Durrant, Nurse & Stoddard 2008). In addition to sea-level rise and extreme weather events such as storm surges contaminating underground aquifers, rainfall records averaged for 100 years (1900-2000) have shown a consistent reduction of 0.18 mm per year—a trend that is expected to continue (Jury and Winter 2010). Increasingly severe droughts and flash floods further threaten freshwater availability, both in terms of quality and quantity, such as the 2009-10 drought during which communities of the Eastern Caribbean experienced nearly 10 months without significant rainfall (Farrell, Trotman & Cox 2010). These impacts of climate change are occurring in some of the most water-scare communities of the world (WRI 2013) and are affecting the already limited

amount of freshwater available for agricultural purposes, household and community-use, and the replenishment of groundwater supplies (Jury & Winter 2010). The combined impacts of climate change to the Caribbean region are estimated to amount to $22 billion by 2050 (Bueno et al. 2008), representing 7% of the region's current cumulative GDP[2].

The sensitivity to the impacts of climate change in the Caribbean is increased by the inherent geophysical constraints of remote small islands, such as scarce resources, lack of economies of scale, susceptibility to natural disasters, remoteness from large markets, high costs for transportation, communications and energy, and a dependence on international trade (UNFCCC 2005). In addition, small island communities are also faced with concerns common to many developing countries, including income inequality, high unemployment, economic stagnation, and weak education and health institutions (Mimura et al. 2007). Climate change vulnerability is high in small island communities because of the acute exposures to climatic stressors and the generally high sensitivity to these stressors. However this vulnerability can be reduced through the development of effective adaptation strategies that minimize local-level risks, maximize benefits, and therefore enhance local-level adaptive capacity (Smit & Wandel 2006; Mimura et al. 2007; also see Figure 1).

[2] Author's calculations. Percentages based on 2011 GDP of the 25 Caribbean countries and dependent territories (or most recent figures available) listed in Bueno et al. (2008).

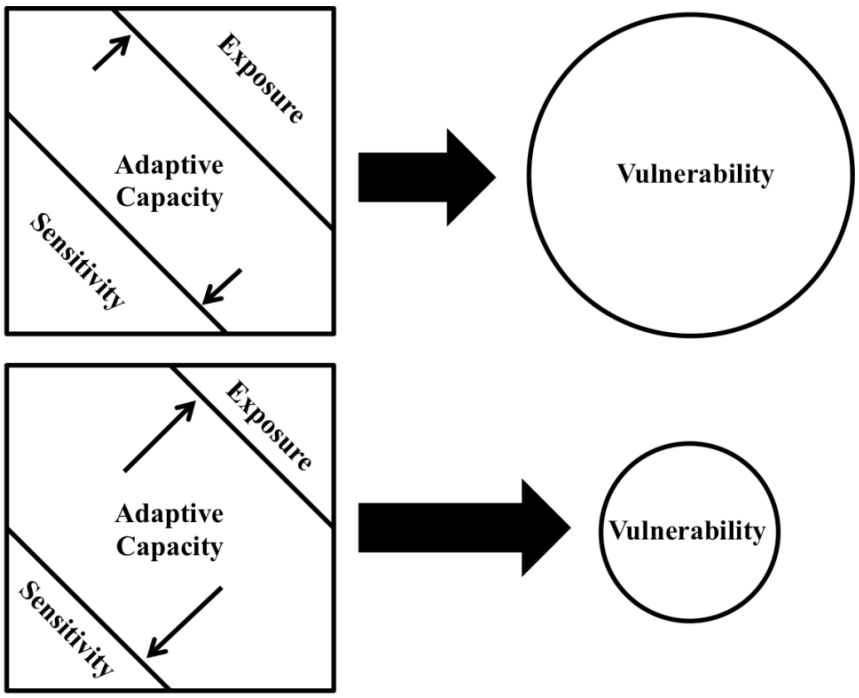

Figure 1. A conceptual representation of the link between climate change adaptive capacity and vulnerability (adapted from Engle 2011).

1.3.2. Climate change adaptation and adaptive capacity

Efforts to adapt to climate change have increased in recent years given the profound climatic transformations that confront Caribbean small island communities. (Pielke et al. 2007; Arnell 2010; IPCC 2014b). Climate change adaptation refers to a system's (e.g. local community) adjustment in response to actual or predicted climate stimuli and their impacts, undertaken to moderate harm, or exploit beneficial opportunities (McCarthy et al. 2001). Examples of adaptation can include soft measures such as institutional reforms, incentives for better resource management, and education about the risks and response options. They can also include hard measures such as mangrove restoration and rainwater harvesting initiatives to the construction of seawalls and desalination plants. A foundational concept in climate change adaptation research is adaptive capacity, which refers to the ability of a system to prepare for and adjust to climate

variability and change (Smit et al. 2001). In practice and in the context of this study, adaptive capacity is the overall ability of a local community to design, develop and implement successful adaptation strategies (Brooks & Adger 2005). Adaptive capacity has gained limited but growing research interest since, unlike exposure and sensitivity, it is a positive system property that decreases climate change vulnerability exclusively through human actions (Eakin & Luers 2006). Because the adaptive capacity of local communities is unequal within and beyond the Caribbean region, it is important to better understand the factors that facilitate or hinder the development of high adaptive capacity (Engle 2011).

The literature on climate change adaptation lists several different determinants of adaptive capacity, which commonly fall within the following categories (e.g. Smit et al. 2001; Smit & Pilifosova 2003; Engle 2011):

- Economics;
- Technology;
- Infrastructure;
- Information and skills;
- Institutions;
- Social capital and networks; and
- Equity.

Economics, technology and infrastructure have long been heralded in popular discourses and within governments and the private sector as the panaceas of climate change adaptation. While factors such as the availability of adaptation funds (Adger et al. 2004); research and development investments (Niang-Diop & Bosch 2004); and the quality of basic infrastructure (Brooks et al. 2005) have been shown to be of importance, they have not always been sufficient or necessary for successful adaptation in small island communities (Moss et al. 2001; Huq et al. 2005; Barnett 2008; Nunn 2009). For example, a widespread strategy to adapt to rising sea levels is the construction of seawalls. While the initial construction is typically funded by external donor

agencies, it is common for no financial and technical resources to be provided beyond project completion (Nunn 2010). After a few years, seawalls start to breakdown and require general maintenance that requests specialized skills and knowledge. If communities are unable to solve this issue, whether through financial or other resources, they may experience a reduction in adaptive capacity to an equal or lower level than prior to the implementation of the original adaptation strategy/project (e.g. Kumar 2007; Nunn 2010). This example illustrates that while economic, technical and infrastructural factors (i.e. including information and skills) may contribute to adaptive capacity, there is an increasing need for research that assesses underlying institutional and social determinants (O'Riordan & Jordan 1999; Young 2002; Gupta et al. 2010; Keskitalo 2010; Dixit et al. 2012).

1.3.3. Institutional and social determinants of adaptive capacity

Institutions, including their structure, function and capacity, influence processes of adaptation by guiding the behaviour of agents and shaping the social, economic and political decisions by actors at all scales (Huq et al. 2005; Williamson et al. 2012). In the context of this research, institutions refer to formalized entities with designed patterns of rules and decision-making. They include but are not limited to local community-based groups, national government ministries, private companies, not-for-profits, and international agencies. Institutions are typically governed by formal rules, laws and regulations, and informal sets of values, norms and traditions that shape expectations and guide actions they undertake (Ostrom 1990; Young 2002; Gupta et al. 2010). It is noted that although there are distinct differences between the terms 'organization' and 'institution' as highlighted in other research fields (see Young 2002), the use of the latter within this thesis can be used interchangeably with the former in keeping with

existing literature in the field of climate change adaptation (e.g. Agrawal 2008, Engle & Lemos 2010; Dixit et al. 2012). It is increasingly recognized that certain institutional determinants play a critical role in determining a community's ability to adapt, including the level of political, technological and financial support from higher levels of governments (Chang & Desai 2001); decision-making ability (Brooks & Adger 2005); the role of state and non-state actors (Pahl-Wostl 2009); and the complexity and diversity of governance regimes (Folke et al. 2005). Institutions that promote greater flexibility and encourage spontaneous and autonomous institutional change appear to display higher adaptive capacity since they may better enable society to adapt fast enough to contemporary environmental and climate change (Gupta et al. 2010). It is critical to highlight that adaptive capacity is not only influenced by the strengths of individual governing institutions but also by the relationships that exist between them (Keskitalo 2010). While very few empirical studies exist, the importance of institutional integration has been suggested—which refers to the vertical (i.e. cross-scale) and horizontal (i.e. cross-sector) linkages between institutions—has been suggested (see for example Olsson et al. 2004; Davies 2005; Ingold et al. 2010; Ingold 2014).

There has been a rise in research on the role of social determinants of adaptive capacity (Adger et al. 2007; Moser & Ekstrom 2010, IPCC 2014a). Values, perceptions, customs, traditions and social capital appear to play a significant role in determining the ability of a system to adapt to climate change (Grothmann & Patt 2005; Adger et al. 2007). Examples of social factors contributing to successful adaptation include: strong social networks, a sense of communal responsibility, access to and participation in decision-making processes, effective local community leaders, informal non-monetary arrangements, high levels of trust between community members, access to risk-spreading mechanisms, and in-depth local ecological

knowledge (e.g. Brooks & Adger 2005; Tompkins 2005; Eriksen & Kelly 2007). It is also widely recognized that systems in which social, cultural and political conditions equitably distribute power and access to resources have higher adaptive capacity (Smit & Pilifosova 2003). As with similar social interaction theories, Adger (2003) maintains that collective action required to adapt to climate change is dependent on the flows of information between individuals and institutions. He argues that some groups may be less vulnerable to climate change than modeling studies suggest since many aspects of adaptive capacity reside in these social networks.

1.4. Research gaps

There are three major gaps in the current literature on local-level adaptive capacity that are addressed within this thesis research. First, much of the empirical research conducted thus far has addressed adaptive capacity at the local scale in isolation, failing to consider the influence of external, non-local determinants (e.g. Sutherlands et al. 2005; Allen 2006; Dumaru 2010). It is recognized that climate change adaptation is a localized phenomenon, meaning that the ability of a system to adapt to the impacts of climate change that are locally manifested is reflective of the physical, social, economic and political realities of the local context (Brooks & Adger 2005). It can therefore seem logical to assess the determinants of adaptive capacity uniquely at this scale. However, this focus is limited in its usefulness in that local-level adaptive capacity is almost always influenced by factors operating outside the local sphere (Smit & Pilifosova 2003; Smit & Wandel 2006; Adger et al. 2007). A household's ability to adapt is dependent on the enabling environment of the community, which itself is reflective of the conditions and processes that exist within the state and so on (Smit & Pilifosova, 2003). While the local scale is often considered the most appropriate scale at which to conduct adaptation research, it must also be reflective of broader forces, drivers and determinants that contribute to the ability of local

communities to respond to climate change (Smit & Wandel 2006; Wesche & Armitage 2010, Cameron 2012).

Second, much of the existing research on the determinants of local-level adaptive capacity involve community case studies that were assessed prior to the implementation of specific adaptation strategies. This results in a speculative approach to any assessment of adaptive capacity because of its latent nature, which makes its determinants difficult if not impossible to assess until a community has mobilized and adapted to climate change (Engle 2011; Williamson et al. 2012). While many challenges to successful adaptation lie ahead, institutions and actors are actively and increasingly developing strategies that address climate change impacts in small island communities. These adaptation strategies are manifestations of adaptive capacity (Smit & Wandel 2006) and provide us with important opportunities to study internal and external factors that contribute to their "successful" completion.

Third, there has been a lack of empirical research investigating the role of institutional networks and climate change adaptive capacity. Institutional networks are challenging to study because they represent intangible formal and informal relationships that exist between spatial scales and sectors (Adger 2003). In addition, these institutional networks are not static but rather evolve over time. These changing interactions simultaneously affect the structure of the overall network, which further shapes the types of interactions that are possible between institutions (Doreian 2001). The use of powerful and relatively new software tools such Social Network Analysis (SNA) can help assess and understand how relationships between institutions contribute to local-level adaptive capacity by not only visualizing but also quantitatively examining their interactions.

1.5. Organization of the thesis

This thesis follows an article-based format and consists of four chapters including this first introductory chapter, which provides an overview of the literature guiding this research. The following two chapters are articles that address the research objectives by presenting empirical results. Chapter Two uses a qualitative case study approach based on semi-structured interviews with key informants and local residents of Paget Farm to assess internal and external factors that seem to contribute to successful climate adaptation in the Caribbean (Objectives 1, 3). Chapter Three uses SNA to delve more deeply into the role of institutional networks in the adaptive capacity of Caribbean small island communities. Specifically, the paper visually and quantitatively evaluates the level of integration within the network of institutions involved in the desalination plant project over time (Objectives 2, 4). Chapter Four concludes by summarizing the main findings of the two articles, discussing the contributions of the study, and presenting limitations and suggestions for future research.

CHAPTER TWO

Climate change in retrospect: Assessing the determinants of adaptive capacity in Caribbean small island communities

Jessica Jaja[31]

Manuscript in preparation for submission to the journal *Regional Environmental Change*

[1] *Department of Geography, University of Ottawa, ON, Canada*

Abstract

Small island communities of the Caribbean region are among the most vulnerable to the impacts of climate change globally. While local communities are faced with responding to the acute exposures of climate change and tend to be highly sensitive to the associated impacts, successfully developing adaptation strategies can minimize risks, maximize beneficial opportunities, and ultimately decrease vulnerability. In light of the increasing number of local-level adaptation projects in the region, great potential exists to study the determinants (i.e. factors) that facilitated and enhanced the adaptive capacity of these communities, which increases through project implementation. Using qualitative, semi-structured interviews with key informants and local residents, this paper presents the identified and retrospectively assessed internal and external factors that influenced the implementation of the Caribbean region's first solar-powered desalination plant in the community of Paget Farm, Saint Vincent and the Grenadines. The findings of this research reveal the importance of a number of institutional and social factors that can help build on internal strengths of small island communities and take advantage of external opportunities to implement sustainable strategies that address climate change impacts.

Keywords

Climate change, adaptive capacity, determinants, Caribbean, small island communities

2.1. Introduction

Remote island-based communities of the Caribbean region are among the world's most vulnerable to climate change. This vulnerability stems from complex interactions between physical, economic, and socio-institutional factors that result in their acute exposure to climate change stressors, high sensitivity to the impacts, and generally low adaptive capacity to respond to the changes (Smit & Pilifosova 2003; Füssel & Klein 2006). In many local communities, the most pressing issue linked to climate change is the availability of freshwater (Mimura et al. 2007; Durrant, Nurse & Stoddard 2008). From intense droughts to flash floods, communities are exposed to extremes in rainfall variability that can reduce the already limited amount of freshwater available for agricultural purposes, household and community-use, and the replenishment of groundwater supplies (Jury & Winter 2010). In addition, sea-level rise and extreme events such as storm surges are contributing to the saltwater intrusion of underground aquifers, which can result in brackish waters unfit for human consumption. These and other disproportionate impacts of climate change are expected to further exacerbate challenges that arise from common characteristics and constraints of small islands, such as: scarce resources, lack of economies of scale, susceptibility to natural disasters, remoteness from large markets, dependence on international trade, and the high costs for transportation, communications and energy (UNFCCC 2005; Mimura et al. 2007). While local communities are faced with the compounding impacts of climate change and the pre-existence of sustainable development concerns, successfully developing adaptation strategies and policy options can minimize risks, maximize beneficial opportunities, and ultimately decrease vulnerability.

Climate change adaptation through the implementation of adaptation strategies has increased significantly in Caribbean small island communities in recent years (Medeiros et al.

2011). Adaptation refers to a system's (e.g. local community) adjustment in response to actual or predicted climate stimuli and their effects, undertaken to moderate harm, or exploit beneficial opportunities (McCarthy et al. 2001). Examples of adaptation strategies include soft measures such as institutional reforms, incentives for better resource management, and education about the risks and response options. They can also include hard measures such as mangrove restoration and rainwater harvesting initiatives to the construction of seawalls and desalination plants. Intimately connected to climate change adaptation is adaptive capacity, which represents the ability of a system to prepare for and adjust to climate variability and change (Smit et al. 2001). In practice and in the context of this paper, adaptive capacity is the overall ability of a local community to design, develop and implement successful adaptation strategies (see Brooks & Adger 2005). According to Adger (2005), successful adaptation strategies—which can lead to enhanced local-level adaptive capacity—tend to be effective, efficient, equitable and legitimate (see Jaja & Dawson 2014 for additional details defining successful climate adaptation). Since the response of Caribbean small island communities to climate change varies in terms of success, it is important to identify the factors that contribute to the development of a community's high adaptive capacity.

Several studies have attempted to identify the determinants of adaptive capacity (e.g. Adger 2003; Wesche & Armitage 2010; Engle 2011; IPCC 2014b). Commonly identified factors contributing to successful adaptation lie within the following categories: economics, technology, infrastructure, information and skills, institutions, social capital and networks (e.g. Smit et al. 2001; Smit & Pilifosova 2003; Engle 2011). Since the Intergovernmental Panel on Climate Change's Fourth Assessment Report, research has increasingly highlighted the importance of institutional and social dimensions in enhancing local-level adaptive capacity (e.g. Moser &

Ekstrom 2010; Wesche & Armitage 2010; Engle 2011; IPCC 2014b).

Institutions are defined as formalized entities with designed patterns of rules and decision-making (Agrawal 2008; Engle & Lemos 2010; Dixit et al. 2012). They typically have formal rules, laws and regulations and informal sets of values, norms and traditions that shape expectations and guide actions undertaken by actors (Ostrom 1990; Young 2002; Gupta et al. 2010). Institutions are seen to influence processes of adaptation by structuring the behaviour of agents and shaping the social, economic and political decisions by actors at all scales (Huq et al. 2005; Williamson et al. 2012). Institutional factors have been shown to play a critical role in influencing adaptive capacity via decision-making ability, political, technological and financial support from higher levels of governments, the role of state and non-state actors, and the complexity and diversity of governance regimes (e.g. Chang & Desai 2001; Folke et al. 2005; Pahl-Wostl 2009; Gupta et al. 2010). Social factors, including values, perceptions, customs, traditions and social capital, have also been identified as playing a significant role in determining the ability of a system to adapt to climate change (Grothmann & Patt 2005; Adger et al. 2007). Examples of social factors identified as contributing to adaptive capacity include strong social networks; a sense of communal responsibility; access to and participation in decision-making processes; effective local community leaders; informal non-monetary arrangements; high levels of trust between community members; access to risk spreading mechanisms; and in-depth local ecological knowledge (e.g. Klein & Smith 2003; Brooks & Adger 2005; Tompkins 2005; Eriksen & Kelly 2007; Pelling 2011).

While there have been increases in our understanding of the social and institutional determinants of local-level adaptive capacity, there are two major limitations in the existing

literature. First, much of our current knowledge has been generated from community-based adaptation case studies (IPCC 2014b), and although these efforts represent positive strides in the field over the past several years, they do not adequately illustrate the complexities of local-level adaptive capacity. This oversimplification occurs when research does not situate communities within the multiple and interacting factors and conditions operating at different scales that may limit or facilitate adaptive capacity (Cameron 2012). While it is acknowledged that adaptation is a localized phenomenon, systems at the local scale do not operate in isolation of but are rather nested within national, regional (i.e. supranational in the context of the Caribbean region) and international systems (Smit & Pilifosova, 2003; Adger, Eakin & Winkels 2008; Pelling 2011). It is therefore critical for empirical research to not only acknowledge or pay lip service to the importance of considering multiple scales, but also to reflect the broader forces, drivers and processes that facilitate and enhance local-level adaptive capacity directly within methodological frameworks and approaches (Wesche & Armitage 2010; Cameron 2012).

Second, much of the existing research identifying the factors that contribute to successful climate adaptation have involved community case studies and other approaches that were employed prior to the implementation of a specific adaptation program. As a result, they are largely speculative versus investigative in nature. This presents significant limitations because of the latent nature of adaptive capacity; referring to it only being visible when a system is exposed to actual climate change impacts and therefore making its determinants difficult if not impossible to identify and measure until a community has adapted (Smit et al. 2001; Engle 2011; Williamson et al. 2012). However we are now at a time where international-scale attention to the issue of climate change has influenced a significant increase in the amount of funding available for adaptation projects globally (UNFCCC 2014). These projects are in many places now fully

operational and in certain cases making significant differences in communities (Medeiros et al. 2011). The increased presence of communities that have "successfully" adapted to climate change (see Jaja & Dawson 2014) now provides us with important opportunities to study determinants retrospectively.

The Caribbean small island community of Paget Farm located on the island of Bequia (pr. Bek-way) in Saint Vincent and the Grenadines was used in this research as a case study to examine retrospectively social and institutional factors that seem to contribute to the successful implementation of climate adaptation projects and strategies. While climate change can have significant effects at the national and regional scales, it is the local communities that are at the forefront of change and it is at this scale that impacts are felt most intensely (Brooks & Adger 2005). In this research, a community case study was employed while also considering multi-scale factors that could influence local-level adaptive capacity. Paget Farm represents an ideal analogue for understanding the multiple and interacting factors that influence local-level adaptive capacity since it is the location of the Caribbean's first carbon-neutral desalination plant, which was implemented by actors and institutions at multiple scales as a direct strategy to adapt to climate change. The following sections of this paper present an overview of the case study context, followed by methods, results and discussion, and concluding remarks.

2.2. Case study background

Paget Farm is located on the 18 square kilometer island of Bequia in Saint Vincent and the Grenadines, a Caribbean Small Island Developing State west of Barbados and south of Saint Lucia (Figure 1). The predominantly fishing community of approximately 750 individuals of mixed African, Scottish and Carib Indian descent is located on the southwest coast near the

island's airport. As explained by a local resident of Paget Farm, community dynamics are intricately linked to the sea:

> A lot of the people on this side depend on the sea for their livelihood. Not just fishing, we do whaling which is indigenous to us and seafaring like going sailing and cruise ships, bulkcarriers […] so this side of the island, Paget Farm, depends a lot really on the sea.

Paget Farm's local economy has been significantly impacted by the recent loss of the country's seafood export rights to the European Union in 2004, which consequently prohibits the sale of products to their main market in Martinique (Staskiewicz & Mahon 2007). In addition to the small-scale and subsistence fishing activities that remain, tourism represents the primary source of income and employment for many in the community as well as the island's 5,389 inhabitants (Statistical Office 2001). Paget Farm is the largest of the 14 communities living on the island, and residents often self-describe as "community-spirited" and "friendly" people.

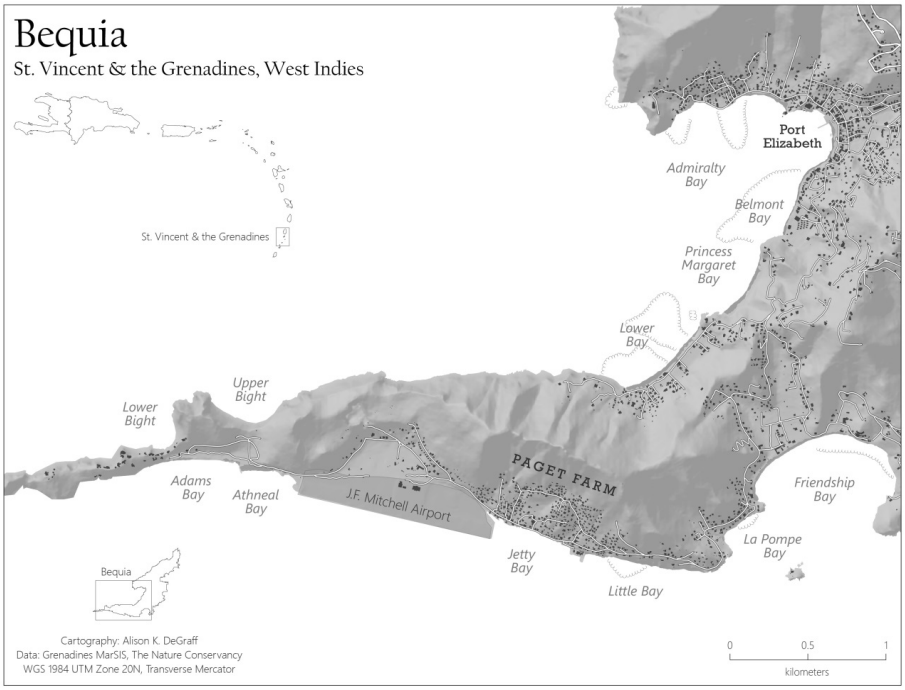

Figure 1: Map of the community of Paget Farm and the southwest coast of Bequia with the entire island (bottom left) and the Eastern Caribbean (top left) shown as insets. Map courtesy of Alison K. DeGraff using spatial data from Grenadines MarSIS and The Nature Conservancy.

With no surface waters and very limited groundwater resources to support local residents, let alone a tourism or fisheries industry, Bequia is one of the most water-scarce islands in the world (Durrant, Nurse & Stoddard 2008; WRI 2013). Before the desalination plant was in operation, households in Paget Farm relied almost exclusively on rooftop-collected rainwater for domestic use and were not serviced by a public distribution system. The water was, and still is, collected in tanks of various holding capacities that can amount to 30% of the cost of building a house (approximately US$0.40 per gallon capacity or US$8,000 for a 20,000 gallon tank). Paget Farm has historically been the most affected community on the island by water scarcity due in large part to the overall lower socio-economic status of households in addition to the close proximity of houses and the community's relatively high slope elevation, which make it difficult to build large tanks. Many households in Paget Farm have inadequately-sized plastic tanks or no water tank at all, inevitably leading to water shortages during mild dry seasons and at times during the rainy season. While there are currently no government regulations or monitoring in place for rainwater collection, there exist many local strategies to improve water quality including boiling water, buying filters, cleaning the tanks yearly, and adding small fish locally called *Millions* inside the tanks to eat insect larvae.

The primary threat of climate change in Paget Farm is freshwater availability (Durrant, Nurse & Stoddard 2008). While historically the dry season extended three to four months between November and March, the island has experienced more intense and frequent droughts in recent decades. A particularly devastating and unprecedented example of climate-related impacts was the 2009-10 drought, during which communities experienced 10 months without significant rainfall. Paget Farm and many other rainwater-dependent communities in the Eastern Caribbean were acutely impacted, leading to disruptions in community dynamics (e.g. school and business

closures and searching for and lugging water throughout the island), losses in local subsistence and market agriculture, and an increased incidence of waterborne diarrheal diseases (Farrell, Trotman & Cox 2010; CCCCC 2012; Figure 2). The Vincentian Government responded by supplying weekly "water boats" to the different Bequian communities from the island of Saint Vincent. The water was provided at no charge to residents but was in insufficient quantity to meet local needs, and individuals either paid to have it transported by vehicle or often walked with several containers back to their homes (Durrant, Nurse & Stoddard 2008; H. Belmar, personal communication, October 29, 2012).

Figure 2. Images of the 2009-10 drought response in Bequia, Saint Vincent and the Grenadines. Left: The Geronimo Ferry serving as a water boat in Port Elizabeth, Bequia. Right: An individual carrying water containers from his house in Paget Farm towards the water boat. Images courtesy of H. Belmar.

In response to changing rainfall patterns and the pre-existence of development concerns, a solar-powered desalination plant was implemented to supply a safe and reliable source of freshwater to Paget Farm local residents (Figure 3). The pilot project fell under the 2007-2011 Special Program for Adaptation to Climate Change (SPACC) initiative, *"Implementation of pilot adaptation measures in coastal areas of Dominica, St. Lucia and St. Vincent & the Grenadines"*.

The plant was financed by the Global Environment Facility, and implemented by the World Bank, the Caribbean Community Climate Change Centre, and the Environmental Management Unit of the Vincentian Ministry of Health, Environment and Wellbeing (MoHEW) at the international, regional and national scales, respectively (World Bank 2005). The desalination plant has been in operation since 2012, and the photovoltaic system on which it relies produces excess energy that is redirected to the island's central electricity grid (Green 2012). Water is collected in a 20,000-gallon holding tank located above Paget Farm and distributed by a gravity-fed system to three main water outlets within the community.

Figure 3. Images of the solar-powered desalination plant project in Paget Farm. Top left: Solar panels located on the hangar of the J.F. Mitchell Airport (image courtesy of M. Bento). Top right: Reverse osmosis desalination system. Bottom left: One of three desalinated water outlet. Bottom right: The 20,000 gallon water holding tank.

2.3. Methods

Qualitative methods were employed to facilitate an in-depth understanding of the contextual nature of the factors of adaptive capacity (Maxwell 2012). Data collection included a set of semi-structured interviews with both key informants involved in the implementation of desalination plant and with local residents of Paget Farm. The focus of study was at the local level but included an analysis of external factors (national, regional and international) (see Wesche & Armitage 2010; Cameron 2012). Over a five-month period between May and September 2013, in-person interviews were conducted in Saint Vincent and the Grenadines and additional interviews were carried out using Voice over IP (VoIP) technology for interviewees located in Antigua, Barbados, Belgium, Belize, and the United States. Interviews were conducted in English, ranged in duration from approximately 30 minutes to 1.5 hours, and were audio-recorded with prior consent (see Table 1). No set number of interviews was determined; rather the process was continued until saturation was reached (Krueger 1988). The interview process was deemed complete when additional interviews did not provide significantly new information (Bertaux 1981). A purposive snowball sampling approach was employed for both sets of interviews (Patton 2002). For key informants, individuals that were most involved in the desalination plant project within their respective institutions were targeted and interviewed when possible. Interviews were carried out with individuals working in institutions that include the World Bank, the Caribbean Community Climate Change Centre, the Ministry of Health, Environment and Wellbeing, as well as other national government ministries, independent project consultants, desalination plant operators, local self-employed individuals, and community leaders (see Appendix D). Local residents were selected on the basis of their attendance to a community meeting discussing the desalination plant project in 2010 (CCCCC 2012), in addition

to targeting individuals with a higher need for water access within the community (i.e. households with either small tanks or no tanks at all).

In total, 25 key informant and 20 local resident interviews were conducted, representing an 83% (25/30 respondents approached) and 80% (20/25 respondents approached) response rate respectively (Table 1). Key informant interviews were loosely structured around the development of the desalination plant project, and the perceived critical factors to the project's completion. Local resident interviews focused on water scarcity and changes in rainfall patterns, as well as perceptions surrounding the project.

Table 1. Interviewee characteristics

Interviewees	n
Key informants (n = 25)	
Local (LI)	5
National (NI)	15
Regional (RI)	3
International (II)	2
Local residents (LR; n=20)	
Community meeting participation	9
Experienced water shortages in 2010	15
Desalination plant use	13
Female	12
Male	8

All interviews were transcribed, coded and analyzed using the qualitative analysis software NVivo (QSR International) through a constant comparison methodology to identify underlying patterns in the data and generate theory on the determinants of adaptive capacity

(Jackson & Verberg 2007). External and internal factors contributing to adaptive capacity emerged in an iterative manner by comparing previously identified codes with each additional interview analyzed in an ongoing manner to enhance, confirm or discount their validity. In addition to interviews, an in-depth review of primary and secondary sources pertaining to water scarcity and climate change adaptation in Paget Farm, such as project documents, government and implementing agencies' reports, and scholarly literature, was undertaken to triangulate data and enhance validation the findings (Bradshaw & Stratford 2010). Although analyses were guided by existing literature on the determinants of adaptive capacity, it was flexible enough to allow for case-specific and potentially novel findings to emerge.

2.4. Results and Discussion

Analysis of results revealed a number of external (i.e. non-local) and internal (i.e. local contributing factors to the success of Paget Farm's climate adaptation project (Table 2). While the themes that emerged are distinct, some overlap naturally exists considering these thematic areas do no operate in isolation of one another but rather influence each other creating positive and negative feedbacks. For example, the strength of one interaction can reinforce others, can change over time and, in some cases, the absence of factors can reinforce weakness.

Table 2. External and internal factors of adaptive capacity

Factors	
External	**Internal**
Financial expectations and flexibility	Adaptation need and relevance
Institutional fit	Buy-in and participation
Bridging institutions	Cross-scale actors
Institutional integration	Champions and leadership

2.4.1. External factors of adaptive capacity

External findings are presented first since they are seen as the overarching conditions that can either hinder or facilitate the ability of local communities to respond to climate change. This is not to say that local communities cannot adapt to climate change in the absence of favourable external conditions, however it must be acknowledged that broader structural processes that operate outside the local sphere shape adaptive outcomes and therefore adaptive capacity (Wesche & Armitage 2010; Cameron 2012). While multiple and intertwining external factors exist, the following section highlights the importance of: (1) financial expectations and flexibility; (2) institutional fit; (3) bridging institutions; and (4) institutional integration.

2.4.1.1. Financial expectations and flexibility

The adaptive capacity of Caribbean small island communities seems to be influenced by the expectations of adaptation project outputs by funding institutions, as well as the amount of flexibility given to national and local actors and institutions to allocate financial resources. By having realistic rather than ideal expectations of project outputs in relation to the financial resources available, it may be possible to avoid the reduction in scope or the incompletion of adaptation projects that often occurs as stakeholders try to reach unattainable commitment benchmarks. In a similar vein, it appears that the flexibility to allocate or pool resources from different funding sources towards pre-existing or larger projects can help ensure the long-term viability of adaptation initiatives.

The availability and size of external financial resources for climate adaptation projects also appear to be important, noted by multiple respondents as "instrumental in providing the tools" (II #2) to implement the desalination plant project, and "too big and too important to fail" (NI #7). As one respondent pointed out:

> […] once the [desalination] system was purchased, when that had been done, it was obvious that we could not turn back. We had already invested so much so we had to find resources to complete it (NI #3).

However it was highlighted that financial resources are not the only factor contributing to adaptive capacity. The associated expectations and flexibility that come with external financing were noted as crucial to the development of high adaptive capacity. It was suggested that donor "expectations" should be "in line with moneys that they provided" to avoid maladaptive outcomes when project stakeholders are given "X amount, which is too little, and they [donor agencies] are still pushing you to achieve X+Y" (NI #2). It appears previous financial expectations may have to be reassessed as adaptation strategies move increasingly away from "hiring consultants to write policies and strategies" (RI #3) towards physical adaptation that require "quite a lot of overhead and supervision, and technical input" (II #2). Given the rising costs of adaptation, it appears that more flexibility and authority for local and national stakeholders to pool external financial resources and to allocate them to pre-existing projects contributes significantly to adaptive capacity:

> That is a good way of trying to use funds that are allocated to the same country to address the problem of climate change […] you pool the [financial] resources together to do one project that is worth, could make impact on the ground as opposed to doing a little bit here and a little bit there. (NI #2)

2.4.1.2. Institutional fit

According to Young (2002), an essential element of adaptive capacity is how well institutional arrangements match the socio-environmental problems institutions seek to address. It appears that institutional fit should be assessed based on the nature of individual adaptation projects and that it may change during different project phases. Ministries of the Environment are often the national implementing agencies for climate adaptation projects (Keskitalo 2010) since they are

assumed to have "the knowledge, the skills" and the ability "to dictate what is needed" (II #1) when it comes to climate change. However, as was highlighted by an international key informant, technical or management-oriented institutions that are often less involved in adaptation projects may have the required skills and expertise for "the execution of works and execution of actual infrastructure" involving "the dispersal of funds, […] having earth works, and having technology being set up" (II #1). In other words, these institutions may be in better positions than Ministries of the Environment to implement certain adaptation projects once fully conceptualized to "make it now an engineering problem" (RI #3). While they may not "understand the [climate change] issues" technical institutions may at times be more appropriate for the implementation phases of adaptation projects:

> They know how to get their projects done. They have a lot more staff, they have people who understand the system, how it works, how to interact with the World Bank and those things (NI #3).

It appears that although environmental institutions should maintain a key role in the conceptualization and development of adaptation strategies due to their assumed wealth of knowledge on climate change and sustainable development, the implementation phases of certain adaptation projects may better "fit" within other institutions that can tap into pre-existing assets, knowledge and experience to successfully adapt to climate change.

2.4.1.3. Bridging institutions

Institutions that play an intermediary function or "bridge" between institutions of different sectors and operating at different scales appear to play a key role, both through the pooling of resources and institutional learning. The pooling of climate resources at the regional scale (here the Caribbean region), which may be materialized and facilitated through institutions such as the

Caribbean Community Climate Change Centre, appear pivotal to a small island community's adaptive capacity by acting as "a conduit through which we [the Government] can attract funding" (NI #5). As one key informant highlighted, "it's hard to handle all sets of needs that are required but if you can concentrate everything into one place" then it can "provide support for the whole Caribbean community" (II #2). In addition, institutional learning and the "transfer of knowledge" (NI #3) can be facilitated by bridging institutions since they may have "a great commitment to continue this [desalination plant project] because all the other countries are watching and they're interested in learning about the experience and replicating it if it is successful" (II #2). This appears to contribute significantly to adaptive capacity at the local level since bridging institutions can also build on the knowledge gained during the implementation of previous adaptation strategies in other communities.

2.4.1.4. Institutional integration

Institutional integration, which refers to the vertical (i.e. cross-scale) and horizontal (i.e. cross-sector) linkages that exist between institutions, emerged as an important factor contributing to Paget Farm's adaptive capacity. Especially in small island communities where resources to undertake larger adaptation initiatives can often be limited, it appears critical to build on a "network [that is] already established, where the flow of information between ministries [institutions] is always encouraged and facilitated" (NI #5). Integration between these networks of institutions that are involved in adaptation projects appears critical. As one international key informant intimately involved the desalination plant project explained:

> It's always the soft part of things that is the most difficult. The difficulty is not in designing a water distribution system or installing a pipe… that's really easy technology, it's easy. The difficult part is to coordinate, reach agreements, reach solid understanding, have all the parties involved and coordinated. That's where a lot of effort needs to be put

> […] You always have to have an eye on the institutional coordination part of it even though it's an infrastructural project (II #2).

It was shown however that it may not be sufficient to have only the linkages established but also to ensure that "all of these organizations with their different imperatives and mandates […] see eye-to-eye so to speak on delivering a single project to a community" (NI #8). This appears to be important in facilitating adaptation projects "because the knowledge doesn't rely on any one person and also they're [other institutions] a key part to making it work" (RI #3). This may be accomplished through the utilization of the "collective resources of all these agencies to come to the table to agree on what can they provide to the project to make it work" (NI #8). Institutional integration may help contribute to the ability of project stakeholders to access the institutional capital that may exist by avoiding duplication of efforts and inefficient utilization of available resources outside of their respective institutions.

The timing of institutions' involvement within adaptation projects may also influence outcomes. As a national key informant mentioned, institutional networks that involve the majority of stakeholders in "the *very* early stages of coming up with the concept" (NI #3) are more likely to be successful. A number of key informants highlighted that to ensure successful adaptation, "the details of the project need to be known before you actually start the implementation. That's all. That's basically it" (NI #2). The importance of institutional integration and associated temporal dynamics seemed to be amplified when adaptation strategies require multiple key institutions to be successfully implemented.

2.4.2. Internal factors of adaptive capacity

While enabling factors operating outside the local sphere are important to climate change adaptive capacity, local-level factors and their within and cross-scale interactions are critical to

ensure the successful completion of projects. Individual and collective agency to respond to and address issues locally were shown throughout this research, and appear to be causal factors in determining whether adaptation occurs. The following subsection highlights four internal factors that influenced adaptive capacity: (1) adaptation need and relevance; (2) buy-in and participation; (3) cross-scale actors; and (4) champions and leadership.

2.4.2.1. Adaptation need and relevance

Adaptive capacity appears to be influenced by the local need for and relevance of a climate change adaptation project. Local residents may associate a need for adaptation with perceived changes in climate conditions such as noticing that "every year dry weather getting harder and harder […] because the rain ain't coming… six months of dry weather is hard" (LR #7). It may also be influenced by how recently an extreme weather event, whether due to climate variability or change, occurred: "[…] it's very, very important to the community because I think it was two years ago we had one of the worst drought that we ever experienced […] it was really terrible" (LR #8). However the perceived need for and relevance of adaptation projects may not be attributed to climate change or environmental threats but rather to pre-existing development challenges:

> Over the years I've noticed, in Paget Farm in particular and there's a reason for it too, no matter if you're having rain often, that even in rainy season people in Paget Farm still have to transport water to their homes, or still have to get water. And you know one of the reasons for that? There are a number of persons in Paget Farm that do not have water tanks (LI #3).

Irrespective of rationale, adaptation seems to be influenced by how much a community sees the necessity of responding to a local issue—be it climate change, capacity, or other factors. In addition, the ability of local residents to collectively voice these concerns appears to contribute

to adaptive capacity: “It’s the cry of the people that caused them to do that [the adaptation strategy]… because it was really a cry here on the island” (LR #6). This was echoed by a national key informant stating that the community had “always expressed as their greatest need the question of water security, [to have] some mechanism to provide them with safe drinking water” (NI #8).

2.4.2.2. Buy-in and participation

While local residents may agree on the need for adaptation, also important in determining adaptive capacity seems to be the community’s overall buy-in and participation in the proposed adaptation project. These factors appear to be facilitated when proposed projects reflect locally-relevant needs, desires, and values. Local residents in Paget Farm seemed “very hyped up and excited about the project from the very first community consultation that we had” (NI #12) and “there wasn’t very much difficulty at all” in initiating conversation because “certainly all of the stakeholders in Paget Farm were keenly interested” (II #2). When adaptation strategies are crafted to the needs of a community, it appears to help increase the level of local engagement since “knowing about the water problem for all those years” (LR #19) may influence the willingness of local residents to contribute resources needed to bringing adaptation projects to successful completion:

> They [local residents] are very happy to participate in the whole process because everybody understands the health issues and the environmental issues and the need to provide water for the community. And they’re willing to do whatever they can. Even if they have to give away their property, they would do it. Just to help the community (NI #12).

When local residents have an “*interest* in the project”, they may be more committed to bringing it to completion because “we *live* the situation. They don’t. We live it, you know?” (LI #3).

Local residents involved in adaptation projects from which they or their own community can benefit may go "over and beyond the call of duty to make it happen" (NI #12) because of "their own civic mindedness" (RI #2). Local participation is distinct however in that "talking to them [local residents] about their needs and then trying to craft a project to address that need" (NI #3) does not ensure adequate engagement of the community. Although local residents may not always be or have to be intimately involved in every phase of project implementation, a certain level of participation can help ensure the accountability of actors and institutions directly involved to the community: "There was a lot of public expectation that the project would be completed… and you know politically it would not have been expedient to not complete it" (NI #3).

2.4.2.3. Cross-scale actors

Local residents that not only cross scales (i.e. national, regional, international), but also have the ability to influence actors and institutions operating at different scales appear to contribute to successful adaptation. These actors may facilitate successful adaptation, as highlighted by a regional key informant who spoke about one such cross-scale actor: "[The cross-scale actor] has a history of doing community work on Bequia so it was easy for him to come on board, and in addition he had a role in Government […] he had that kind of capacity" (RI #3). Adaptive capacity seems to be facilitated and enhanced when local residents are involved, whether formally or informally, in adaptation projects since they better understand lived realities while being able to communicate and "sell the project" to actors and institutions at higher scales: "they were convinced, that's my belief, that the project was really necessary" (LI #3). The value of cross-scale actors can not only been seen from local residents' perspective but also from actors and institutions working outside the local sphere. The local knowledge and relationships of trust

that cross-scale actors may possess can also facilitate the adaptation process for nonlocals: "[The cross-scale actor] received a lot of help locally because he know people […] he received a lot of help (laughs)…that project would not have been there" (LI #2). These informal ties between cross-scale actors and local residents appear important since they may help facilitate local buy-in and participation.

2.4.2.4. Champions and leadership

Lastly, local project champions appear to play a significant role in climate change adaptive capacity. The existence of individuals that are "the driving force" of adaptation initiatives (LR #15), showing "dedicated leadership" (NI #8) and determined to "see this thing *really* work" (LI #3), were highlighted as essential to bringing the Paget Farm project to completion. Indeed many key informants adamantly highlighted that "… if there was no [champion], there would be no water project—no desalination plant" (LI #3). The role of individual characteristics and traits of a person rather than the position they occupy seems of importance (LI #2):

> You see, it depends on the individual. Because [the champion] has this *push* that once he touches something, once he decides he's going to work on this project, he will put his all into it just to ensure it comes to completion. […] Even if it means he alone will have to go and do all the work, he will do that.

Local project champions appear to play a critical role to the point where adaptation projects may not occur without them. It appears the Paget Farm project succeeded in part because of the presence of a local champion with the appropriate technical and social expertise: "Bequia [Paget Farm] really emerged because [the champion] really took the initiative to be involved and to drive the project […] there was a strong champion pushing a train that was already moving" (RI #3).

2.5. Conclusion

Climate change is one of the greatest challenges to societies globally, and one which disproportionately impacts Caribbean small island communities (Mimura et al. 2007; IPCC 2014a). Nonetheless, while exposures and sensitivities to climate change impacts are generally high in the Caribbean, there is great potential to decrease local vulnerability by increasing adaptive capacity. Adaptive capacity has received growing interest in recent years as it is shaped exclusively by human actions that can either serve to increase or decrease vulnerability and negative impacts (Eakin & Luers 2006). Small island communities are often described as having among the lowest ability to adapt, yet in reality, local-level adaptation strategies are increasingly being designed, developed and implemented by actors and institutions operating at all scales. The Paget Farm case study is one example that provides insights into how to assess and identify some of the social and institutional factors that contribute to highly successful adaptation.

The case study community of Paget Farm in Saint Vincent and the Grenadines revealed important insights into adaptive capacity through an examination of external and internal factors that led to the successful implementation of a solar-powered desalination plant. Notably, the research identified four predominantly institutional external factors: (1) Financial expectations and flexibility; (2) institutional fit; (3) bridging institutions; and (4) institutional integration. While climate finance has substantially increased in recent years, these findings further suggest that external financial resources alone do not suffice to adapt successfully. Rather, it has been shown that the associated expectations of recipient institutions by donor agencies should reflect realistic, rather than ideal, expectations in order to avoid maladaptive outcomes as actors and institutions strive to reach unattainable commitment benchmarks. A potential opportunity to increase adaptive capacity also exists with an increased flexibility by local and national actors to

allocate financial resources from different funding sources towards a common project. It also seems to be influenced not only by how well institutions match the problems they seek to address, but also by the presence of institutions that can coordinate with other institutions found at different scales and representing a range of sectors to pool resources and promote institutional learning. Lastly and importantly in the context of small island communities, adaptive capacity appears to be facilitated by the level of integration between multiple institutions that may be involved in adaptation projects. While this research did not delve into the complexities of institutional networks and their dynamics, the findings presented here suggest the need for additional research into the role of institutional integration in contributing to the ability of project stakeholders to coordinate and tap into resources that may exist outside of their own institutions to bring adaptation projects to successful completion.

While external factors may be seen as the overarching structural processes that either limit or promote adaptive capacity in Caribbean small island communities, many internal factors and their interactions are critical for successful adaptation. The mostly social factors that arose from this research included: (1) Adaptation need and relevance; (2) buy-in and participation; (3) cross-scale actors; and (4) champions and leadership. The level of collective agreement by local residents on the need to respond directly to a local concern appears to facilitate adaptive capacity. While the perceived need for adaptation by local residents may be associated directly with climate change impacts, it may also be seen as a mechanism to address other environmental threats or pre-existing development challenges. But irrespective of rationale, adaptive capacity seems to be facilitated and increased when proposed strategies reflect local needs. Although local residents may acknowledge the need to adapt to a particular impact and this need is adequately and collectively voiced to actors and institutions involved in adaptation projects,

adaptive capacity appears to also be a function of how well local residents identify with and "buy into" proposed adaptation projects. In addition, the level of community participation in these projects may help facilitate the adaptation process. Cross-scale actors in turn appear not only to help to bridge communication between actors and institutions operating at different scales, but also to increase local buy-in and participation. Lastly and importantly the presence of local project champions that are recognized as leaders within their community and have a commitment to bring projects to completion seems to play a significant role in contributing to adaptive capacity.

This research addressed two of the most significant limitations identified in previous local-level adaptive capacity research. First, an attempt was made to assess adaptive capacity by situating small island communities within the multiple and interacting factors that operate outside the local sphere. The Paget Farm case study provides pragmatic insight into these processes as the adaptation strategy addressed local-level climate change impacts (e.g. freshwater scarcity) yet was implemented by a large number of institutions operating at all spatial scales (i.e. local, national, regional, international). Second, adaptive capacity in this context was more easily gauged than in previous adaptation research since it used a retrospective approach to examine a community that had already adapted to climate change and thus displayed high adaptive capacity. While foundational research in the field used previous responses to climate variability as proxies for climate change adaptive capacity (Adger et al. 2007; Bussey et al. 2010; Ford et al. 2010; Nielsen & Reenberg 2010), climate change poses new and additional threats as well as benefits that make studying adaptive capacity using this approach challenging and increasingly problematic. By using a case study approach to understanding how a community has already successfully adapted to climate change, research may take into account

the new and additional challenges climate change poses as well as the benefits, such as an increase in international climate funds, growing awareness regarding climate change, and new institutions emerging designed to address to mitigate the causes and adapt to the impacts.

While this research only examined one successful case study community, it opens the door for further research examining commonalities and differences in the determinants of adaptive capacity among local communities. It may be fruitful to conduct comparative case study research examining communities faced with similar socio-environmental exposures and sensitivities (as suggested by Engle 2011) yet exhibit differential levels of adaptive capacity determined by whether they "successfully" adapted to climate change. Although the context in which these factors and conditions are manifested is specific, it is possible to provide some level of generalization regarding the determinants of local-level adaptive capacity. These investigations are important because while there has been an increase in the number of adaptation strategies there have also been growing concerns regarding their successful implementation (see Barnett 2008; Nunn 2009). This dissonance highlights the gap that exists between the increased *interest* in and *willingness* to adapt and the *factors* that lead to long-term successful/sustainable adaptations. Research focusing specifically on the determinants of adaptive capacity can narrow that gap by further investigating cases of successful local-level adaptation strategies and identifying *how* they were implemented and *what* could have enhanced and facilitated success. It is by focusing on adaptive capacity, in contrast to existing exposures and sensitivities, that we may shift the conversation from identifying and listing problems to understanding and strengthening positive attributes of communities as we move towards sustainable strategies that address climate change impacts.

References

Adger, W.N. (2003). Social capital, collective action, and adaptation to climate change. Economic Geography, 79, 387-404.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005). Successful adaptation to climate change across scales. Global Environmental Change, 15, 77-86.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., et al. (2007). Assessment of adaptation practices, options, constraints and capacity. In M.L. Parry, O.F. Canziani, J.P. Palutikof et al. (Eds.), Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press (pp. 717-743).

Adger, W.N., Eakin, H. and Winkels, A. (2008). Nested and teleconnected vulnerabilities to environmental change. Frontiers in Ecology and the Environment, 7, 150-157.

Agrawal, A. (2008). The role of local institutions in adaptation to climate change. Paper prepared for the Social Dimensions of Climate Change, Social Development Department, World Bank. Washington DC, March 5-6, 2008.

Bradshaw, M. and Stratford, E. (2010). Qualitative research design and rigour. In I. Hay (Ed.), Qualitative research methods in human geography. Oxford: Oxford University Press (pp. 69-80).

Bertaux, D. (1981). Biography and society: The life history approaches in the social sciences. Beverly Hills: Sage Publications.

Brooks, N. and Adger, W.N. (2005). Assessing and enhancing adaptive capacity. In B. Lim and E. Spanger-Siegfried (Eds.), Adaptation policy frameworks for climate change: Developing strategies, policies and measures. United Nations Development Program, Global Environment Facility. Cambridge: Cambridge University Press (pp. 165-181).

Bussey, M., Carter, R.W., Carter, J., et al. (2010). Societal responses to significant change: A historical analysis of adaptive capacity. Report for the South East Queensland Climate Adaptation Research Initiative. Sustainability Research Centre, University of the Sunshine Coast, Sippy Downs, Australia.

Cameron, E. (2012). Securing Indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. Global Environmental Change, 22, 103-114.

CCCCC. (2012). Environmental impact assessment of the installation of a photovoltaic solar powered salt water reverse osmosis plant at Paget Farm Bequia. Technical Report 5C/SPACC-11-08-02 prepared by the Caribbean Community Climate Change Centre, Belmopan, Belize.

Chang, Y.M. and Desai, A. (2001). Local control, local capacity and regulatory effectiveness: Issues in municipal water pollution control. In M.R. Daniels (Ed.), Creating sustainable community programs: Examples of collaborative public administration. Westport: Praeger Publishers (pp. 176–191).

Dixit, A., McGray, H., Gonzales, J., and Desmond, M. (2012). Ready or Not: Assessing institutional aspects of national capacity for climate change adaptation. World Resources Institute. Washington: WRI.

Durrant, S., Nurse, L. and Stoddard, A. (2008). Monitoring the effects of below average precipitation on water resources in Paget Farm, Bequia, the Grenadines. Technical Report No. 22 prepared for the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados.

Eakin, H. and Luers, A.L. (2006). Assessing the vulnerability of social-environmental systems. Annual Review of Environment and Resources, 31, 365–394.

Engle, N.L. (2011). Adaptive capacity and its assessment. Global Environmental Change, 21, 647-656.

Eriksen, S.H. and Kelly, P.M. (2007). Developing credible vulnerability indicators for climate adaptation policy assessment. Mitigation and Adaptation Strategies for Global Change, 12, 495-524.

Farrell, D., Trotman, A. and Cox, C. (2010). Drought early warning and risk reduction: A case study of the Caribbean drought of 2009-2010. Global Assessment Report on Disaster Risk Reduction prepared for the United Nations International Strategy for Disaster Reduction.

Folke, C., Hahn, T., Olsson, P., et al. (2005). Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30, 441-473.

Ford, J.D., Keskitalo, E.C.H., Smith, T., et al. (2010). Case study and analogue methodologies in climate change vulnerability research. Wiley Interdisciplinary Reviews: Climate Change, 1, 374-392.

Green, E. (2012). Special Programme for Adaptation to Climate Change (SPACC). Implementation of adaptation measures in coastal zones. Technical Note 5C/SPACC-12-05-01 prepared by the Caribbean Community Climate Change Centre, the Global Environment Facility, and the World Bank.

Grothmann, T. and Patt, A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. Global Environmental Change, 15, 199-213.

Gupta, J., Termeer, C., Klostermann, J., et al. (2010). The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environmental Science & Policy, 13, 459-471.

Huq, S., Yamin, F., Rahman, A., et al. (2005). Linking climate adaptation and development: A synthesis of six case studies from Asia and Africa. IDS Bulletin, 36, 117-122.

IPCC. (2014a). Small Islands. In C.B. Field, V.R. Barros, D.J. Dokken, et al. (Eds.), Climate change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press (pp. 1-60).

IPCC. (2014b). Summary for policymakers. In C.B. Field, V.R. Barros, D.J. Dokken, et al. (Eds.), Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press (pp.1-32).

Jackson, W. and Verberg, N. (2007). Methods: Doing social research. Toronto: Pearson Education Canada.

Jaja, J. and Dawson, J. (2014). What contributes to climate change adaptive capacity? A retrospective case study in a Caribbean small island community. In W. Leal (Ed.), International perspectives on climate change: Latin America and beyond. New York: Springer.

Keskitalo, E.C.H. (2010). Adaptation to climate change in Europe: Theoretical framework and study design. In E.C.H. Keskitalo (Ed.), Developing adaptation policy and practice in Europe: Multi-level governance of climate change, London: Springer (pp. 1-38).

Klein, R.J.T. and Smith, J.B. (2003). Enhancing the capacity of developing countries to adapt to climate change: A policy relevant research agenda. In: J. Smith, J. Klein and S. Huq (Eds.), *Climate Change, adaptive capacity and development.* London: Imperial College Press (pp. 317-334).

Krueger, R. (1988). Focus Groups: A Practical Guide for Applied Research. Thousand Oaks: Sage.

Maxwell, J.A. (2012). Qualitative Research Design: An Interactive Approach. London: Sage Publications.

Medeiros, D., Hove, H., Keller, M., et al. (2011). Review of current and planned adaptation action: The Caribbean. Report for the International Institute for Sustainable Development.

Moser, S.C. and Ekstrom, J.A. (2010). A framework to diagnose barriers to climate change adaptation. Proceedings of the National Academy of Science, 107, 22026-22031.

Moss, R.H., Brenkert, A.L. and Malone, E.L. (2001). Vulnerability to climate change: A quantitative approach. Technical Report PNNL-SA-33642, Pacific Northwest National Laboratories, Richland.

Mimura, N., Nurse, L, McLean, R.F., et al. (2007). Small islands. : Impacts, Adaptation and Vulnerability. In M.L. Parry, O.F. Canziani, J.P. Palutikof et al. (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press (pp. 687-716).

Nielsen, J.Ø. and Reenberg, A. (2010). Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. Global Environmental Change, 20, 142–152.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. Cambridge: Cambridge University Press.

Pahl-Wostl, C. (2009). A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change, 19, 354–365.

Patton, M.Q. (2002). Qualitative Evaluation and Research Methods. 3rd Edition. Beverly Hills: Sage.

Pelling, M. (2011). Adaptation to climate change: From resilience to transformation. New York: Routledge.

Smit, B. and Pilifosova, O. (2003). From adaptation to adaptive capacity and vulnerability reduction. In: J. Smith, J. Klein and S. Huq (Eds.), Climate Change, adaptive capacity and development. London: Imperial College Press (pp. 1-20).

Smit, B., Pilifosova, O., Burton, I., et al. (2001). Adaptation to climate change in the context of sustainable development and equity. In J.J. McCarthy, O.F. Canziani, N.A. Leary et al. (eds.), Climate change 2001: Impacts, adaptation and vulnerability. Contributions of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press (pp. 877-912).

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16, 282-292.

Staskiewicz, T. and Mahon, R. (2007). A livelihoods analysis of fishers in the Grenadine Islands. CERMES Technical Report No. 12. Prepared for the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados.

Statistical Office. (2001). Population and housing census database. Ministry of Finance and Economic Planning, Government of Saint Vincent and the Grenadines. Retrieved February 4, 2013, from http://celade.cepal.org/svgbin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=SVG2001&MAIN=WebServerMain.inl

Tompkins, E.L. (2005). Planning for climate change in small islands: Insights from national hurricane preparedness in the Cayman Islands. Global Environmental Change, 15, 139-149.

UNFCCC. (2005). Climate change: Small island developing states. Issued by the Climate Change Secretariat. United Nations Framework Convention on Climate Change. Bonn: UNFCCC

UNFCCC. (2014). Focus: Climate Finance. Retrieved October 10, 2014, from http://unfccc.int/focus/climate_finance/items/7001.php#intro

Wesche, S. and Armitage, D.R. (2010). From the inside-out: A multi-scale analysis of adaptive capacity in a Northern community and the governance implications. In D.R. Armitage and R. Plummer (Eds.), Adaptive capacity: Building environmental governance in an age of uncertainty. Heidelberg: Springer (pp. 107-132).

Williamson, T., Hesseln, H. and Johnston, M. (2012). Adaptive capacity deficits and adaptive capacity of economic systems in climate change vulnerability assessment. Forest Policy and Economics, 15, 160-166.

World Bank. (2005). Special program on adaptation to climate change project. Global Environment Fund (GEF) project brief to the Governments of Dominica, Saint Lucia, and St. Vincent and the Grenadines. Report No. 34152-LAC.

World Bank. (2012). Implementation completion and results report for the implementation of adaptation measures in coastal zones project. Prepared by the World Bank. Report No. ICR2362

WRI. (2013). Aqueduct country and river basin rankings interactive map. Retrieved October 10, 2014, from http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=0.00&y=0.00&l=2&v=home&d=bws&f=0&o=139

Young, O.R. (2002). The Institutional dimensions of environmental change: Fit, interplay, and scale. London: The MIT Press.

CHAPTER THREE

A temporal social network approach to assessing the role of institutional networks in the climate change adaptive capacity of Caribbean small island communities

Jessica Jaja[1]

Manuscript in preparation for submission to the journal *Local Environment*

[1] Department of Geography, University of Ottawa, ON, Canada

Abstract

This paper uses Social Network Analysis (SNA) to examine how institutional networks contribute to the adaptive capacity of Caribbean small island communities. It retrospectively investigates the role of vertical and horizontal institutional integration as networks change over time during the different phases of a solar-powered desalination plant project implementation; a climate change adaptation strategy in the community of Paget Farm, Saint Vincent and the Grenadines. Previous studies have suggested that a high level of both vertical and horizontal institutional integration contribute to high adaptive capacity. Results of this study found that while the level of vertical integration varied throughout different project phases (i.e. pre-project, planning, development, operational, post-project), horizontal integration was consistently low. Through the incorporation of temporality within SNA studies, research findings suggest that high integration between institutions may not be required during all project phases in order to ensure the development of high levels of climate change adaptive capacity. While temporal dynamics may be more important to vertical integration, a more consistent rather than high level of horizontal integration may be more meaningful in contributing to adaptive capacity.

Keywords: Climate change; adaptive capacity; Caribbean small islands communities; institutional integration; Social Network Analysis; temporality

3.1. Introduction

Caribbean small island communities experience some of the most severe impacts of climate change globally (IPCC 2014). Sea-level rise is threatening coastal infrastructure and is linked to an increase in saltwater intrusion of underground aquifers, while ocean acidification is contributing to the loss of coral reef systems. These impacts make coastal communities more vulnerable to hurricanes and tropical storms, which are predicted to increase in frequency and intensity in the coming years. The Caribbean region is also experiencing a decrease in freshwater availability—due to the compounding impacts of changes in rainfall patterns, sea-level rise, and changes in extreme weather events such as storm surges—depleting an already strained drinking water supply in many communities (Jury and Winter 2010). Based on increased hurricane damages, loss of tourism revenue and infrastructure damages alone, the costs of climate change to the Caribbean are estimated to amount to $22 billion by 2050 (Bueno et al. 2008), which represents 7% of the region's current cumulative GDP[2]. While many challenges lie ahead, institutions and actors that are linked formally and informally and that operate at different spatial and temporal scales are developing adaptation strategies that address local-level climate change impacts. These networks of institutions represent one mechanism through which communities can mobilize and increase their adaptive capacity to facilitate, promote, and implement successful climate change adaptation strategies (Engle 2011).

The effectiveness of institutions and the networks they collectively form play a significant role in determining the capacity of communities to successfully adapt to climate change (e.g. Ivey et al. 2004; Agrawal 2008; Brown et al. 2010; Gupta et al. 2010). While it is acknowledged that institutions are not always synonymous with organizations (see for example

[2] Author's calculations. Percentages based on 2011 GDP of the 25 Caribbean countries and dependent territories (or most recent figures available) listed in Bueno et al. (2008).

Young 2002), for the purpose of this paper and in keeping with existing literature in the field of climate change adaptation, institutions are considered to be formalized entities with designed patterns of rules and decision-making (e.g. Agrawal 2008, Engle & Lemos 2010; Dixit et al. 2012). They include but are not limited to national government, private companies, not-for-profits, and regional (i.e. supranational in the context of the Caribbean region) and international agencies. Institutions typically have formal rules, laws, and regulations, and informal sets of values, norms and traditions that shape expectations and guide actions undertaken by actors (Ostrom 1990; Young 2002; Gupta et al. 2010). As summarized by Agrawal (2008), institutions influence local-level adaptive capacity by (a) structuring the impacts of and vulnerability to climate change; (b) mediating between individual and collective responses and therefore shaping the outcome of adaptation strategies; and (c) acting as a conduit through which external resources can reach local communities. Institutional factors that shape a community's adaptive capacity include decision-making ability (Brooks & Adger 2005); the level of political, technological and financial support from higher levels of governments (Chang & Desai 2001); the role of state and non-state actors (Pahl-Wostl 2009); and the complexity and diversity of governance regimes (Folke et al. 2005; Gupta et al. 2010).

Understanding the influence that institutions have on local-level adaptive capacity to climate change requires not only an analysis of the strengths of individual governing institutions but also the linkages that exist between institutions (Keskitalo 2010). As so aptly described by Young (2002, p.83),

> […] Human societies at all levels of social organization are more or less densely populated with well defined and widely recognized institutions organized around a variety of functional concerns and spatial domains. And these arrangements frequently interact with one another producing consequences that are too important to disregard.

The ability to successfully adapt to local impacts of climate change requires the collective resources of a wide range of institutions operating at different spatial scales. Recent research on institutional networks and climate change adaptive capacity has revealed the importance of institutional integration (see for example Olsson et al. 2004; Davies 2005; Ingold et al. 2010). Institutional integration refers to the vertical (i.e. cross-scale) and horizontal (i.e. cross-sector) linkages that exist between institutions. Vertical integration refers to the level of coordination between institutions operating at different spatial levels (i.e. local, national, regional, international), while horizontal integration reflects the coordination between different sectors. Ingold et al. (2010, p. 653) have suggested that adaptive capacity is a function of "the embeddedness of local communities in vertical and horizontal governance structures through the integration of actors from different sectors and governmental levels in policy formulation and implementation". They argue that a high level of both vertical and horizontal integration contribute most to adaptive capacity due to higher chances for institutional collaboration and cohesion.

The impacts of climate change are often felt at the local level, yet decisions concerning what type of adaptation strategies to implement are often made at higher spatial levels (Keskitalo 2008). For example, the impacts of reduced rainfall due to climate change may cause increasingly severe droughts in a small island community, which threaten crop production and yield. While these climate change impacts may be felt and acknowledged first by local farmers and their cooperatives, the decision-making ability to increase water storage capacity or to build a desalination plant may lie within national government departments. However power may ultimately be held within an international funding agency that has the financial resources to implement the selected adaptation strategies. In such instances, successful vertical integration

would incorporate local knowledge and protect the rights and interests of local stakeholders while ensuring that decisions regarding adaptation strategies take into account the dynamic nature of a changing climate at national, regional and even global levels (Young 2002; Leichenko et al. 2010). Vertical interactions between institutions tend to occur between those located at adjacent scales (e.g. international-regional, regional-national, national-local). However globalization and paradiplomacy—a relatively new type of institutional arrangement that can link international funding agencies directly to local communities—may leapfrog certain levels to help create linkages between more remote levels (Young 2002; Soldatos & Michelmann 1992). While not all adaptation strategies involve top-down management such as the example given above, a local community's adaptive capacity is nevertheless dependent on its ability to acquire and access financial, human, technological and other resources that exist outside the local sphere (Thompkins, Adger & Brown 2002; Keskitalo 2010).

Horizontal integration is often based on conscious decisions guided by a desire to solve specific problems intended to maximize social welfare (Young 2002). Climate change adaptation is inherently multi-sectoral (Mickwitz et al. 2009), often requiring pre-existing or additional horizontal coordination of institutions working in a diverse range of sectors. Among others, water supply is often under the jurisdiction of multiple institutions. Therefore the implementation of a desalination plant, to expand on the above example, may be dependent on the level of national coordination of environmental departments, engineering firms, constructions companies and physical planning units to ensure the adaptation strategy's success. While issues can arise when the motives behind actors' involvement within a network relate to the pursuit of individual institutional opportunities that may not be in line with the promotion of the common good

(Young 2002), horizontal integration is argued to influence a community's adaptive capacity through the multi-sectoral linkages that are required to coordinate adaptation strategies.

Institutional networks are not static but rather evolve over time. Relations between institutions change, new agreements are formalized and actors working within institutions tap into their own personal or informal networks, which can subsequently transform into formal ties between institutions. These changing interactions simultaneously affect the structure of the overall network, which further shapes the types of interactions that are possible between institutions (Doreian 2001). Evolving institutional networks have clear implications for the climate change adaptive capacity of small island communities by facilitating or hindering their ability to gain access to human, social, financial and technical resources available between and across scales. The difficulty in understanding network structure and dynamics without temporality lies in not knowing how a particular network was generated from previous networks (Snijder 2005; De Nooy 2008). It is therefore critical for researchers and practitioners to increase their understanding of temporal dynamics that influence institutional networks and as a consequence adaptive capacity to climate change (Ingold 2014).

While it has been argued that institutional networks influence climate change adaptive capacity, little empirical research has been undertaken to either qualitatively visualize or quantitatively assess how they facilitate or hinder this capacity for adaptation in local communities (notable exceptions include Ingold et al. 2010; Luthe et al. 2012; Rotberg 2013; Ingold 2014). A powerful and relatively new tool to assess institutional networks and how they evolve temporally is Social Network Analysis (SNA). SNA can help understand social relationships between various types of actors such as individuals, groups or institutions (i.e. the nodes of a network) by visualizing and investigating their interactions (i.e. the ties of a network)

within a defined network. The use of SNA can help illustrate and interpret the role of certain determinants of adaptive capacity linked to institutional networks that have been identified as important to climate change adaptive capacity.

Social network theory and analysis was used in this study to understand how the networks of institutions involved during the different implementation phases of a solar-powered desalination plant influenced the adaptive capacity of a Caribbean small island community. The plant was implemented in the community of Paget Farm, Saint Vincent and the Grenadines as a climate change adaptation strategy to address an observed decrease in rainfall precipitation and increased droughts in a community almost exclusively reliant on rainwater collection. Specifically, the role of vertical and horizontal institutional integration within the generated networks is examined, which represent the different phases of the desalination plant project implementation between 2007-2011. While the research is exploratory in nature, the novelty of the approach lies in the use of SNA to investigate how the relations between institutions change over time during adaptation project implementation. The remainder of the paper presents the research methods, including the case study context, data collection, and data analysis, followed by the results and a discussion of the findings.

3.2. Methods

3.2.1. Case study

The community of Paget Farm is a Caribbean small island community located on the southwest coast of Bequia in Saint Vincent and the Grenadines. Tourism and fishing represent the two main employment sectors for the 724 local residents of Paget Farm, the most populated community on the island of 5389 inhabitants (Statistical Office 2001). While Paget Farm shares many of the

same climate change impacts as other small islands communities, freshwater availability was identified as the primary threat (Durrant et al. 2008). The island of Bequia has no rivers and lakes, and the already limited groundwater resources are increasingly threatened by saltwater intrusion, low replenishment rates, and pollution. Most households on the island harvest rainwater collected from rooftops, which serve as the primary source of drinking water. However increases in the intensity and frequency of droughts, such as in 2009-2010 during which the community faced a 10-month drought, severely hinders the ability of community members to access sufficient water to meet personal consumption and basic household needs (Durrant et al. 2008).

As a direct response to climate change, the first solar-powered desalination plant in the Caribbean region was implemented in Paget Farm. The adaptation strategy was part of the 2007-2011 Special Program for Adaptation to Climate Change (SPACC) initiative, "Implementation of pilot adaptation measures in coastal areas of Dominica, St. Lucia and St. Vincent & the Grenadines". The plant was financed by the Global Environment Facility, which worked with the following international, regional and national implementing agencies, respectively: The World Bank, the Caribbean Community Climate Change Centre (CCCCC), and the Vincentian Ministry of Health, Environment and Wellbeing (MoHEW). Multiple institutions were also involved in the planning, development and operational phases of the project, including local community-based organizations, national government departments, industry, regional agencies and international consultancy companies (See Table 1; Appendix D). The desalination plant has been in operation since 2012, and the photovoltaic system on which it relies produces excess energy that is redirected to the central grid (Green 2012). Water is collected in a 20,000-gallon holding tank located above Paget Farm and distributed to three main water outlets within the community.

The lack of empirical research on institutional networks with regards to climate change adaptive capacity is in part due to the intangible nature of the relationships that exist between civil society, institutions and governing bodies (Adger 2003). Another challenge lies in the latency of adaptive capacity, referring to it only becoming visible when a system is exposed to actual climate change impacts and making it difficult if not impossible to study unless a community has successfully adapted (Smit et al. 2001; Engle 2011). In addition, much of the SNA research focuses on single time unit networks, which represent a snapshot in time and do not adequately represent the continuously changing, evolving and dynamic properties of institutional networks. These challenges can be overcome by examining networks at different time periods during the implementation of climate change adaptation projects such as the solar-powered desalination plant in Paget Farm to better understand the dynamic processes that influence institutional networks and therefore the adaptive capacity of small island communities. This case study is an example of an extreme case (Flyvbjerg 2006) of a community that has "successfully" adapted to climate change (see Jaja and Dawson (2014) for additional information on successful adaptation).

3.1.2. Data collection

To create institutional networks using SNA, a survey was conducted over a five-month period (May to September 2013) with the institutions involved in the different phases of the adaptation project. Through a review of primary and secondary literature and snowball sampling, 23 institutions were identified as participating in the desalination plant project (Table 1; see Appendix D for complete list of institutions involved and surveyed). These included 3 local, 12 national, 4 regional and 4 international institutions working predominantly in the following sectors: administration and management; technical and scientific; construction and

manufacturing; and financial. Once institutions were identified, survey recruitment was done through poster distribution and in-person, phone or e-mail communication. A total of 20 individuals representing 17 institutions responded (17/23 institutions; 74% response rate) to the network survey conducted using an online survey tool (SurveyGizmo 2014).

Table 1. Characteristics of institutions

Institutions	**N total**	**N surveyed**
Scales		
Local (L)	3	3
National (N)	12	10
Regional (R)	4	2
International (I)	4	2
Sectors		
Administration and management	7	7
Technical and scientific	8	6
Construction and manufacturing	6	4
Financial	2	0
Total	**23**	**17**

The purpose of the network survey was to understand how contact between different institutions helped or hindered adaptive capacity throughout the five different phases of the implementation of the solar-powered desalination plant in Paget Farm. The phases of the project were defined in the survey as follows:

1. **Pre-project:** Prior to the start of the project
2. **Planning:** Initial idea generation, proposal writing, early consultations
3. **Development**: Securing funding, construction, early implementation
4. **Operational:** Late implementation, and general maintenance
5. **Post-project:** After the completion of the project

The names of all the institutions involved in the project were listed in the network survey but the names of individuals and institutions remain anonymous in any publications as per research ethical guidelines. The survey included general questions regarding the institution itself, including its mandate and roles and responsibilities within the desalination plant project. To collect network data, the survey respondents were asked to identify and provide details on their interaction with all the institutions with which their own institution was in contact during the five phases of the project.

3.2.3. Data analysis

Data obtained from the network survey were used to create full network matrices in Microsoft Excel. These matrices were then imported into the social network software UCINET (version 6.497; Borgatti et al. 2002) in order to generate institutional network maps for each of the five project phases using NetDraw (a component of UCINET). For each project phase, descriptive network statistics were generated in addition to a number of visual and quantitative analyses to assess the level of vertical and horizontal integration.

3.2.3.1. Network statistics

The characterization of the five generated networks was first undertaken independent of spatial scale or sector. In line with existing research, indicators of overall integration included four SNA measures: network density, average degree, network centralization, and betweenness centrality (e.g. Bodin and Crona 2009; Luthe et al. 2012). Density represents the number of ties in a network, expressed as a proportion of the total number of ties possible (Borgatti et al. 2013). It has been suggested that a positive relationship exists between density and adaptive capacity, as the chances for collaboration increase with a larger number of ties (Olsson et al. 2004). This has

been postulated since higher density can strengthen trust (Granovetter 1985) and facilitate the spread of information (Weimann 1982). However it is to be noted that excessively dense networks may lower adaptive capacity through a homogenization of knowledge and experiences and therefore similar perceptions regarding appropriate adaptation strategies to implement (Oh et al. 2004; Crona and Bodin 2006). While network density can provide useful insight into network structures that contribute to local-level adaptive capacity, the value of the measure is best when comparing networks of similar size since large networks almost always have lower network densities than smaller networks (Borgatti et al. 2013). To circumvent the issue and to validate the results obtained, the network's average degree, calculated as the average number of ties of a given node, can be used as another indication of network integration.

Network centralization refers to the extent to which a single node dominates a network. Bodin et al. (2006) suggest that the ideal level of network centralization is dependent on the type and phase of a given process. While research has shown that in small groups high centralization of networks may be effective for the resolution of simple problems, more complex problems require more diverse network structures (Leavitt 1951). High centralization may increase adaptive capacity through the ability of central institutions to prioritize and coordinate activities (Sandström 2009). However, highly centralized networks have been shown to be problematic with regards to the distribution of power and influence (Ernstson et al. 2009), legitimacy, and representation of peripheral actors and institutions (Bodin & Crona 2009). Lastly, betweenness centrality, an indication of how often a given node is present in the shortest path between two other nodes (Borgatti et al. 2013), was calculated. An institution that has a high betweenness centrality may act as a bridge or a broker between institutions that would otherwise not be in

contact, which influences the flow of information and resources and thus network integration (Granovetter 1973).

To further explore adaptive capacity temporally, Quadratic Assessment Procedure (QAP) correlation analyses were conducted to visually examine how institutions shifted within the networks over time. QAP correlation is a standard method used to examine the similarity between entire networks since it does not assume independence of observations, which are always dependent in social networks (Borgatti et al. 2013; Whitbred 2011). While these network measures and general descriptive statistics provide a general indication of overall network integration, further characterization of individual nodes by scale and sector is required to determine vertical and horizontal integration.

3.2.3.2. Network integration

A number of visual and quantitative analyses were conducted to assess the level of vertical and horizontal institutional integration (Ingold 2010; Luthe et al. 2012). For vertical integration all nodes within each generated network map were organized into one of four quadrants representing each spatial scale, which allowed for a visual examination of cross-scale institutional ties. Similarly for horizontal integration, nodes were sorted based on sectors. Next, systematic assessments of the level of vertical (cross-scale) and horizontal integration (cross-sector) were conducted independently using a four-step process (Figure 1).

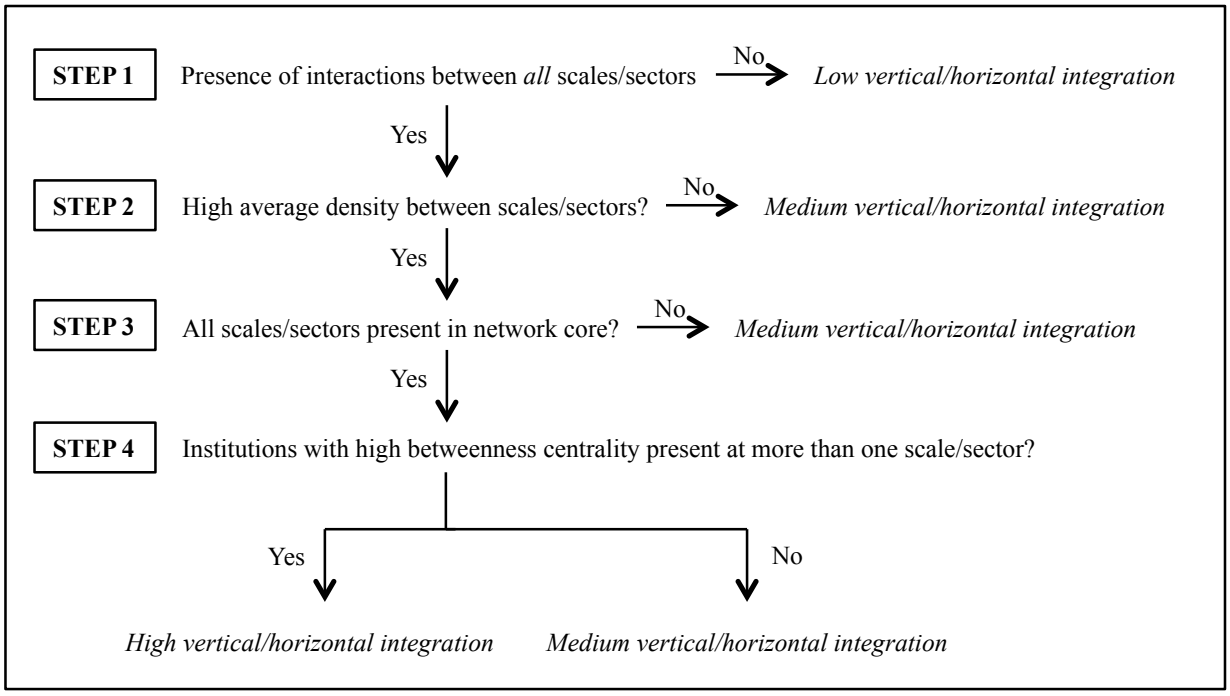

Figure 1. Systematic assessment of vertical and horizontal institutional integration

In step one institutional ties are examined between all scales/sectors. The absence of ties between any two scales/sectors represents low integration since there is a disruption in cross-scale/sectoral communication flow. Step two involves calculating the average density for each set of cross-scale/sectoral interactions (e.g. local and national or financial and technical-scientific). If ties exist between all scales/sectors yet there is low average density between scales/sectors, then there is a medium level of integration. Step three involves an examination of the core-periphery structure of each network, which attempts to determine which nodes form the densely connected network core and which are part of the sparsely connected periphery (Borgatti et al. 2013). Core nodes are well-connected to peripheral nodes, but the latter are not well-connected to core nodes or to each other. Although there may be the presence of ties between all scales/sectors and high cross-scale/sector density, the exclusion of certain scales/sectors from the network's core impacts power and influence of associated institutions on network dynamics. It

was therefore determined that in these instances, there is a medium level of integration of the institutional network as well. In step four the scales/sectors at which high betweenness centrality nodes exist are identified. Institutions with high betweenness centrality found across multiple scales/sectors, in addition to ties between all scales/sectors, high cross-scale density, and all scales/sectors found within the network core, qualify a network as having high vertical/horizontal integration.

3.3. Results

Institutional network maps and associated network measures are presented for the different phases of the desalination plant project in the community of Paget Farm. Following an overview of the general network characteristics, the levels of vertical and horizontal network integration over time are assessed.

3.3.1. General network characteristics

The number of institutions that formed the main component of the networks varied between 17-21 (out of a possible 23) throughout the different phases[3] (Table 1). The overall network density ranged between 22.9% and 41.5%, with the densest network being the development phase and the least dense being the post-project phase. Institutions were tied on average to between 4.8 and 7.5 institutions; the operational phase had the lowest average degree and the development phase the highest. Network centralization varied widely between the different phases, with the planning (39.18%) and operational (77.06%) phases having lowest and highest respectively. Three institutions emerged as central nodes (as measured by betweenness centrality) although to

[3] Network ties were non-directed which assumes reciprocity of organizational contact. Therefore organizations that did not participate in the survey could still be included in the networks produced if a survey respondent identified contact with those organizations.

varying degree during the different phases of the desalination plant implementation: the regional implementing institution (R1), the national implementing institution (N1), and a national institution responsible for the oversight of the Vincentian government's involvement in Bequia (N2; Figure 2). R1's betweenness centrality was low during the pre-project and planning phases but increased in prominence during the development phase of the project to its maximum during the operational phase of the project. R1 also maintained a central position within post-project network (4th most central institution). N2 was the most central institution in the pre-project and planning phases of the project—a position that decreased in importance during the development and operational phases of the project but increased again during the post-project phase. Although N1 never became the most central node in any network, the institution maintained a consistently high betweenness centrality (top 3) throughout all but the planning phase of the project when it decreased to the 7th position.

Table 2. Descriptive network data and statistics of the institutional network maps representing the five phases of the desalination plant project.

	Phase				
	Pre-project	Planning	Development	Operational	Post-project
Total no. of nodes[4]	20	17	19	**21**	19
Total no. of ties	125	118	**142**	101	116
Network density (%)	24.7	23.3	**41.5**	24.0	22.9
Average degree	5.435	5.130	**7.474**	4.810	5.043
Network centralization (%)	47.40	39.18	53.46	**77.06**	54.55
Highest betweenness centrality	N2	N2	R1	**R1**	N2

Note: Results in bold represent the highest value for the given category.

[4] Total number of nodes within the network's main component. In all five phases there were no minor components, only isolates.

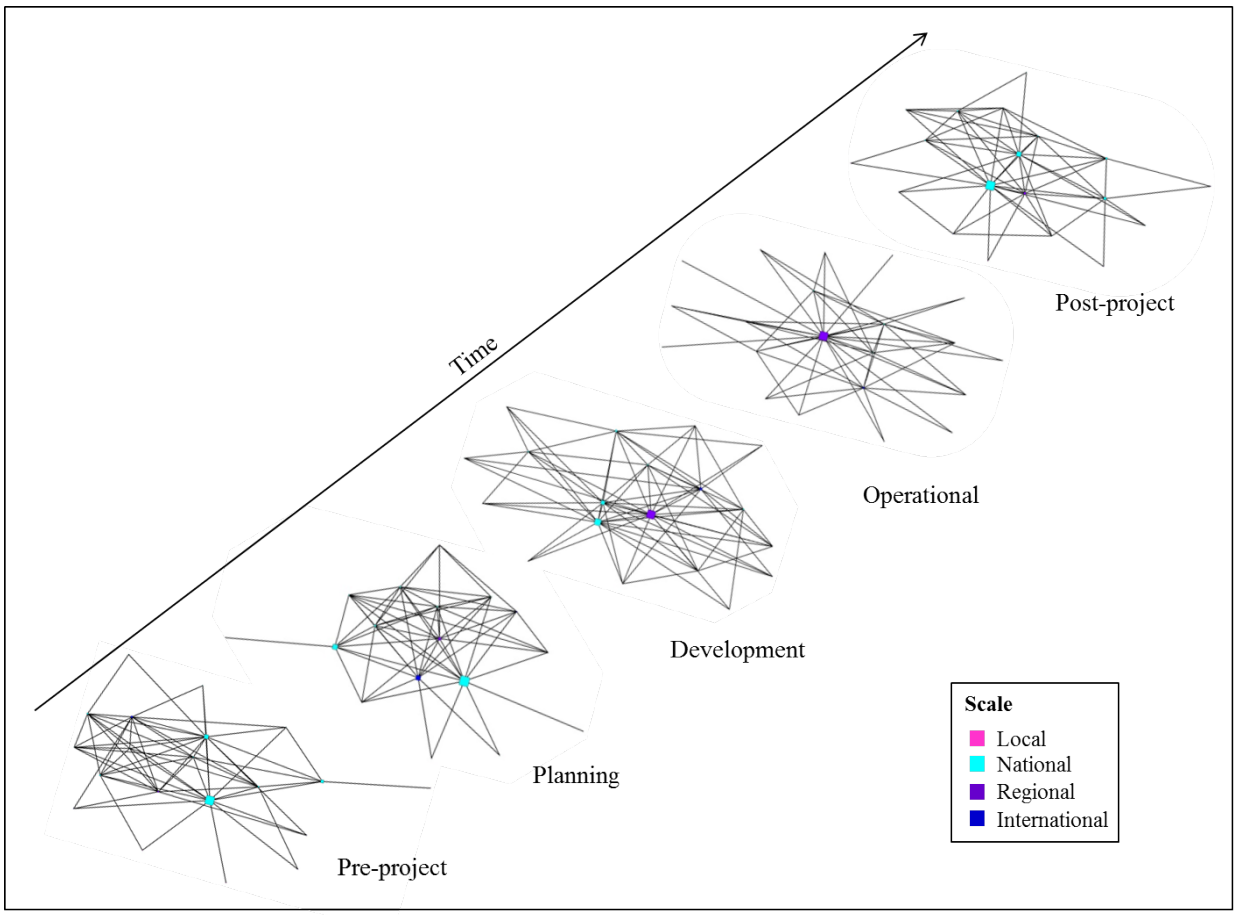

Figure 2. Institutional network maps representing contact between institutions involved in the different phases of the desalination plant project implementation. The ties are undirected and nonvalued, and the node size is a function of betweenness centrality. Colours represent different spatial scales (local, national, regional, and international). The networks were visualized using the Spring Embedding Layout algorithm in NetDraw (Borgatti 2002). Figure adapted from Tang et al. (2010).

While correlation between the planning-development-operational phases increased incrementally, more radical change occurred between those phases and the pre- and post-project (Table 2). Pre- and post-project networks had the highest correlation to each other (QAP correlation = 0.734; p-value < 0.001). Only the institutions that were in contact with each other prior to the start of the project (pre-project phase) maintained contact after project completion (post-project phase). All but two institutions, a local (L1) and international (I4) institution, were in contact with each other prior to the start of the project. L1 became involved in the project

during the planning phase and maintained contact until the operational phase, while I4 was involved only during the operational phase of the project. Although the number of total ties decreased between the pre- and post-project phases, new ties were formed and maintained between institutions involved in the project while other ties were lost (Figure 1; Table 1). The decrease in total ties is largely due to the complete loss of contact between one international consultancy institution (I2) and the rest of the network.

Table 3. Intercorrelations between the institutional networks representing the five phases of the desalination plant project implementation.

	Phase				
	Pre-project	Planning	Development	Operational	Post-project
Pre-project	1**	0.703*	0.598**	0.382**	0.734**
Planning	0.703**	1**	0.597**	0.331*	0.5**
Development	0.598**	0.597*	1**	0.615**	0.686**
Operational	0.382**	0.331*	0.615**	1**	0.511**
Post-project	0.734**	0.5**	0.686**	0.511**	1**

*$0.001<p<0.002$
**$p<0.001$

3.3.2. Vertical and horizontal institutional integration

The levels of vertical institutional integration varied throughout the different phases of the desalination plant project, while a low level of horizontal integration was found for all institutional networks (Table 3). During the pre- and post-project phases, there was a low level of vertical integration due to a lack of contact between all scales (Figure 3). During the pre-project phase, there were no interactions between the local-regional and the local-international scales. Similarly during the post-project phase, there was no contact between local-international scales yet a single tie between a local construction company (L3) and the regional implementing agency (R1) was formed and maintained beyond project completion. The planning and

operational phases of the project saw a large increase in vertical integration. Although the operational phase represented a more centralized network around node R1 in comparison to other networks, a high level of vertical integration was observed due to the presence of ties between all scales; a high average cross-scale density; all institutions being present in the network core; and high betweenness centrality institutions spanning multiple scales. The development phase saw a medium level of vertical integration, attributable to the absence of local institutions within the network core.

Table 3. Summary of institutional network integration

Network integration	Phase				
	Pre-project	Planning	Development	Operational	Post-project
Vertical	Low	High	Medium	High	Low
Horizontal	Low	Low	Low	Low	Low

(Refer to Figure 1)

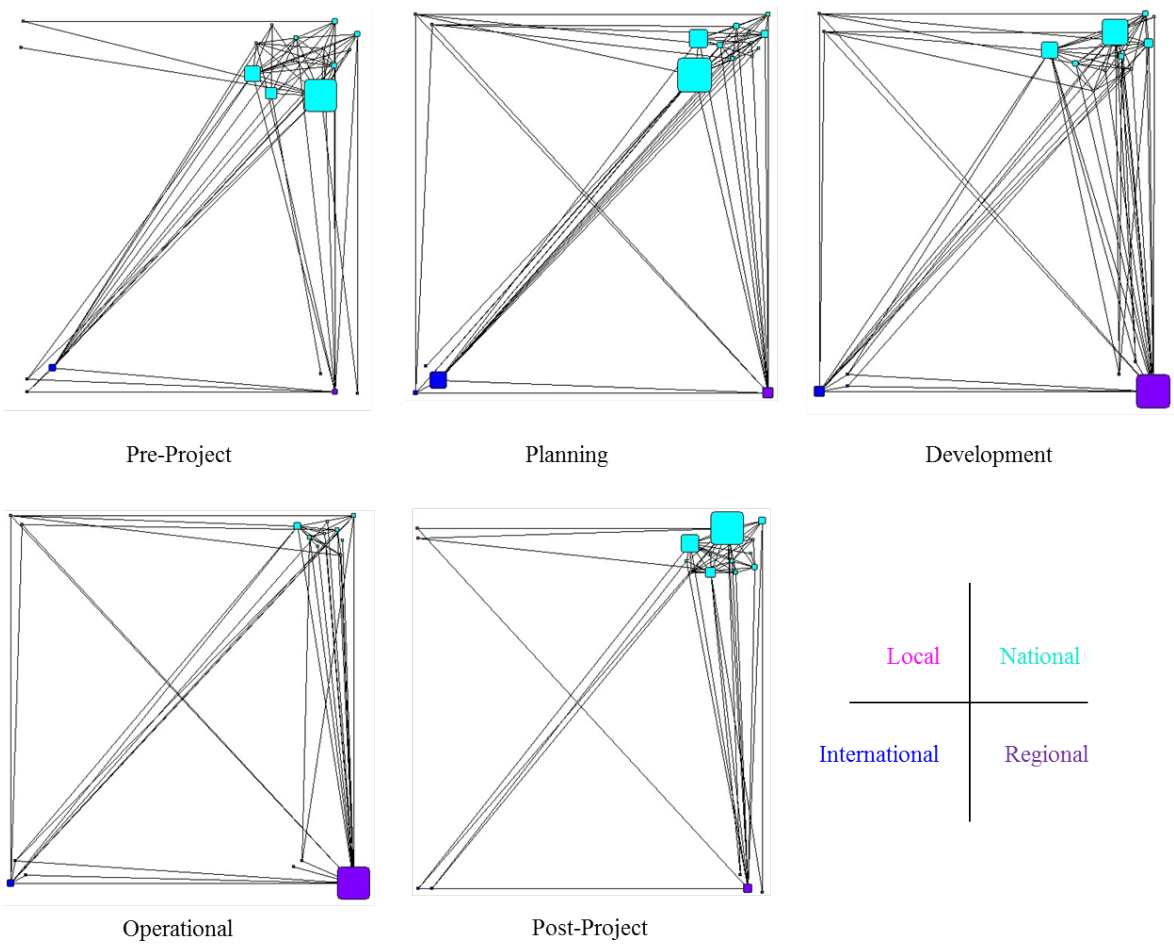

Figure 3. Institutional network maps representing contact between institutions across spatial scales. The ties are undirected and nonvalued, and the node size is a function of betweenness centrality. Colours represent different spatial scales (local, national, regional, and international). All nodes were organized into one of four quadrants representing each spatial scale (clockwise top left from local to international) in NetDraw (Borgatti 2002).

The level of horizontal network integration was consistently low throughout the different project phases (Table 3). This low integration was attributed to the lack of ties between all sectors (Figure 4). The financial sector was the least well connected to other sectors, with no ties found with the construction/manufacturing sector during the pre-project, planning, and operational phases, and with the technical/scientific sector during the development, operational, and post-project phases. No nodes from the financial sector were present in the network's core, nor did they have high betweenness centrality.

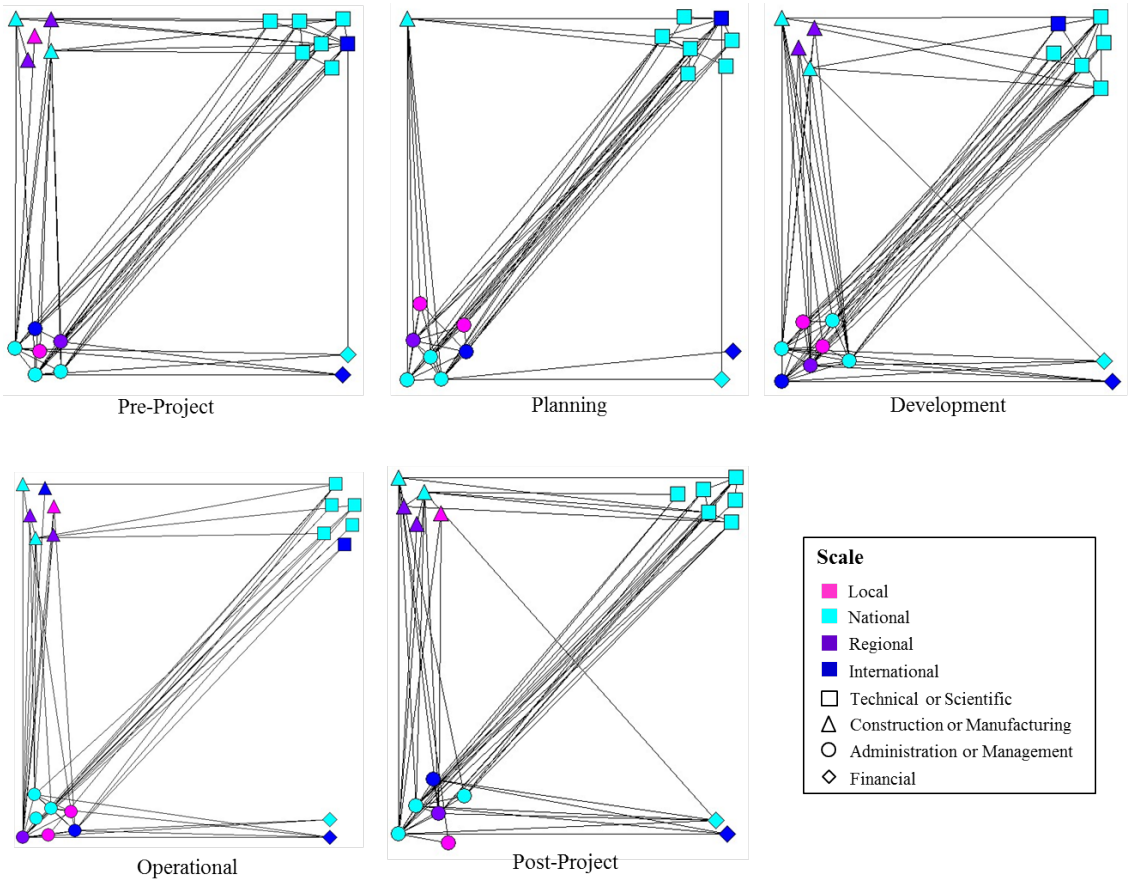

Figure 4. Institutional network maps representing contact between institutions across sectors. The ties are undirected and nonvalued, the colours represent different spatial scales (local, national, regional, and international) and the node shapes reflect the sectors involved. All nodes were organized into one of four quadrants representing a different sector in NetDraw (Borgatti 2002).

Following the complete network analysis, the nodes representing the financial sector were removed and the analysis was repeated to better examine the level of horizontal integration during the different phases of the desalination plant project (Figure 5; Table 4). It was found that there was a high level of horizontal integration between the remaining three sectors during the pre-project, planning and development phases. A medium level of horizontal integration was observed during the operational and post-project phases due to high centrality nodes not being present across sectors. The level of cross-sector interactions remained relatively consistent throughout the five phases with the exception of a low density between the technical/scientific

and construction/manufacturing sectors during the planning phase. The sector with the most ties was the administration/management sector, which itself had the highest number of cross-sector ties with the technical/scientific sector during all phases followed by construction/manufacturing. However proportionally, as measured through network density, the level of cross-scale interactions varied. While interactions between the administration/management and technical/scientific sectors were densest during the pre-project and planning phases, they were densest between the administration/management and financial sectors during the development, operational and post-project phases. All sectors were found within the network's core throughout the different phases of project implementation.

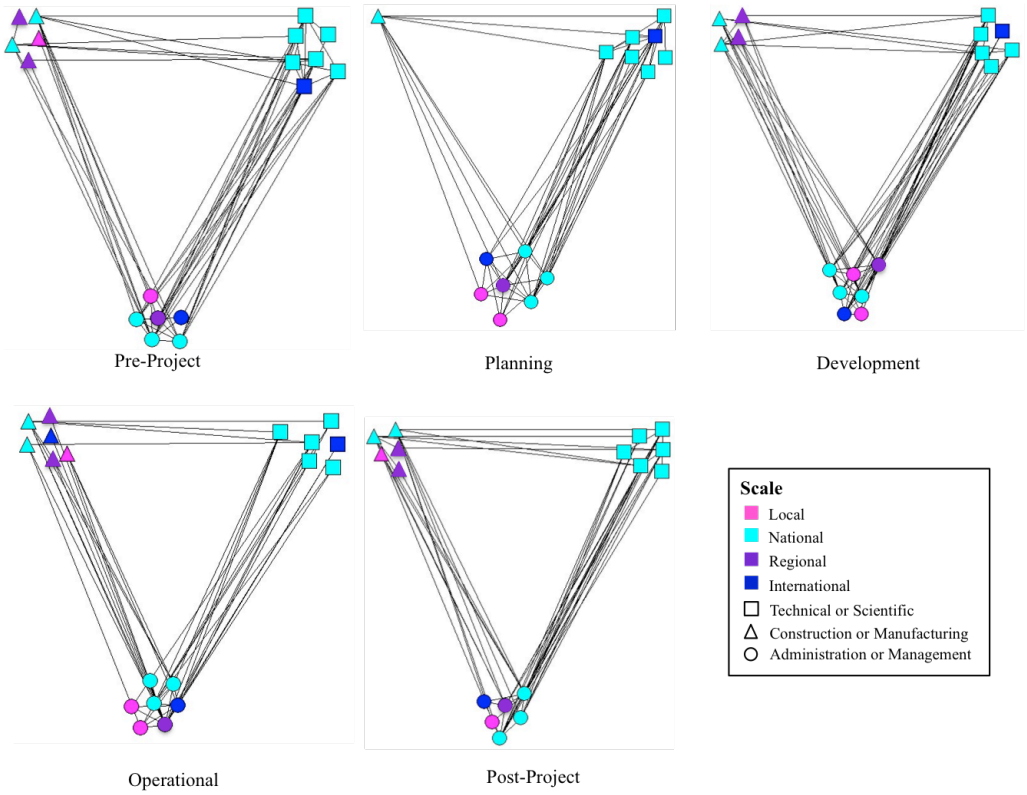

Figure 5. Institutional network maps representing contact between institutions across sectors with the removal of the financial sector. The ties are undirected and nonvalued, the colours represent different spatial scales (local, national, regional, and international) and the node shapes reflect the sectors involved. All nodes were organized into one of three sections representing a different sector in NetDraw (Borgatti 2002).

Table 4. Horizontal institutional network integration without the financial sector

Network integration	Phase				
	Pre-project	Planning	Development	Operational	Post-project
Horizontal	High	High	High	Medium	Medium

3.4. Discussion and conclusion

Climate change will undoubtedly continue to pose serious threats to Caribbean small island communities throughout the 21st century. While climate change is felt locally, adaptation involves complex processes that interact across scales and sectors and also change over time. Increasingly, networks of actors and institutions are collectively implementing adaptation strategies that aim to address climate change impacts that are often manifested at the local level. This research contributes to the limited body of literature that exists on institutional networks and adaptive capacity by empirically examining the role of vertical and horizontal integration in the implementation of a climate change adaptation strategy as the networks of institutions involved changed over time. Previous studies assessing static networks have suggested that high vertical and horizontal integration leads to high adaptive capacity by facilitating the flow of knowledge, information and resources between scales and sectors (Ingold et al. 2010). However it was found that while high vertical integration was observed during the planning and operational phases of the desalination plant project, this decreased to a medium level of integration during the development phase. In contrast, a low level of horizontal integration was shown throughout the project's implementation due to the lack of cross-sector interactions with the financial sector. While more variability in vertical integration may be observed over time, a lower but more consistent level of horizontal integration may contribute to high adaptive capacity. Similar to Bodin et al. (2006) who propose to build on existing institutional network theory by incorporating temporality, the findings suggest that the high integration of institutions

between scales and sectors may not be required during all project phases for successful adaptation.

Vertical integration, especially in small island communities where resources to undertake larger adaptation initiatives can often be limited, contributes to the ability of project stakeholders to coordinate and tap into resources that exist outside the scale at which they operate. A high level of integration may be required during the planning phase of project implementation as it sets the foundations to bring an adaptation strategy to successful completion. The proper conceptualization prior to the start of any project is an important component to its sustainability, which may be facilitated by high interactions between institutions (Tacconi 1997). High vertical integration also allows for the better the incorporation of local and scientific knowledge spheres during the initial phase of project implementation, which can in turn help promote local-level legitimacy and equity (Adger et al. 2005). Upon completion of the planning of adaptation projects however, the same level of integration may not be required. Development may be the phase to effectively streamline the process by reducing the level of contact between institutions. For example, while main implementing agencies may remain in contact throughout the development phase of the project, more technical and peripheral institutions may only need to interact with the implementing agency found at their respective scales. This may be sufficient for the successful implementation of adaptation projects provided these peripheral institutions obtain required information from and deliver sufficient input to institutions outside their own scale during the planning phase of projects; and the institutions that do maintain cross-scale contact possess central positions within the network capable of adequately communicating or brokering between these institutions during the development phase.

Previous research suggests a high level of horizontal integration linked to high adaptive capacity (e.g. Ingold et al. 2010), however the results presented here provide new insights into institutional network dynamics. Low integration was observed due to the lack of direct ties between the financial sector and certain sectors. While this lack of interaction may pose a barrier, direct contact between the financial sector and all other sectors may not always be required if there are institutions playing central roles within the networks to coordinate and communicate effectively across sectors. The three most central institutions (R1, N1, and N2) were found in the administration/management sector, which was the most well connected sector and was also in direct contact with the financial sector throughout implementation. Financial institutions involved in climate change adaptation in small island communities typically represent international donor agencies such as the Global Environment Facility and the World Bank (AOSIS 2008). Using the principle of common but differentiated responsibility, financial resources provided to these institutions by high-income countries are meant to address the disproportionate impacts of climate change in low-income countries and communities that are among the least responsible for the causes of climate change. It may not be necessary or beneficial for these institutions to be highly integrated and central in institutional networks involved in adaptation strategies. The three other sectors involved in the desalination plant project (administration/management, technical/scientific, and construction/manufacturing) displayed a relatively high and consistent level of cross-scale interactions throughout the different phases. These findings suggest that a more detailed characterization of the level of integration between types of sectors may be more important than the need for all sectors to be in contact during every phase of project implementation. Furthermore, the findings suggest that a

consistent rather than high level of horizontal integration may be required to facilitate successful adaptation.

The examination of institutional networks prior to the start of and after the completion of the adaptation strategy provided insights on their role in contributing to the adaptive capacity of local communities. It is difficult to assess any social network without first knowing the structure of the networks that preceded it (Doreian 2001). As shown in this research, institutions that play central roles prior to the start of adaptation strategies may control or influence how subsequent networks unfold. When institutions play a brokerage role in pre-project networks, they are in positions to control the flow of information and knowledge, which has implications on what other institutions have access to the project (e.g. which consulting firm or construction company to hire); and the level of involvement by institutions only in contact with that institution. Institutions that display high centrality prior to the start of a project's implementation have access to a pre-established network of contacts that may also be important to the development of relationships of trust between local residents and local institutions, and institutions operating at other scales. Trust is an important component of building networks of constructive engagement in order to, for example, resolve conflicts and ensure local institutions and individuals are well represented at higher scales (Adger 2003). Furthermore, trust may be critical for the successful implementation of adaptation projects in cases where many local institutions are peripheral within a network and may not have direct contact with, for example, international implementing institutions. These local institutions must rely on high-centrality institutions to act as gatekeepers and thus adequately represent their best interest. It therefore appears of critical importance to engage with these institutions when implementing projects due to not only the pre-established network they possess but also the relationships of trusts that may have been developed.

Conversely for institutions that do not have pre-existing ties with local institutions seeking to implement adaptation projects, existing relationships based on trust are more likely to foster the acceptance of projects that are developed and implemented at higher scales but that have direct implications on local residents and institutions.

The findings also support the notion that local systems do not operate in isolation from but rather are connected to those operating at higher scales (Adger et al. 2008; Eakin et al. 2009), often in a non-hierarchical manner (Eckerberg & Joas 2004). This suggests that although local communities and their institutions may be limited in terms of the resources and capacity to adapt to global climate change impacts alone, they may have access to institutions that are able to implement adaptation strategies relevant at the community level. As Adger (2003) argues, the collective action required to adapt to climate change is dependent on the flows of information between individuals and institutions. He suggests that some groups may be less vulnerable to climate change than modeling studies suggest since many aspects of adaptive capacity reside in networks. However it is important to highlight that although local institutions may be in cross-scale contact with institutions operating outside the local sphere, contact alone does not guarantee power, influence or decision-making ability as it relates to climate change adaptation. SNA measures such as betweenness centrality are useful and practical tools to help assess the position of institutions within networks and how those positions influence the flow of information. As it was shown in this research, cross-scale contact existed for local institutions in this research however they did not represent central institutions within the generated networks. Although the level of local involvement needed is context- and project-specific (Thompkins, Adger & Brown 2002), it is important to reflect on what roles local institutions are and should be playing in the implementation of local-level climate change adaptation strategies. In any case, it

is of prime importance that local institutions are in positions that allow them to help define the nature and direction of adaptation strategies so as not to be detrimental to the autonomy and resilience of local stakeholders (Berkes 2002) while facilitating local stakeholder involvement and therefore more equitable outcomes.

This research provides insight into the role of networks in contributing to the ability of Caribbean small island communities to adapt to climate change. The findings presented here indicate that there is value in using a Social Network Analysis lens to assess the role of institutional networks in contributing to local-level adaptive capacity in the Caribbean. Furthermore, it has also been shown that a temporal approach offers a more detailed, fine-grained analysis and understanding of the dynamic nature of institutional networks. While this research is exploratory in nature, it suggests that research into institutional network dynamics using SNA can lead to further insights into climate change adaptive capacity. Through such temporal examinations of institutional networks we may better understand current institutional network dynamics of Caribbean small island communities to help design more appropriate and effective networks as local communities move towards implementing sustainable strategies that address climate change impacts in a way that is effective, efficient, legitimate and equitable.

References:

Adger, W.N. (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography*, 79, 387-404.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, 15, 77-86.

Adger, W.N., Brooks, N., Bentham, G. et al. (2004). New indicators of vulnerability and adaptive capacity. Technical Report 7 prepared by the Tyndall Centre for Climate Research.

Adger, W.N., Eakin, H. and Winkels, A. (2008). Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment*, 7, 150-157.

Agrawal, A. (2008). The role of local institutions in adaptation to climate change. Paper prepared for the Social Dimensions of Climate Change, Social Development Department, The World Bank. Washington DC, March 5-6, 2008.

AOSIS. (2008). Global climate change and small island developing states: financing adaptation. Green paper prepared by the Alliance of Small Island States and the United Nations Foundation. February 5, 2008.

Berkes, F. (2002). Cross-scale institutional linkages for commons management: Perspectives from the bottom up. In E. Ostrom, T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, E.U. Weber (Eds.), *The Drama of the Commons*. Washington: National Academy Press (pp. 293-321).

Bodin, O. and Crona, B. (2009) The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, 19, 3, 366-374.

Bodin, O., Crona, B., and Ernstson, H. (2006). Social networks in natural resource management: What is there to learn from a structural perspective? *Ecology and Society*, 11 (online).

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). *UCINET 6 for Windows: Software for Social Network Analysis*. Boston: Analytic Technologies.

Borgatti, S.P. and Halgin, D.S. (2011). On Network Theory. *Organization Science*, Articles in Advance, 1-14.

Borgatti, S.P., Everett, M.G. and Johnson, J.C. (2013). *Analyzing social networks.* London: Sage Publications Limited.

Brooks, N. and Adger, W.N. (2005). Assessing and enhancing adaptive capacity. In B. Lim and E. Spanger-Siegfried (Eds.), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures*. United Nations Development Program, Global Environment Facility. Cambridge: Cambridge University Press (pp. 165-181).

Brown, H.C.P., Nkem, J.N., Sonwa, D.J., and Bele, Y. (2010). Institutional adaptive capacity and climate change response in the Congo Basin forests of Cameroon. *Mitigation and Adaptation Strategies for Global Change*, 15, 263-282.

Bueno, R., Herzfeld, C., Stanton, E.A., et al. (2008). The Caribbean and climate change: The costs of inaction. U.S. Global Development and Environment Institute, Tufts University.

Chang, Y.M. and Desai, A. (2001). Local control, local capacity and regulatory effectiveness: Issues in municipal water pollution control. In M.R. Daniels (Ed.), *Creating sustainable community programs: Examples of collaborative public administration.* Westport: Praeger Publishers (pp. 176–191).

Crona, B. and O. Bodin. (2006). What you know is who you know? Communication patterns among resource users as a prerequisite for comanagement. *Ecology and Society*, 11 (online).

Davies, A.R. (2005). Local action for climate change: Transnational networks and the Irish experience. *Local Environment*, 10, 21-40.

De Nooy, W. (2008). Signs over time: statistical and visual analysis of a longitudinal signed network. *Journal of Social Structure*, 9.

Dixit, A., McGray, H., Gonzales, J., and Desmond, M. (2012). Ready or not: Assessing institutional aspects of national capacity for climate change adaptation. World Resources Institute. Washington: WRI.

Doreian, P. (2001). Causality in social network analysis. *Sociological Methods and Research*, 30, 81-114.

Durrant, S., Nurse, L. and Stoddard, A. (2008). Monitoring the effects of below average precipitation on water resources in Paget Farm, Bequia, the Grenadines. Technical Report No. 22 prepared for the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados.

Eakin, H., Tompkins, E.L., Nelson, D.R. and Anderies, J.M. (2009). Hidden costs and disparate uncertainties: trade-offs involved in approaches to climate policy. In W.N. Adger, I. Lorenzoni, K. O'Brien (Eds.), *Adapting to climate change: thresholds, values, governance*. Cambridge: Cambridge University Press.

Eckerberg, K. and Joas, M. (2004). Multi-level environmental governance: a concept under stress? *Local Environment*, 9, 405–412.

Engle, N.L. (2011). Adaptive capacity and its assessment. *Global Environmental Change*, 21, 647-656.

Engle, N.L. and Lemos, M.C. (2010). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*, 20, 4-13.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12, 219-245.

Folke, C., Hahn, T., Olsson, P. and Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review on Environmental Resources*, 30, 441-473.

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, 78, 1360-1380.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91, 481-510.

Green, E. (2012). *Special Programme for Adaptation to Climate Change (SPACC). Implementation of adaptation measures in coastal zones.* Technical Note 5C/SPACC-12-05-01 prepared by the Caribbean Community Climate Change Centre, the Global Environment Facility, and the World Bank.

Gupta, J., Termeer, C., Klostermann, J., et al. (2010). The adaptive capacity wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy*, 13, 459-471.

Ingold, K., Balsiger, J. and Hirschi, C. (2010). Climate change in mountain regions: How local communities adapt to extreme events. *Local Environment*, 15, 651-661.

Ingold, K. (2014). How involved are they really? A comparative network analysis of the institutional drivers of local actor inclusion. *Land Use Policy*, 39, 376-387.

IPCC. (2014). Small Islands. In C.B. Field, V.R. Barros, D.J. Dokken, et al. (Eds.), *Climate change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press (pp. 1-60).

Ivey, J.L., Smithers, J., De Loë, R.C., and Kreutzwiser, R.D. (2004). Community capacity for adaptation to climate-induced water shortages: Linking institutional complexity and local actors. *Environmental Management*, 33, 36-47.

Jaja, J. and Dawson, J. (2014). What contributes to climate change adaptive capacity? A retrospective case study in a Caribbean small island community. In W. Leal (Ed.), *International perspectives on climate change: Latin America and beyond*. New York: Springer.

Jury, M.R. and Winter, A. (2010). Warming of an elevated layer over the Caribbean. *Climatic Change*, 99, 247-259.

Keskitalo, E.C.H. (2008). *Climate change and globalization in the Arctic. An integrated approach to vulnerability assessment.* London: Earthscan.

Keskitalo, E.C.H. (2010). Adaptation to climate change in Europe: Theoretical framework and study design. In E.C.H. Keskitalo (Ed.), *Developing adaptation policy and practice in Europe: Multi-level governance of climate change*, London: Springer (pp. 1-38).

Leichenko, R., Thomas, A. and Barnes, M. (2010). Vulnerability and adaptation to climate change. In C. Lever-Tracy (Ed.), *Routledge handbook of climate change and society*, London: Routledge (pp. 133-151).

Luthe, T., Wyss, R. and Schuckert, M. (2012). Network governance and regional resilience to climate change: empirical evidence from mountain tourism communities in the Swiss Gotthard region. *Regional Environmental Change*, 12, 839-854.

Mikwitz, P., Aix, F., Beck, S., et al. (2009). *Climate policy integration, coherence and governance*. PEER Report No 2, Helsinki: Partnership for European Environmental Research.

Oh, H., Chung, M.-H., and Labianca, G. (2004). Group social capital and group effectiveness: The role of informal socializing ties. *Academy of Management Journal*, 43, 486-501.

Olsson, P., Folke, C. and Hahn, T. (2004). Social-ecological transformation for ecosystem management: The development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society*, 9, [online] URL: http://www.ecologyandsociety.org/vol9/iss4/art2/

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. The political economy of institutions and decisions. Cambridge: Cambridge University Press.

Pahl-Wostl, C. (2009). A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19, 354–365.

Rotberg, F.J.Y. (2013). Social networks, brokers, and climate change adaptation: A Bangladeshi case. *Journal of International Development*, 25, 599-608.

Sandström, C. (2009). Institutional dimensions of comanagement: Participation, power, and process. *Society and Natural Resources*, 22, 230-244.

Scott, J. (2000). *Social network analysis*. London: Sage Publications Limited.

Scott, J. (2013). *Social network analysis: A handbook* (3rd edition). London: Sage Publications Limited.

Smit, B. and Pilifosova, O. (2001). Adaptation to climate change in the context of sustainable development and equity. In: J.J. McCarthy, O. Canziani, N.A. Leary, et al. (Eds.), *Climate change 2001: Impacts, adaptation and vulnerability*, IPCC Working Group II. Cambridge: Cambridge University Press (pp. 877-912).

Snijders, T.A.B. (2005). Models for longitudinal network data. In P.J. Carrington, J. Scott & S. Wasserman (Eds.), *Models and methods in social network analysis*. Cambridge: Cambridge University Press (pp. 215-247).

Soldatos, P. and Michelmann, H.J. (1992) Subnational units' paradiplomacy in the context of European integration. *Journal of European Integration*, 15, 129-134.

Statistical Office. (2001). *Population and housing census database.* Ministry of Finance and Economic Planning, Government of Saint Vincent and the Grenadines. Retrieved February 4, 2013, from http://celade.cepal.org/svgbin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=SVG2001&MAIN=WebServerMain.inl

SurveyGizmo. (2014). *SurveyGizmo*. Retrieved on July 14, 2014, from http://www.surveygizmo.com/

Tacconi, L. (1997). An ecological economic approach to forest and biodiversity conservation: The case of Vanuatu. *World Development*, 25, 1995-2008.

Tang, J., Musolesi, M., Mascolo, C., et al. (2010). Analysing information flows and key mediators through temporal centrality metrics. In Proceedings of the Third Association for Computing Machinery Workshop on Social Network Systems. Colocated with ACM SIGOPS EuroSys'10, Paris, France, April 2010.

Thompkins, E., Adger, W.N. and Brown, K. (2002). Institutional networks for inclusive coastal management in Trinidad andTobago. *Environment and Planning,* 34, 1095-1111.

Weimann, G. (1982). On the importance of marginality: One more step into the two-step flow of communication. *American Sociological Review*, 47, 764-773.

Whitbred, R. (2011) Quadratic Assignment Procedure (QAP). In G.A. Barnett (Ed.), *Encyclopedia of Social Networks.* London: Sage Publications Limited (pp. 733-735).

Young, O.R. (2002). The Institutional dimensions of environmental change: Fit, interplay, and scale. London: The MIT Press.

CHAPTER FOUR

Summary and Conclusion

4.1. Introduction

Climate change is arguably the single largest threat to human society and will be especially pronounced in Caribbean small island communities (IPCC 2014a). The compounding effects of climate change on pre-existing sustainable development challenges underscore the urgency to develop adaptation strategies and policy that minimize local-level risks and importantly, increase the ability of small island communities to respond to a changing climate (Adger et al. 2003). This research took a mixed-methods case study approach to understand how various internal (i.e. local) and external (i.e. non-local) factors can interact to facilitate and enhance climate change adaptive capacity in Caribbean small island communities. Using semi-structured interviews and a network survey, the factors that led to the implementation of a solar-powered desalination plant in the community of Paget Farm, Saint Vincent and the Grenadines were retrospectively examined. This final chapter summarizes the findings according to the four objectives of the study, followed by a discussion of the research contributions and limitations, and suggestions for future research.

4.2. Summary of findings

Objective 1: Trace the development and implementation of climate change adaptation projects in Paget Farm (historical context)

Due to the retrospective nature of the research, a comprehensive review and analysis of climate change adaptation projects in Paget Farm was necessary to better understand the community's adaptive capacity. One of the limitations of much of the previous research is its assessment of the

determinants of adaptive capacity prior to the implementation of specific climate adaptation projects. Examining community-based adaptive capacity prior to the implementation of an adaptation project results in a speculative analysis that may or may not be legitimate or accurate (Engle 2011). To overcome this challenge, an in-depth single case-study assessment of implemented adaptation projects in Paget Farm was undertaken. The focus was to identify the set of causal factors that made possible the successful completion of these projects (Blatter & Haverland 2012). This objective was addressed by first reviewing project documents and related literature on climate change adaptation in Paget Farm. Semi-structured interviews were subsequently conducted with both local residents of Paget Farm and key informants to allow for a better contextualization of project documentation; and to confirm and triangulate the findings. According to discussions with research participants and the reviewed literature, the only adaptation project implemented in the community was the solar-powered desalination plant project.

Objective 1 set the foundation for the remainder of the research, notably for Chapter 2, which involved qualitatively identifying the institutional and social determinants of adaptive capacity. A summary of the development and implementation of the desalination plant project is provided in the case study background of that chapter.

Objective 2: Generate an inventory of institutions and project stakeholders involved in project development and implementation

Through a review of project documents and relevant literature, and snowball sampling, a large number of institutions were found to be involved during the different phases of desalination plant project implementation (n=23). While the institutions were found to be operating at all spatial scales and also represented a diverse range of sectors, the large majority were national-level

institutions (n=12) from the administration/management and technical/scientific sectors. Local institutions represented the smallest number of institutions (n=3) representing the administration/management and construction/manufacturing sectors. An equal number of regional (n=4) and international (n=4) institutions were found across all sectors. This multi-scale, multi-sector initiative to implement a climate adaptation project in a local community provided an ideal case study to investigate the role of institutional networks in influencing local-level adaptive capacity.

The identification of the institutions and key project stakeholders involved in the adaptation project, combined with an in-depth review of project development and implementation provided me with the foundation needed to achieve both Objectives 3 and 4.

Objective 3: Identify the relative importance of internal and external factors contributing to project development and process

It takes a combination of internal and external factors dynamically interacting for local communities to successfully adapt to the impacts of climate change. The semi-structured interviews with project stakeholders revealed a number of factors that influenced project outcomes in Paget Farm (Chapter 2). Several overarching factors operating outside the local sphere helped to create an enabling environment for adaptation. While financial resources and technology emerged as important in influencing adaptive capacity, they were not sufficient to ensure project success. The realistic expectations with regards to project outputs from funding agencies combined with the flexibility to use financial resources from different sources towards the same adaptation project were perceived by research participants as critical. It was also noted that adaptation projects should not only be housed within appropriate institutions, but also

include institutions capable of bridging knowledge and resources within a multi-scalar, multi-sectoral institutional network. In the same vein, the level of integration between institutions was perceived as key to mobilizing these resources and coordinating effectively. To further hone into the role of institutional network integration, Chapter 3 (Objective 4) focused on the level of vertical and horizontal linkages that existed between institutions during the different phases of the adaptation project.

While external factors can help enable communities to adapt, local factors and their within and cross-scale interactions, are of prime importance to the success of any local climate adaptation project. Throughout this research, individual and community-level agency to respond to environmental threats in Paget Farm were clearly highlighted. Irrespective of stakeholders' rationale—whether to address climate change impacts, environmental threats, or development concerns—adaptive capacity appeared to be facilitated and increased by reflecting local needs. Beyond addressing a specific need, the acceptance of the proposed adaptive solution and the level of community participation seemed to be of importance. Local residents who played formalized roles at other scales (e.g. national or regional) appear not only to help bridge communication between formalized institutions and local residents, but also to increase local buy-in and participation. Lastly, the relevance of community champions and overall leadership was perceived as the glue that holds external and internal factors together by helping steer adaptation projects to successful completion.

Objective 4: Assess the role of institutional networks in influencing project implementation

The role of institutional integration, or the linkages that exist between institutions, emerged from this research as a key component of adaptive capacity to climate change. In Chapter 2, it was

highlighted qualitatively by multiple key stakeholders that, especially in small islands, success appeared contingent upon a network of institutions in which the flow of resources and information is always encouraged and facilitated; and where consensus-building is promoted. It was further noted that the timing of key institutions' involvement seemed important, and details of the project should be communicated effectively and agreed upon early in the adaptation process.

In Chapter 3, institutional integration and temporality were further analyzed quantitatively. Through the use of Social Network Analysis (SNA), I visualized and examined the level of vertical (i.e. cross-scale) and horizontal (i.e. cross-sector) linkages between institutions. Although existing literature suggests that a high level of vertical and horizontal integration is needed for high adaptive capacity (Ingold 2010), the findings presented here provide new insights into the role of institutional networks in part through the incorporation of temporal dynamics. It was shown that the level of vertical integration varied over time during the implementation of the desalination plant project, with a high level of integration being found during the planning and operational phases while a decrease was observed during the development phase to a medium level. In contrast, low horizontal integration was observed during all project phases. These findings suggest that high institutional integration may not be required during all project phases, and temporality may play a more important role in vertical rather than horizontal integration.

4.3. Contributions of the study

This research made important theoretical and practical contributions to the field of climate change adaptation. The contributions presented below directly address the three main research gaps identified in the introductory chapter:

1. Research on local-level adaptive capacity does not always include external (i.e. non-local) dynamics directly into methodological frameworks;
2. Adaptive capacity is often studied speculatively prior to the implementation of specific adaptation projects; and
3. The role of institutional networks and their temporal dynamics in influencing local-level adaptive capacity is under-researched empirically.

Contribution 1: Embedding external dynamics directing within methodological frameworks

This study contributed to the growing body of work on climate change adaptation by responding to calls for research on the adaptive capacity of local communities to be reflective of processes and drivers than operate outside the local sphere (Wesche & Armitage 2010; Cameron 2012). This research not only acknowledged the role of external factors in influencing local-level adaptive capacity, but also sought to embed the forces, drivers and processes directly within the methodological framework. Using semi-structured interviews and a network survey, this was accomplished by assessing the role of national, regional (supra-national in the context of the Caribbean region) and international actors and institutions in facilitating and enhancing adaptive capacity in the community of Paget Farm. This case study was particularly ideal to assess multi-scalar dynamics since the adaptation project was implemented by a range of institutions operating at different scales yet addressed a locally-felt climate change impact.

Contribution 2: Overcoming the latency barrier to studying adaptive capacity

An important contribution of this thesis is its use of a retrospective case study to overcome the difficulty of studying adaptive capacity due to its latent property. This latency refers to adaptive capacity only being visible when a system is exposed to actual climate change impacts, making it

difficult if not impossible to study unless a community has successfully adapted (Smit et al. 2001; Engle 2011). Foundational research has used community responses to climate variability as proxies for their adaptive capacity to climate change (Adger et al. 2007; Bussey et al. 2010; Ford et al. 2010; Nielsen & Reenberg 2010). While these studies have provided us with useful insights on local-level adaptive capacity, communities are now presented with new and additional challenges as well as benefits in the face of climate change; making this approach increasingly problematic. This study is among the first to use a retrospective case study approach to assess the determinants of local-level adaptive capacity in a community that recently adapted to climate change. The approach allows for the integration of new factors that can enhance adaptive capacity, such as climate financing, growing climate change awareness, and new institutions mandated to help local communities adapt to climate change.

Contribution 3: Introducing temporality to examine the role of institutional networks in adaptive capacity

There has been a rise in theoretical research highlighting the role of institutional networks in climate change adaptive capacity. However empirical research has not enjoyed the same level of attention since institutional networks: (1) represent intangible formal and informal relationships that exist between and among scales and sectors; and (2) are dynamic and evolve over time. Recent studies have used SNA to study climate change adaptive capacity by visualizing and assessing quantitatively institutional networks (Ingold et al. 2010; Luthe et al. 2012; Rotberg 2013; Ingold 2014). While this research was exploratory in nature, it was novel in its use of SNA to investigate how relationships between institutions change over time during the implementation of adaptation projects. It also proposed a systematic approach to assessing the level of vertical

and horizontal integration using an SNA lens to assess the role of institutional networks in influencing local-level adaptive capacity. Furthermore, this research also showed that a temporal approach offers a more detailed, fine-grained analysis and understanding of the dynamic nature of institutional networks. Contrary to some of the existing literature, the findings of this research suggest that high integration of institutions between scales and sectors may not be required during all project phases for successful adaptation.

4.4. Limitations

The overall goal of the research was to generate useful knowledge on the determinants of climate change adaptive capacity by drawing conclusions that go beyond the case study. However, the scope of the study is limited by the nature of the research design, which involved carrying out an in-depth, retrospective assessment of one adaptation project within one community. Although the research revealed various interacting factors that contributed to the high adaptive capacity of Paget Farm, it is important to recognize that (a) there are many different pathways to similar social outcomes, and (b) the same causal factor may lead to different outcomes and effects in other communities (Blatter & Haverland 2012). Local-level adaptive capacity is not static but rather varies temporally and in function of the nature of the hazard, the system affected, and the context of the adaptation (IPCC 2014b). This means that not only is the combination of factors highlighted here specific to Paget Farm but that they may not be representative of all the factors contributing to the community's adaptive capacity since the latter was only assessed in relation to changes in rainfall patterns and the subsequent implementation of the desalination plant project. While the retrospective approach taken to assess adaptive capacity provides many theoretical benefits, it also lends itself to recall bias. Data collection took place over a year after the completion of the desalination plant project (2007-2012), which may have impeded on the

ability of research participants to recall the sequence of certain events or important factors that may have influenced the adaptation process. This however seemed to be less of a limitation for individuals most involved and invested in the project than for those less intimately involved. Research participants were encouraged to review internal project files and e-mail exchanges prior to their interview and the completion of the network survey to reduce the impacts of this limitation. The findings were also triangulated between research participants and with available project documentation.

Specific to the data collection process of the research, there was an under-representation of international interviewees and survey respondents, as well as institutions from the financial sector. While the individuals most involved in the project within the institutions involved were targeted, it was not always possible to obtain an interview or to have them complete the survey for several reasons, including: being out of town (either temporarily or permanently); no longer being employed at the same institution; and generally easier access to local and national stakeholder than those considered at the regional or international scales. It would have also been ideal to have participants first complete the survey, followed by a preliminary analysis of the results obtained, and subsequently conduct a semi-structured interviewed with the same participant. While it would have allowed for a more contextual understanding of the institutional linkages (Chapter 2 and 3), this process presented several challenges logistically; notably the general reluctance to complete a fairly lengthy survey prior to participants getting to know me and understanding my research goals. Also with regards to the network survey, a limitation was the lack of defined timeframes for each project phase. While each phase was clearly described, respondents may have interpreted these phases differently based on the timing of their own

involvement within the project. For example, an individual working in a construction company may have considered the development phase of the entire project to be their "planning" phase.

It is also important to mention my positionality and subjectivity in the research, how they may have influenced this research, and how I attempted to address the associated limitations. I am an outsider to the community of Paget Farm, Saint Vincent and the Grenadines, and the Caribbean region in general. This may have impacted the types of interactions and conversations had with local residents and various individuals involved in the adaptation process in many ways. First and most evident was my lack of familiarity with Vincentian English and its many expressions. Second, Caribbean history, politics and social dynamics are complex and intertwined, and my understanding of their nuances and intricacies barely scratches the surface. I acknowledge this as a limitation to my contextualization and interpretation of the findings presented in this research. Along the same vein and importantly, colonialism and its legacies are an indelible part of the Caribbean region, which makes my positionality as a white North American researcher (likely to benefit from the research process) all the more important to mention. Although I do not know to what extent, I am conscious that it affected (at times limited but most often facilitated) my ability to navigate places, gain access to information, and be granted interviews with individuals. My position as a young female researcher may at times have been a limitation, especially in the context of interviews with some male participants in senior positions within institutions involved in the project. One particular example was an individual making remarks about my perceived age and responding in a particularly patronizing manner during the interview. However I do want to emphasize this was by no means representative of my overall experience with local residents and key informants. I also think that as a young woman, I may have made it easier for other women and some men to feel more comfortable.

Indeed, a larger number of women in Paget Farm were interviewed than men. Many local residents and key informants interviewed have such rich and in-depth local knowledge and decades of experience in their respective fields, and my inexperience conducting social research may have hindered my ability to fully contextualize the information shared within a larger scope.

I fully acknowledge these limitations, and tried to continuously seek advice and guidance from various sources to ensure the appropriateness and value of my research. This included discussions with local residents and community leaders, professors at the University of the West Indies, and Caribbean friends and colleagues. Spending over six months in Saint Vincent and the Grenadines and Barbados during my Master's also helped me gain a better sense of island community dynamics in the Caribbean region. While in Bequia I tried to actively participate in community life, such as a volunteering for the UNESCO Sandwatch program, which aims at providing the island's high school students with the skills and tools to monitor and collect information on environmental changes in their community. I also presented at several conferences, including the Caribbean Studies Association conference (Grenada, June 2013); European and Latin American Academic Conference on Climate Change Management (Guatemala, August 2014); and Canadian Association for Latin American and Caribbean Studies Congress (Québec City, May 2014). These presentations allowed me to share and discuss my research findings with a wider audience engaged in sustainable development work in the Caribbean, address critiques as they emerged, and integrate suggestions into my research. These conferences provided me with unique opportunities to learn from veteran and young researchers, activists and community leaders alike.

4.5 Suggestions for future research

While the impacts of climate change continue to be felt and the amount of global greenhouse gas emissions being released show no signs of decreasing, a growing number of small island communities are actively adapting to decrease local-level risks and increase beneficial opportunities that may arise. The findings presented in this thesis open the door for further research assessing the commonalities and differences that exist between the factors that influence adaptive capacity not only in the Caribbean region but other low-lying and small island communities around the world. An obvious way forward is to undertake additional case study research retrospectively assessing the factors that led to the implementation of specific adaptation projects. Especially fruitful would be to conduct comparative case study research investigating the differential responses shown by communities faced with similar exposures and sensitivities. This would allow for a better understanding of causal factors and their dynamic interactions. Future research should also consider how factors differ (or not) with the type of climate change impact and associated adaptation projects.

The findings highlighted suggest that the use of SNA to examine institutional networks can provide insights into what contributes to local-level adaptive capacity. Additional research is recommended to test the validity of the systematic assessment of vertical and horizontal network integration proposed in Chapter 3. While the research was novel in examining institutional networks as the change over time, new software tools are emerging to allow for more interactivity than static social network maps. Dynamic Network Analysis merges traditional SNA with simulations to visualize network evolution over time (Carley, forthcoming). Research on institutional networks should also consider examining not only the presence or absence of ties between institutions but also the communication frequency and the quality of interactions (see

Ingold et al. 2010). In order to reduce the impacts of recall bias, researchers would benefit from tracking the ties formed between institutions as adaptation projects unfold.

Lastly, in parallel to any retrospective research on the determinants of adaptive capacity it is suggested that an assessment of the level of adaptation project success be completed. This suggestion is emphasized in light of recent research coming out of Pacific small islands exposing "unsuccessful" adaptation projects (see Barnett 2008; Nunn 2009). The example provided in the introductory chapter is the common adaptation strategy of building seawalls. Since it is common for no financial and technical resources to be provided beyond project completion (Nunn 2010), seawalls often breakdown and fail; leaving communities as vulnerable (if not more) than prior to the adaptation strategy implementation. This assessment of success is of critical importance to avoid maladaptation to climate change.

REFERENCES

Adger, W.N. (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography*, 79, 387-404.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, 15, 77-86.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., et al. (2007). Assessment of adaptation practices, options, constraints and capacity. In M.L. Parry, O.F. Canziani, J.P. Palutikof et al. (Eds.), *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press (pp. 717-743).

Adger, W.N., Eakin, H. and Winkels, A. (2008). Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment*, 7, 150-157.

Adger, W.N., Huq, S., Brown, K. et al. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, 3, 179-195.

Allen, K.M. (2006). Community-based disaster preparedness and climate change adaptation: Local capacity building in the Philippines. *Disasters*, 30, 81-101.

Agrawal, A. (2008). The role of local institutions in adaptation to climate change. Paper prepared for the Social Dimensions of Climate Change, Social Development Department, World Bank. Washington DC, March 5-6, 2008.

AOSIS. (2008). Global climate change and small island developing states: financing adaptation. Green paper prepared by the Alliance of Small Island States and the United Nations Foundation. February 5, 2008.

Barnett, J. (2008). The effect of aid on capacity to adapt to climate change: Insights from Niue. *Political Science*, 60, 31-45.

Berkes, F. (2002). Cross-scale institutional linkages for commons management: Perspectives from the bottom up. In E. Ostrom, T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, E.U. Weber (Eds.), *The Drama of the Commons*. Washington: National Academy Press (pp. 293-321).

Blatter, J. and Haverland, M. (2012). Designing case studies. New York: Palgrave MacMillan.

Bodin, O. and Crona, B. (2009) The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, 19, 3, 366-374.

Bodin, O., Crona, B., and Ernstson, H. (2006). Social networks in natural resource management: What is there to learn from a structural perspective? *Ecology and Society*, 11 (online).

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). *UCINET 6 for Windows: Software for Social Network Analysis*. Boston: Analytic Technologies.

Borgatti, S.P. and Halgin, D.S. (2011). On Network Theory. *Organization Science*, Articles in Advance, 1-14.

Borgatti, S.P., Everett, M.G. and Johnson, J.C. (2013). *Analyzing social networks.* London: Sage Publications Limited.

Bradshaw, M. and Stratford, E. (2010). Qualitative research design and rigour. In I. Hay (Ed.), *Qualitative research methods in human geography.* Oxford: Oxford University Press (pp. 69-80).

Brooks, N. and Adger, W.N. (2005). Assessing and enhancing adaptive capacity. In B. Lim and E. Spanger-Siegfried (Eds.), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures*. United Nations Development Program, Global Environment Facility. Cambridge: Cambridge University Press (pp. 165-181).

Brown, H.C.P., Nkem, J.N., Sonwa, D.J., and Bele, Y. (2010). Institutional adaptive capacity and climate change response in the Congo Basin forests of Cameroon. *Mitigation and Adaptation Strategies for Global Change*, 15, 263-282.

Bueno, R., Herzfeld, C., Stanton, E.A., et al. (2008). The Caribbean and climate change: The costs of inaction. U.S. Global Development and Environment Institute, Tufts University.

Bussey, M., Carter, R.W., Carter, J., et al. (2010). Societal responses to significant change: A historical analysis of adaptive capacity. Report for the South East Queensland Climate Adaptation Research Initiative. Sustainability Research Centre, University of the Sunshine Coast, Sippy Downs, Australia.

Cameron, E. (2012). Securing Indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. *Global Environmental Change*, 22, 103-114.

Carley, K.M. (Forthcoming). Dynamic Network Analysis. In R. Breiger and K.M. Carley (Eds.), *Summary of the NRC workshop on Social Network Modeling and Analysis*. National Research Council.

CCCCC. (2012). Environmental impact assessment of the installation of a photovoltaic solar powered salt water reverse osmosis plant at Paget Farm Bequia. Technical Report 5C/SPACC-11-08-02 prepared by the Caribbean Community Climate Change Centre, Belmopan, Belize.

Chang, Y.M. and Desai, A. (2001). Local control, local capacity and regulatory effectiveness: Issues in municipal water pollution control. In M.R. Daniels (Ed.), Creating sustainable community programs: Examples of collaborative public administration. Westport: Praeger Publishers (pp. 176–191).

Church, J.A. and White, N.J. (2011). Sea-level rise from the late 19th to the early 21st century. *Surveys in Geophysics*. 32, 585-602.

Crona, B. and O. Bodin. (2006). What you know is who you know? Communication patterns among resource users as a prerequisite for comanagement. *Ecology and Society*, 11 (online).

Davies, A.R. (2005). Local action for climate change: Transnational networks and the Irish experience. *Local Environment*, 10, 21-40.

De Nooy, W. (2008). Signs over time: statistical and visual analysis of a longitudinal signed network. *Journal of Social Structure*, 9.

Dixit, A., McGray, H., Gonzales, J., and Desmond, M. (2012). Ready or not: Assessing institutional aspects of national capacity for climate change adaptation. World Resources Institute. Washington: WRI.

Doreian, P. (2001). Causality in social network analysis. *Sociological Methods and Research*, 30, 81-114.

Doria, M.D.F., Boyd, E. and Adger, W.N. (2009). Using expert elicitation to define successful adaptation to climate change. *Environmental Science and Policy*, 12, 810-819.

Dumaru, P. (2010). Community-based adaptation: Enhancing community adaptive capacity in Druadrua Island, Fiji. *WIREs Climate Change*, 1, 751-763.

Durrant, S., Nurse, L. and Stoddard, A. (2008). Monitoring the effects of below average precipitation on water resources in Paget Farm, Bequia, the Grenadines. Technical Report No. 22 prepared for the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados.

Eakin, H. and Luers, A.L. (2006). Assessing the vulnerability of social-environmental systems. *Annual Review of Environment and Resources*, 31, 365–394.

Eakin, H., Tompkins, E.L., Nelson, D.R. and Anderies, J.M. (2009). Hidden costs and disparate uncertainties: trade-offs involved in approaches to climate policy. In W.N. Adger, I. Lorenzoni, K. O'Brien (Eds.), *Adapting to climate change: thresholds, values, governance*. Cambridge: Cambridge University Press.

Eckerberg, K. and Joas, M. (2004). Multi-level environmental governance: a concept under stress? *Local Environment*, 9, 405–412.

Engle, N.L. (2011). Adaptive capacity and its assessment. *Global Environmental Change*, 21, 647-656.

Engle, N.L. and Lemos, M.C. (2010). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*, 20, 4-13.

Eriksen, S.H. and Kelly, P.M. (2007). Developing credible vulnerability indicators for climate adaptation policy assessment. *Mitigation and Adaptation Strategies for Global Change*, 12, 495-524.

Farrell, D., Trotman, A. and Cox, C. (2010). Drought early warning and risk reduction: A case study of the Caribbean drought of 2009-2010. Global Assessment Report on Disaster Risk Reduction prepared for the United Nations International Strategy for Disaster Reduction.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12, 219-245.

Folke, C., Hahn, T., Olsson, P., et al. (2005). Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30, 441-473.

For, J.D. and Goldhar, C. (2012). Climate change vulnerability and adaptation in resource dependent communities: a case study from West Greenland. *Climate Research*, 54, 181-196.

Ford, J.D., Keskitalo, E.C.H., Smith, T., et al. (2010). Case study and analogue methodologies in climate change vulnerability research. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 374-392.

Ford, J.D., Smit, B. and Wandel, J. (2006). Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change*, 16, 145-160.

Gassert, F., Luck, M., Landis, M. et al. (2013). *Aqueduct Global Maps 2.0.* Working Paper prepared for the World Resources Institute. Washington: WRI.

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, 78, 1360-1380.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91, 481-510.

Greaves, G.E. (2012). On water augmentation strategies for small island developing states: case study of Bequia, St. Vincent. Master's thesis submitted to the National Central University of China.

Green, E. (2012). *Special Programme for Adaptation to Climate Change (SPACC). Implementation of adaptation measures in coastal zones.* Technical Note 5C/SPACC-12-05-01 prepared by the Caribbean Community Climate Change Centre, the Global Environment Facility, and the World Bank.

Grothmann, T. and Patt, A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change*, 15, 199-213.

Gupta, J., Termeer, C., Klostermann, J., et al. (2010). The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy*, 13, 459-471.

Huq, S., Yamin, F., Rahman, A., et al. (2005). Linking climate adaptation and development: A synthesis of six case studies from Asia and Africa. IDS Bulletin, 36, 117-122.

Ingold, K., Balsiger, J. and Hirschi, C. (2010). Climate change in mountain regions: How local communities adapt to extreme events. *Local Environment*, 15, 651-661.

Ingold, K. (2014). How involved are they really? A comparative network analysis of the institutional drivers of local actor inclusion. *Land Use Policy*, 39, 376-387.

IPCC. (2012). Summary for policymakers. In C.B. Field, V.R. Barros, T.F. Stocker, D. Qin et al. (Eds), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press (pp. 1-19).

IPCC. (2014a). Summary for policymakers. In C.B. Field, V.R. Barros, D.J. Dokken, et al. (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press (pp.1-32).

IPCC. (2014b). Small Islands. In C.B. Field, V.R. Barros, D.J. Dokken, et al. (Eds.), *Climate change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press (pp. 1-60).

Ivey, J.L., Smithers, J., De Loë, R.C., and Kreutzwiser, R.D. (2004). Community capacity for adaptation to climate-induced water shortages: Linking institutional complexity and local actors. *Environmental Management*, 33, 36-47.

Jackson, W. and Verberg, N. (2007). *Methods: Doing social research*. Toronto: Pearson Education Canada.

Jaja, J. and Dawson, J. (2014). What contributes to climate change adaptive capacity? A retrospective case study in a Caribbean small island community. In W. Leal (Ed.), *International perspectives on climate change: Latin America and beyond*. New York: Springer.

Jury, M.R. and Winter, A. (2010). Warming of an elevated layer over the Caribbean. *Climatic Change*, 99, 247-259.

Keskitalo, E.C.H. (2008). *Climate change and globalization in the Arctic. An integrated approach to vulnerability assessment.* London: Earthscan.

Keskitalo, E.C.H. (2010). Adaptation to climate change in Europe: Theoretical framework and study design. In E.C.H. Keskitalo (Ed.), *Developing adaptation policy and practice in Europe: Multi-level governance of climate change*, London: Springer (pp. 1-38).

Klein, R.J.T. and Smith, J.B. (2003). Enhancing the capacity of developing countries to adapt to climate change: A policy relevant research agenda. In: J. Smith, J. Klein and S. Huq (Eds.), Climate Change, adaptive capacity and development. London: Imperial College Press (pp. 317-334).

Krueger, R. (1988). *Focus Groups: A Practical Guide for Applied Research.* Thousand Oaks: Sage.

Leichenko, R., Thomas, A. and Barnes, M. (2010). Vulnerability and adaptation to climate change. In C. Lever-Tracy (Ed.), *Routledge handbook of climate change and society*, London: Routledge (pp. 133-151).

Luthe, T., Wyss, R. and Schuckert, M. (2012). Network governance and regional resilience to climate change: empirical evidence from mountain tourism communities in the Swiss Gotthard region. *Regional Environmental Change*, 12, 839-854.

Manzello, D.P. (2010) Coral growth with thermal stress and ocean acidification: lessons from the eastern tropical Pacific. *Coral Reefs*, 29, 749-758.

Maxwell, J.A. (2012). Qualitative Research Design: An Interactive Approach. London: Sage Publications.

McCarthy, J.J., Canziani, O.F., Leary, N.A. et al. (eds.) (2001). *Climate change 2001: Impacts, adaptation, and vulnerability*. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Merrifield, M., Merrifield, S. and Mitchum, G. (2009). An anomalous recent acceleration of global sea level rise. *Journal of Climate*, 22, 5772-5781.

Mikwitz, P., Aix, F., Beck, S., et al. (2009). *Climate policy integration, coherence and governance*. PEER Report No 2, Helsinki: Partnership for European Environmental Research.

Medeiros, D., Hove, H., Keller, M., et al. (2011). Review of current and planned adaptation action: The Caribbean. Report for the International Institute for Sustainable Development.

Moser, S.C. and Ekstrom, J.A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Science*, 107, 22026-22031.

Moss, R.H., Brenkert, A.L. and Malone, E.L. (2001). *Vulnerability to climate change: A quantitative approach.* Technical Report PNNL-SA-33642, Pacific Northwest National Laboratories, Richland.

Niang-Diop, I. and Bosch, H. Formulating an adaptation strategy. In B. Lim and E. Spanger-Siegfried (Eds.), *Adaptation policy framework for climate change: Developing strategies, policies and measures*. United Nations Development Program. Cambridge: Cambridge University Press (258 pp.).

Nicholls, R.J. and Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. *Science*, 328, 1517-1520.

Nielsen, J.Ø. and Reenberg, A. (2010). Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. *Global Environmental Change*, 20, 142–152.

Nunn, P.D. (2009). Responding to the challenges of climate change in the Pacific Islands: Management and technological imperatives. *Climate Research*, 40, 211-231.

Nunn, P.D. (2010). Bridging the gulf between science and society: Imperatives for minimizing societal disruption from climate change in the Pacific. In Sumi, A., Fukushi, K. and Hiramatsu, A. (Eds.), *Adaptation and mitigation strategies for climate change*. Tokyo: Springer (pp. 233-248).

O'Riordan, T. and Jordan, A. (1999). Institutions, climate change and cultural theory: Towards a common analytical framework. *Global Environmental Change*, 9, 81-93.

Oh, H., Chung, M.-H., and Labianca, G. (2004). Group social capital and group effectiveness: The role of informal socializing ties. *Academy of Management Journal*, 43, 486-501.

Olsson, P., Folke, C. and Hahn, T. (2004). Social-ecological transformation for ecosystem management: The development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society*, 9, [online] URL: http://www.ecologyandsociety.org/vol9/iss4/art2/

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. Cambridge: Cambridge University Press.

Pahl-Wostl, C. (2009). A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19, 354–365.

Patton, M.Q. (2002). *Qualitative Evaluation and Research Methods.* 3rd Edition. Beverly Hills: Sage.

Pelling, M. (2011). Adaptation to climate change: From resilience to transformation. New York: Routledge.

Rotberg, F.J.Y. (2013). Social networks, brokers, and climate change adaptation: A Bangladeshi case. *Journal of International Development*, 25, 599-608.

Sandström, C. (2009). Institutional dimensions of comanagement: Participation, power, and process. *Society and Natural Resources*, 22, 230-244.

Scott, J. (2000). *Social network analysis*. London: Sage Publications Limited.

Scott, J. (2013). *Social network analysis: A handbook* (3rd edition). London: Sage Publications Limited.

Smit, B. and Pilifosova, O. (2003*).* From adaptation to adaptive capacity and vulnerability reduction. In: J. Smith, J. Klein and S. Huq (Eds.), *Climate Change, adaptive capacity and development.* London: Imperial College Press (pp. 1-20).

Smit, B., Pilifosova, O., Burton, I., et al. (2001). Adaptation to climate change in the context of sustainable development and equity. In J.J. McCarthy, O.F. Canziani, N.A. Leary et al. (eds.), *Climate change 2001: Impacts, adaptation and vulnerability. Contributions of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press (pp. 877-912).

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16, 282-292.

Snijders, T.A.B. (2005). Models for longitudinal network data. In P.J. Carrington, J. Scott & S. Wasserman (Eds.), *Models and methods in social network analysis*. Cambridge: Cambridge University Press (pp. 215-247).

Soldatos, P. and Michelmann, H.J. (1992) Subnational units' paradiplomacy in the context of European integration. *Journal of European Integration*, 15, 129-134.

Staskiewicz, T. and Mahon, R. (2007). A livelihoods analysis of fishers in the Grenadine Islands. CERMES Technical Report No. 12. Prepared for the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados.

Statistical Office. (2001). *Population and housing census database.* Ministry of Finance and Economic Planning, Government of Saint Vincent and the Grenadines. Retrieved February 4, 2013, from http://celade.cepal.org/svgbin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=SVG2001&MAIN=WebServerMain.inl

SurveyGizmo. (2014). *SurveyGizmo*. Retrieved on July 14, 2014, from http://www.surveygizmo.com/

Sutherland, K., Smit, B., Wulf, V. et al. (2005). Vulnerability to climate change and adaptive capacity in Samoa: the case of Saoluafata village. *Tiempo*, 54, 11-15.

Tacconi, L. (1997). An ecological economic approach to forest and biodiversity conservation: The case of Vanuatu. *World Development*, 25, 1995-2008.

Tang, J., Musolesi, M., Mascolo, C., et al. (2010). Analysing information flows and key mediators through temporal centrality metrics. In Proceedings of the Third Association for Computing Machinery Workshop on Social Network Systems. Colocated with ACM SIGOPS EuroSys'10, Paris, France, April 2010.

Tompkins, E.L. (2005). Planning for climate change in small islands: Insights from national hurricane preparedness in the Cayman Islands. *Global Environmental Change*, 15, 139-149.

Thompkins, E., Adger, W.N. and Brown, K. (2002). Institutional networks for inclusive coastal management in Trinidad andTobago. *Environment and Planning,* 34, 1095-1111.

UNFCCC. (2005). *Climate change: Small island developing states*. Issued by the Climate Change Secretariat. United Nations Framework Convention on Climate Change. Bonn: UNFCCC

UNFCCC. (2009). International Call for Action at COP 15. Retrieved on April 10, 2013, from http://unfccc.int/meetings/copenhagen_dec_2009/items/5067txt.php

UNFCCC. (2010). *Synthesis report on efforts undertaken to monitor and evaluate the implementation of adaptation projects, policies and programmes and the costs and effectiveness of completed projects, policies and programmes, and views on lessons learned, good practices, gaps and needs.* Report by the United Nations Framework Convention on Climate Change subsidiary body for scientific and technological advice. Bonn: UNFCCC.

UNFCCC. (2014). *Focus: Climate Finance*. Retrieved October 10, 2014, from http://unfccc.int/focus/climate_finance/items/7001.php#intro

Weimann, G. (1982). On the importance of marginality: One more step into the two-step flow of communication. *American Sociological Review*, 47, 764-773.

Wesche, S. and Armitage, D.R. (2010). From the inside-out: A multi-scale analysis of adaptive capacity in a Northern community and the governance implications. In D.R. Armitage and R. Plummer (Eds.), *Adaptive capacity: Building environmental governance in an age of uncertainty.* Heidelberg: Springer (pp. 107-132).

Whitbred, R. (2011) Quadratic Assignment Procedure (QAP). In G.A. Barnett (Ed.), *Encyclopedia of Social Networks.* London: Sage Publications Limited (pp. 733-735).

Williamson, T., Hesseln, H. and Johnston, M. (2012). Adaptive capacity deficits and adaptive capacity of economic systems in climate change vulnerability assessment. *Forest Policy and Economics*, 15, 160-166.

World Bank. (2005). *Special program on adaptation to climate change project*. Global Environment Fund (GEF) project brief to the Governments of Dominica, Saint Lucia, and St. Vincent and the Grenadines. Report No. 34152-LAC.

World Bank. (2012). *Implementation completion and results report for the implementation of adaptation measures in coastal zones project*. Prepared by the World Bank. Report No. ICR2362

WRI. (2013). Aqueduct country and river basin rankings interactive map. Retrieved October 10, 2014, from http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=0.00&y=0.00&l=2&v=home&d=bws&f=0&o=139

Young, O.R. (2002). The Institutional dimensions of environmental change: Fit, interplay, and scale. London: The MIT Press.

APPENDIX A

Key informant interview guide

Introduction: I am a researcher from the University of Ottawa in Canada. I'm interested in understanding how Caribbean communities are responding to climate change. I am interested to hear about your experiences with regards to your involvement in the solar-powered desalination plant in Paget Farm, Bequia. The length of the interview varies, but usually lasts about an hour. With your agreement, I would like to record the interview to ensure that I accurately document your views. Do you have any questions before we begin?	
Questions	**Probes/follow-up questions**
First, I would like to talk to you a bit about you and your organization's involvement in the project.	
Can you tell me a bit more about the organization you work with?	- mandate, role, establishment
How was the organization involved in the project?	- funding, paid staff, volunteers, technical expertise, community connections, fiscal management, leadership, IT resources, etc.
Can you tell me a bit more about your responsibilities within the project? How were you personally involved?	
Can you tell me the story of how the project was conceptualized and implemented? How did it all begin?	
Next I would like to discuss your organization's communication and collaboration with other organizations that were involved in the project.	
Can you tell me how your organization became involved in the project?	Who or what organization approached your organization? How did you hear about the project?
Why'd you decide to get involved in the project?	
When you needed information, advice or general help with the project, who did you approach outside your own organization?	How were they [helpful/unhelpful]? *Was there a key individual that helped make the project happen?*
What barriers did you experience that you had to get over? How did you do it and *who* was instrumental in moving the project forward?	Did you have trouble finding answers to questions you had? Was this organization helpful to obtain answers to questions you had? *Was it a smooth process?*

What organizations do you consider essential to the project's completion? *Was there anyone or any organization that really pushed this project forward? Who's idea was all of this?*	Is there one person/organization that stood out?
Next I would like to ask you a few questions about your general impressions of the desalination plant:	
Would you describe the desalination plant as successful? Why do you think that is?	- funding, community involvement, regional cooperation, industry, process, results
Was the plant implemented because of concerns about climate change or because of other reasons?	- if other, what were they?
What do you think could have been done differently to improve the process?	- collaboration, communication, funding, community participation
Why was Paget Farm chosen for the project?	Why not elsewhere in Bequia? In the Grenadines? In the Caribbean?
How was the community of Paget Farm involved in the project? How was their input taken into consideration?	- Responsive? Actively participated? - Feedback? - Did they provide suggestions? - Like what? Examples? - Approve? Disapprove?
Are you aware of any other projects that had been suggested to address freshwater issues? Why was a solar-powered desalination plant chosen?	
I have a few final questions:	
Is there any information about the desalination plant that hasn't been mentioned you think is important to highlight?	Am I missing something? Is there a question I should be asking?
Are you aware of any other projects that are being implemented because of concerns about climate change?	- environmental, research, awareness groups?
Conclusion That is all the questions I have for you. Is there anything more you would like to add at this point? Do you have any questions for me? Thank you so much for your time. The information you have provided is very important and will go a long way in helping us better understand how communities and organizations are actively developing projects and initiatives to address climate change. If you have any questions about this study, do not hesitate to contact me directly. A final report and any publications that come out from this study will be made available to you.	

APPENDIX B

Local resident interview guide

Beyond Climate Change Theory Interview Guide (Community members)	
Introduction: I am a researcher from the University of Ottawa in Canada interested in understanding how communities are responding to changes in the environment, such as changes in rainfall. I am interested to learn more about your thoughts and impressions on the desalination plant in Paget Farm. The length of the interview varies, but usually lasts about an hour. If it's okay, I would like to record the interview to make sure that I accurately document your views. Do you have any questions before we begin?	
Questions	**Probes/additional questions**
First, I would like to ask you a few general questions about your community:	
How would you describe your community to someone who is not from here? What about Bequia more generally?	- likes and dislikes - social and economic conditions - changes over time?
Are you involved a lot in the community? How so?	- Are you involved in many organizations? - Friends, family, work - social activities (sports, meetings, religious groups, etc.)
Can you tell me a bit about how you access water? What happens during the dry season?	- Rainwater? Imported water? - Are you still accessing water from these sources?
Do you have any concerns about accessing water using these sources?	- Is it always enough? Health? Cost?
Have you noticed any changes in rainfall? Like what?	Did you talk to anybody about your concerns? Who? What was their response?
Next I would like to ask you a few questions more specifically about the desalination plant:	
How did you find out about the project?	- community organization, neighbour, friend, family - Did anyone approach you?
How did you get information about the project?	- Who did you go see when you had questions? - Were there any community meetings? Info sessions?
Did you have any concerns about the desalination plant? Like what?	- costs, water quality, location, emergencies - How were your concerns addressed?

Were you consulted during the various phases of the project?	What phases (design, development, implementation)? Where you happy with the extent to which you were consulted?
How much would you be willing to pay for water?	
Have you ever used the desalination plant? How did it happen?	
How much were you consulted on the project? Are you happy with the extent to which you were consulted?	
Do you think a desalination plant was the best option? Were other options suggested? Why were they not implemented?	- What about wind energy? Why didn't it go through?
Why was Paget Farm chosen for the pilot project?	Why not elsewhere in Bequia? In the Grenadines? In the Caribbean?
I have a few final questions:	
Is there any information about the desalination plant that hasn't been mentioned you think is important to highlight?	Am I missing something? Is there a question I should be asking?
Are you aware of any other similar projects that are being implemented because of concerns about the environment?	- environmental, research, awareness groups?

Conclusion

That is all the questions I have for you. Is there anything more you would like to add at this point? Do you have any questions for me?

Thank you so much for your time. The information you have provided is very important and will go a long way in helping us better understand how communities and organizations are actively developing projects and initiatives to address climate change.

If you have any questions about this study, do not hesitate to contact me directly.

APPENDIX C

Network survey (online)

Thank you for participating in this survey conducted by Jessica Jaja and Dr. Jackie Dawson on behalf of the University of Ottawa's Laboratory for Environment, Society and Policy (Canada).

The purpose of this survey is to understand how different institutions worked together to implement the solar-powered desalination plant in Paget Farm, Bequia (Saint Vincent and the Grenadines). The primary result of this survey will be to create network maps representing the relationships between institutions involved in the different phases of the desalination plant project.

In this survey, the names of all the institutions involved in the project will be listed. However, the names of individuals and institutions will not be presented in any publications (i.e. anonymity will be maintained).

The information that you choose to share will remain strictly confidential and will be used solely for the purposes of this research. The only people who will have access to the primary research data are Ms. Jessica Jaja and Dr. Jackie Dawson.

Section 1. Basic information

1. What institution do you represent?

2. What is your role within this institution?

3. How long have you been in this position?

4. Please outline the primary role played by your institution during the planning, development and operational phases of the desalination plant project.

Section 2. Relationship with other institutions

5. What institutions were you (or your institution) in direct contact specifically to discuss the desalination plant? *You may choose more than one institution.*

(All institutions involved in desalination plant project listed here)

In this section, we would like to know if your institution was in contact with other institutions during each of the five phases of the project:

Pre-project: Prior to the start of the project

Planning: Initial idea generation, proposal writing, early consultations

Development: Securing funding, construction, early implementation

Operational: Late implementation, and general maintenance

Post-project: After the completion of the project

Name of institution	**6. Pre-project** No = 0 Yes = 1	**7. Planning** 0= No 1= Yes	**8. Development** 0= No 1= Yes	**9. Operational** 0= No 1= Yes	**10. Post-project** No = 0 Yes = 1
(list of institutions provided here)					

11. Why was your institution in contact with each of the following institutions?

You may choose more than one option.

Name of institution	Seek information	Seek financial resources	Seek other resources (support, facilities, equipment, etc.)	Provide information	Provide financial resources	Provide a service or a skill	Provide other resources (support, facilities, equipment, etc.)
(list of institutions provided here)							

12. What do you believe are the main assets of each of the following institutions?

You may choose more than one option.

Name of institution	Expertise	Power to make decisions	Reputation	Financial resources	Network of connections	Space and facilities	Materials and equipment	Data	Other
(list of institutions provided here)									

13. What challenges, if any, did you experience working with each institution?

You may choose more than one option.

Name of institution	**Conflicting opinions**	**Different approaches to completing tasks**	**Different approaches to knowing (e.g. scientific vs. traditional/ local knowledge)**	**Different decision-making styles**	**Dominating personalities**	**Lack of commitment /reluctant participants**	**Inability to focus on tasks**	**Ineffective communication**	**Other**
(list of institutions provided here)									

Please answer the following two questions:

Name of institution	**14. How helpful was this institution to your institution's ability to carry out tasks related to the desalination plant?** 1 = Not at all helpful 2 = A little helpful 3 = Neutral (neither helpful nor unhelpful) 4 = Very helpful 5 = Extremely helpful	**15. How easy was it to work with each of the following institutions during the projectÉ** 1 = Always easy 2 = Often easy 3 = Neutral (neither easy nor hard) 4 = Often hard 5 = Always hard
(list of institutions provided here)		

16. In your opinion, what are the <u>three main factors</u> that contributed to the project's completion?

Factors	**1**	**2**	**3**
Access to external financial resources			
Access to new technology			
Bringing together diverse stakeholders			
Collaboration between various institutions			
Collective decision-making			
Community participation			
Exchanging information/knowledge			
Existing/new informal relationships			
Institutional capacity			
Shared mission/goals			
Key individuals			
Local knowledge and capacity			
Meeting regularly			
Sharing resources			
Strong community leaders			
Support from various levels of government			
Other *<u>Describe here:</u>*			

17. In your opinion, were there any factors that made the process challenging?

Factors	**1**	**2**	**3**
Differences in missions/goals			
Inability to bring together diverse stakeholders			
Insufficient informal relationships			
Lack of access to new technology			
Insufficient external financial resources			
Lack of collaboration between various institutions			
Lack of collective decision-making			
Lack of community participation			
Lack of information/knowledge exchange			
Lack of institutional capacity			
Lack of local knowledge and capacity			
Lack of support from various levels of government			
Not meeting regularly			
Not sharing resources			
Specific individuals			
Weak community leaders			
Other *Describe here:*			

18. In your opinion, how successful is the desalination plant project?

( ) Not successful
( ) Somewhat successful
( ) Neutral (Neither successful nor unsuccessful)
( ) Very successful
( ) Completely successful

19. Please expand on your opinion regarding the success of the desalination plant project, if there is anything you would like to add.

20. Would you be willing to take part in an interview about the desalination plant and other climate change adaptation initiatives in Bequia (Saint Vincent and the Grenadines)?

( ) Yes
( ) No

21. Please provide your contact details

22. If there are individuals or institutions involved in the desalination plant project you recommend we contact, please provide their names and/or contact information.

23. Please provide any additional comments you may have about the desalination plant project or this research.

Thank you kindly. The information you have provided is very important and we value the time you have taken to respond to this survey.

APPENDIX D

List of institutions involved in the implementation of the solar-powered desalination plant in Paget Farm, including the number of key informants interviewed and surveyed as part of this thesis.

Scale	Institution	N interviewed	N surveyed
Local	Bequia District Council (Local Government)	1	1
	Local Bequia Committee	2	1
	General Contractors and Quarry Company Limited	2	1
National	Environmental Management Department (Ministry of Health, Wellness and the Environment)	3	1
	Grenadines Affairs (Ministry of National Security, Air and Sea Port Development)	1	1
	Central Water and Sewerage Authority	2	1
	Saint Vincent Electricity Services Limited	1	1
	Central Planning Division (Ministry of Finance and Economic Planning)	1	-
	Physical Planning Unit (Ministry of Housing, Informal Human Settlements, Lands and Surveys, and Physical Planning)	1	1
	Yambou Investment	2	1
	National Emergency Management Organization (Ministry of National Security, Air and Sea Port Development)	1	1
	Bureau of Standards (Ministry of Telecommunications, Science and Technology and Industry)	1	1
	Lands and Survey Department (Ministry of Housing, Informal Human Settlements, Lands and Surveys, and Physical Planning)	1	1
	Public Works (Ministry of Transport, Works, Urban Development and Local Government)	-	-
	Fisheries Division (Ministry of Agriculture, Industry, Forestry, Fisheries and Rural Transformation)	1	1
Regional	Caribbean Community Climate Change Centre	2	1
	Caribbean Water Treatment Limited	1	1
	Grenada Solar Power	-	-
	Trintoplan	-	-
International	World Bank	1	1
	Epsilon Innovation Group Inc.	1	1
	Global Environment Facility	-	-
	Juwi Solar Power	-	-
	Total	**25**	**17**

APPENDIX E

Recruitment poster

uOttawa

Beyond Climate Change Theory: Adaptation in the Caribbean

In the coming months:
Distribution of a short survey and requests for interviews to move the conversation forward on climate change adaptation

LABORATORY FOR ENVIRONMENT, SOCIETY AND POLICY
University of Ottawa, Canada
Director: Dr. Jackie Dawson

CONTACT
Jessica Jaja, BSc
MA Candidate
Department of Geography

Climate change is unequivocal. The Caribbean region is already facing its impacts, including sea level rise, ocean acidification, reduced freshwater availability and changes in extreme weather.

Many challenges lie ahead, but local, national, regional and international initiatives are taking place in an attempt to adapt to a changing climate. Strategies are being designed, developed and implemented with the dual purpose of addressing climate change impacts and moving towards sustainable development.

The carbon-neutral desalination plant on the island of Bequia, Saint Vincent and the Grenadines is one such example. In response to changing climate patterns challenging traditional rainwater harvesting techniques, the plant was inaugurated in 2012 to provide freshwater to the community of Paget Farm. The project combined efforts from all scales, including community members, the Saint Vincent and the Grenadines government, the Caribbean Community Climate Change Center and the Global Environment Fund.

Using the desalination plant in Bequia as a case study, our research seeks to assess which social, institutional, political and economic factors may contribute to local-level adaptation. The goal of the project is to increase our understanding of the real-world interactions and dynamics that allow communities to adapt to climate change in a way that is effective, efficient, legitimate and equitable.

Using a survey and interviews, we hope to gain insight into the interactions between actors and institutions at all levels that were involved in the development and implementation of the project. This includes community members, local NGOs, national government departments, regional players and international agencies. You will receive more information regarding the project soon. If you have any questions or feedback, please do not hesitate to contact us. Thank you!

Project supporters:

Social Sciences and Humanities Research Council of Canada / Conseil de recherches en sciences humaines du Canada
Canada
C-CHANGE CANADA-CARIBBEAN Coastal Climate Adaptation Strategies
THE UNIVERSITY OF THE WEST INDIES AT ST. AUGUSTINE, TRINIDAD AND TOBAGO

APPENDIX F

Ethics Approval

File Number: 05-13-19 **Date (mm/dd/yyyy):** 06/12/2013

Université d'Ottawa University of Ottawa
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

Ethics Approval Notice

Social Science and Humanities REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

First Name	Last Name	Affiliation	Role
Jackie	Dawson	Arts / Geography	Supervisor
Jessica	Jaja	Arts / Geography	Student Researcher

File Number: 05-13-19

Type of Project: Master's Thesis

Title: Beyond climate change theory: What contributes to local level adaptive capacity in Caribbean Small Island Developing States?

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
06/12/2013	06/11/2014	Ia

(Ia: Approval, Ib: Approval for initial stage only)

Special Conditions / Comments:
N/A

550, rue Cumberland 550 Cumberland Street
Ottawa (Ontario) K1N 6N5 Canada Ottawa, Ontario K1N 6N5 Canada
(613) 562-5387 • Téléc./Fax (613) 562-5338
http://www.research.uottawa.ca/ethics/index.html
http://www.recherche.uottawa.ca/deontologie/index.html

Université d'Ottawa University of Ottawa
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

This is to confirm that the University of Ottawa Research Ethics Board identified above, which operates in accordance with the Tri-Council Policy Statement and other applicable laws and regulations in Ontario, has examined and approved the application for ethical approval for the above named research project as of the Ethics Approval Date indicated for the period above and subject to the conditions listed the section above entitled "Special Conditions / Comments".

During the course of the study the protocol may not be modified without prior written approval from the REB except when necessary to remove subjects from immediate endangerment or when the modification(s) pertain to only administrative or logistical components of the study (e.g. change of telephone number). Investigators must also promptly alert the REB of any changes which increase the risk to participant(s), any changes which considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project and safety of the participant(s). Modifications to the project, information/consent documentation, and/or recruitment documentation, should be submitted to this office for approval using the "Modification to research project" form available at: http://www.research.uottawa.ca/ethics/forms.html

Please submit an annual status report to the Protocol Officer 4 weeks before the above-referenced expiry date to either close the file or request a renewal of ethics approval. This document can be found at: http://www.research.uottawa.ca/ethics/forms.html

550, rue Cumberland 550 Cumberland Street
Ottawa (Ontario) K1N 6N5 Canada Ottawa, Ontario K1N 6N5 Canada
(613) 562-5387 • Téléc./Fax (613) 562-5338
http://www.research.uottawa.ca/ethics/index.html
http://www.recherche.uottawa.ca/deontologie/index.html