FINAL TECHNICAL REPORT

MANAGING ADAPTION TO COASTAL ENVIRONMENTAL CHANGE (C-CHANGE): CANADA AND THE CARIBBEAN PROJECT

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This report is presented as received from project recipient(s). It has not been subjected to peer review or other review processes.

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1. Acronym List

C-USG	-	Community-University Support Groups
GIS	-	Geographical Information Systems
ICURA	-	International Community-University Research Alliance
IDRC	-	International Development Research Centre
SALISES	-	Sir Arthur Lewis Institute of Social and Economic Studies
SSHRCC	-	Social Sciences and Humanities Research Council of Canada
UWI	-	University of the West Indies
WRI	-	World Resources Institute

2. Project Abstract

The C-CHANGE Project, *Managing Adaptation to Environmental Change in Coastal Communities: Canada and the Caribbean*, was a collaborative International Community-University Research Alliance (ICURA) initiative with the goal of assisting coastal communities to share experiences and tools that aid adaptation to changes in physical and social coastal environments. Environmental challenges include: (i) seawater intrusion into coastal aquifers, (ii) coastal and sea pollution caused by wastewater and solid waste that have been treated ineffectively, (iii) flooding associated with storm surge, (iv) coastal erosion, (v) rising sea-levels, and (vi) impacts associated with increasingly extreme weather events.

C-CHANGE was initially a five-year (2009-2014), eventually a six-year (2009-2015), project funded by the Social Sciences and Humanities Research Council of Canada (SSHRCC) and the International Development Research Centre (IDRC). Project coordination and administration offices were located at the Sir Arthur Lewis Institute of Social and Economic Studies (SALISES), University of the West Indies in St. Augustine, Trinidad and Tobago, and at the Telfer School of Management of the University of Ottawa in Ottawa, Canada.

The principal objectives of C-CHANGE were to: (1) Establish community-university alliances by sharing global research and evaluating strategies for adaptation in the local context; (2) Profile local community vulnerabilities and risks and declare priorities through understanding local spatial and demographic data in the preparation of community climate guidelines and action plans; (3) Build local capacity for managing adaptation by promoting new institutional arrangements, training, and introducing tools for evaluation of adaptation strategies; and (4) Develop interdisciplinary curricula for undergraduate and graduate university programs and local community schools to raise awareness and train new generations of young people to evaluate opportunities for their coastal communities subject to environmental change.

The C-CHANGE study sites across Canada and the Caribbean consisted of eight coastal communities including five island communities. C-CHANGE study sites were selected based on anticipated similarities between four sets of paired communities:-

(1) the low-lying regional capital cities of Charlottetown, Prince Edward Island, and Georgetown, Guyana (Figure 1);
(2) the indigenous communities of Iqaluit, Nunavut, and San Pedro, Ambergris Caye, Belize (Figure 2);
(3) the eco-touristic, resort communities of Gibsons, British Columbia, and Grande Riviere (Figure 3), Trinidad and Tobago; and
(4) the small island communities of Isle Madame, Nova Scotia, and the Grenadine island of Bequia, St. Vincent and the Grenadines (Figure 4).

Figure 1 : Map of Guyana showing Georgetown

Source: WorldAtlas.come

Figure 2- Map of Belize[1]

[1] Geographical data and Map sourced from http://countrystudies.us/belize/16.htm (Accessed March 13th, 2010.)

Figure 3: Map of Grand Riviere

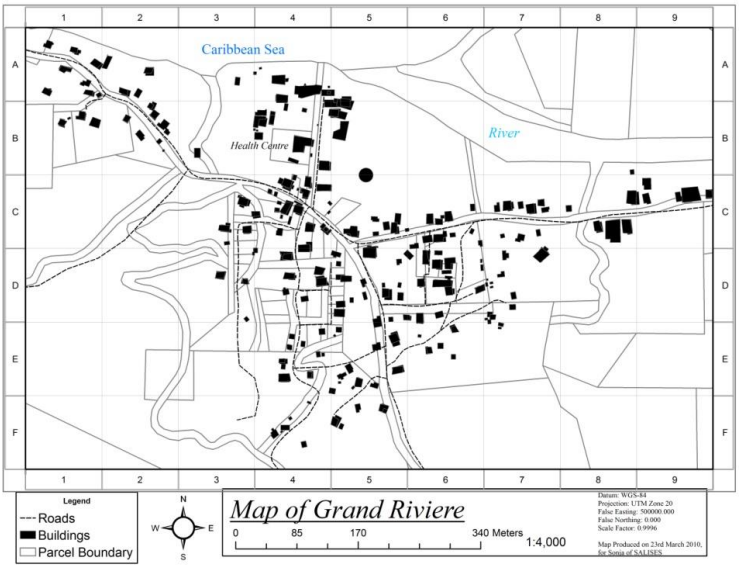
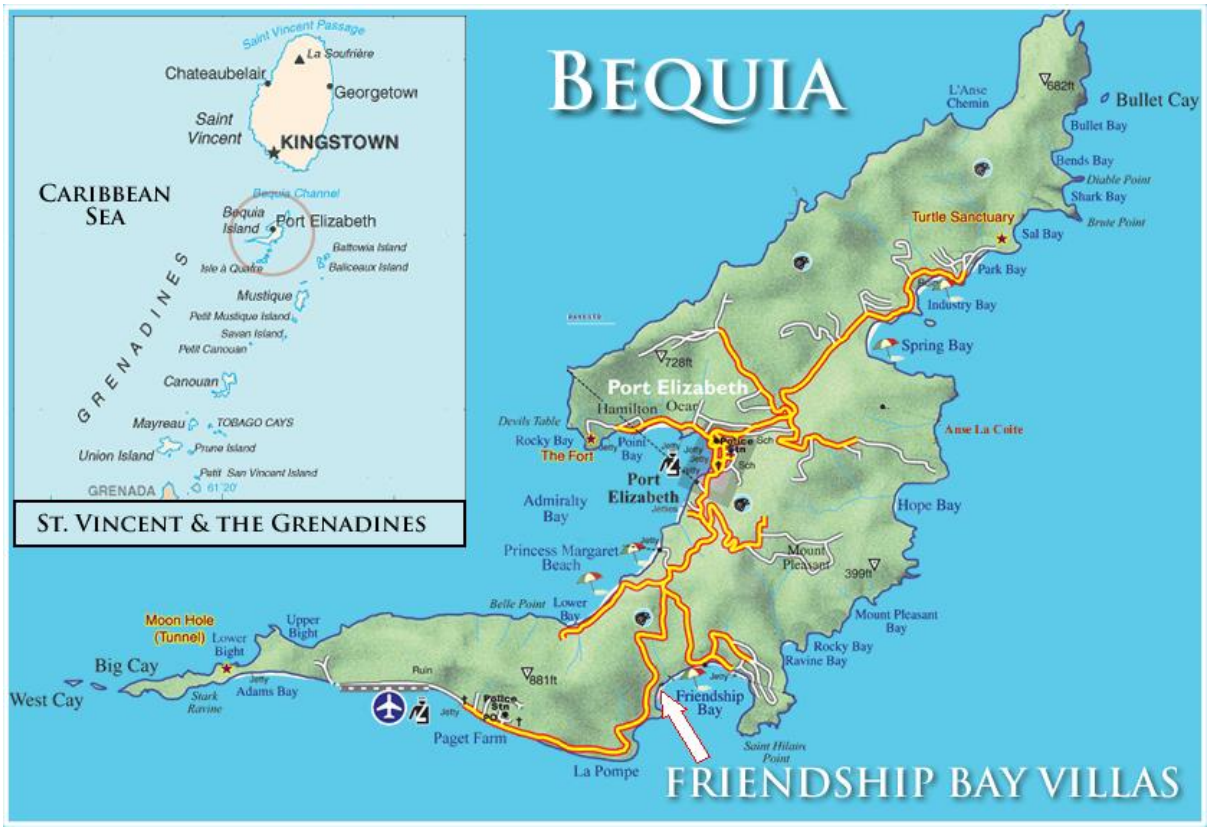


Figure 4:-Map of Bequia



Together, C-CHANGE university-based researchers and community partners processed local feedback, knowledge, contexts, insights and priorities toward improving local and regional policy planning and strategic response, and acted as leaders in the development of C-CHANGE community adaptation action. C-CHANGE placed special emphasis on integrating its

communities in project management through the establishment of the C-CHANGE Community Coordinator role. The Community Coordinator developed Communities of Practice among the C-CHANGE Partners through integrating activities around their mutual interest in adapting to coastal environmental shifts.

This report focuses on activities and results largely funded through the IDRC grant and led by team members based in the Caribbean.

3. The C-CHANGE Problematique

The C-CHANGE project *Managing Adaptation to Coastal Environmental Change: Canada and the Caribbean* developed community capacity toward closing the gap between environmental change, and the need to manage local adaptation efforts in planning for the environmental impacts to communities' physical, economic, and social well-being. It focused on communities, universities, and the created networks and alliances among these groups in keeping with the C-CHANGE program themes, looking specifically at four coastal communities in the Caribbean and four in Canada, whose livelihoods were likely to be affected by environmental change.

Climate change is receiving increased attention internationally since many negative environmental effects may flow from it, for example sea-level rise, increased average global temperatures affecting the normal seasonal cycles, increased incidences and intensity of storms and hurricanes along with the consequent increased risks of storm surges, and increased incidences of droughts and floods. The negative environmental effects have the potential for disrupting human social and economic activity everywhere on Earth, but are particularly threatening to coastal communities. This threat is exacerbated by the fact that more than fifty percent of the Earth's human population lives within sixty miles of coasts, and this population is expected to increase by thirty-five percent by the year 2025. The creation and maintenance of mitigation and adaptation strategies for threats to coastal communities, such as sea-level rise and storm surges, are therefore eminently worthwhile pursuits.

The global climate is changing. Impacts are increasingly visible, and the trends are undeniable. Rising temperatures are melting polar ice and together with thermal expansion of water are contributing to: sea level rise, changing precipitation patterns, more frequent intense weather events, storm surges and flooding, coastal erosion, increased sedimentation of coastal waters, and, especially worrisome, pollution from flooded or destroyed infrastructure and storm runoff (IPCC 2007a,b, IISD 2007, FAO 2007, UNEP 2008). Nowhere is the problem more imminent or intense than in the small island states of the Caribbean, which rank among the most vulnerable economies in the world (UNEP 2007, 2006, UNFCCC 2007, Bueno et al

2008). Coastal communities can be better prepared by linking the national and regional institutional resources and services with local community knowledge, planning and community response networks that may both anticipate potential impacts and strategically apply limited resources to priority areas to reduce negative impacts.

Leveraging the results of previous research and using a multidisciplinary approach, this project incorporated aspects of sociology, economics, management science, and geomatics engineering. Using geomatics, various levels of sea-level rise were modeled to identify potentially impacted community socioeconomic infrastructure. The models provided support for socioeconomic impact assessment, the development of adaptation strategies, and the development of appropriate policy recommendations. By this approach disciplines such as geomatics engineering increased social sciences' and humanities' effectiveness in meeting community needs.

a. Main Objectives

The main objectives of C-CHANGE were as follows:-

1. Establish alliances in each community and among researchers in Canada and the Caribbean, collaborate on global research on climate change impacts on coastal zones due to more frequent storm surge and sea level rise over the longer term, and research the ways and means of mitigating local coastal community vulnerabilities and risks.
2. Identify local vulnerabilities and risks by profiling communities' environmental, economic, social, and cultural dimensions through researching local spatial and demographic data used to prepare community action plans for emergencies.
3. Build local capacity by strengthening community institutional arrangements through research on new local management instruments, by training students, and through workshops and meetings with local community partners and participants.
4. Research best practices for curricula in managing adaptation to environmental change in universities and in community public schools, to raise awareness and train new generations of young people to evaluate and address the integrated, interdisciplinary coastal community systems subject to environmental change.

b. Community Objectives

1. Establish formal Community-University alliances for management of the impacts of environmental change in each study area, with members from each community assisting in information gathering, priority-setting, decision making, reporting, and application of research deliverables.
2. Strengthen community institutional arrangements through the development of new management instruments, planning policy, guidelines, strategic plans, and decision support methods.
3. Establish long-term linkages among research institutions and the communities within each community, to facilitate the flow of information, access to outside resources, and capacity building.
2. Prepare community action plans based on existing governance and institutional structures and, in collaboration with the Community-University alliance groups, to advance preparedness for environmental shifts and emergencies.

a. University Objectives

1. Develop academic alliances among university researchers in Canada and the Caribbean to share comparative knowledge, resources and expertise on the adaptive capacity of coastal communities re coastal health and vulnerabilities, to combine resources to improve the capacity of local areas to anticipate, to respond to the challenges presented by environmental change and to use insightful alternatives to promote the sustainable use of coastal marine resources.
2. Collaborate on global research to compare and share the results of socioeconomic research with international links and global institutions (e.g., the United Nations, the IPCC) related to environmental change impacts affecting coastal communities throughout the world through publication in scholarly revues, participation in international conferences, and membership in Canada and in the Caribbean region environmental change institutions.
3. Develop new curricula for managing adaptation to environmental change in Canada (among the Canadian partner universities) and in the Caribbean (in the University of West Indies network) including joint graduate and undergraduate level courses in science, social science, and management prepared by researchers in Canada and Trinidad and Tobago to provide training and research for evaluating and addressing the integrated and interdisciplinary physical and socioeconomic impacts of coastal community-based systems and infrastructure from environmental change.

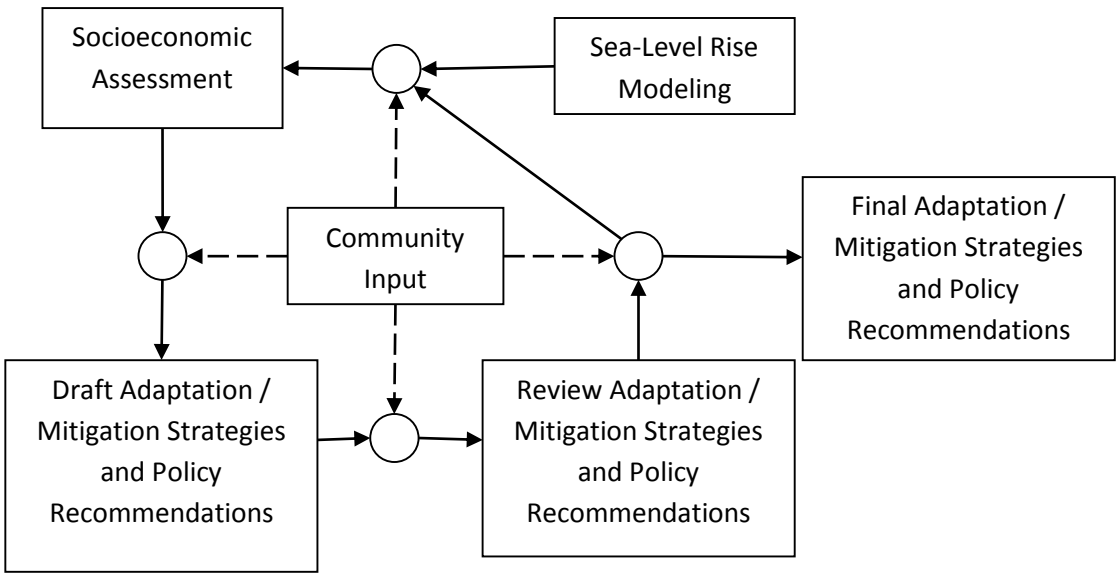
b. Joint Community-University Alliances objectives

1. Identify the short and long term vulnerabilities for each coastal community due to sea level rise, storm surge and severe storm events by developing and cataloguing risks.
2. Mobilize knowledge and innovation to mitigate coastal community risks through workshops, data and research collaboration, and linkages within the Canada-Caribbean communities and among the academic participants.
3. Build capacity through the training of graduate and undergraduate students in the universities, and local participants and decision-makers in the communities re coastal environmental impacts by regular exposure to workshops, seminars, and local field work and reports to the community.
4. Develop impact scenarios, and prepare adaptation action plans using university resources in partnership with the priorities and concerns of the local community government, services, and community members.

4. Methodology

This project incorporated comparative and action research. Alliances were formed among a number of Canadian coastal communities and universities, as well as among selected Caribbean coastal communities and the University of the West Indies. Using a multidisciplinary approach, this research incorporated aspects of sociology, economics, management science, and geomatics engineering.

Figure 5 - Simplified Research Methodology.



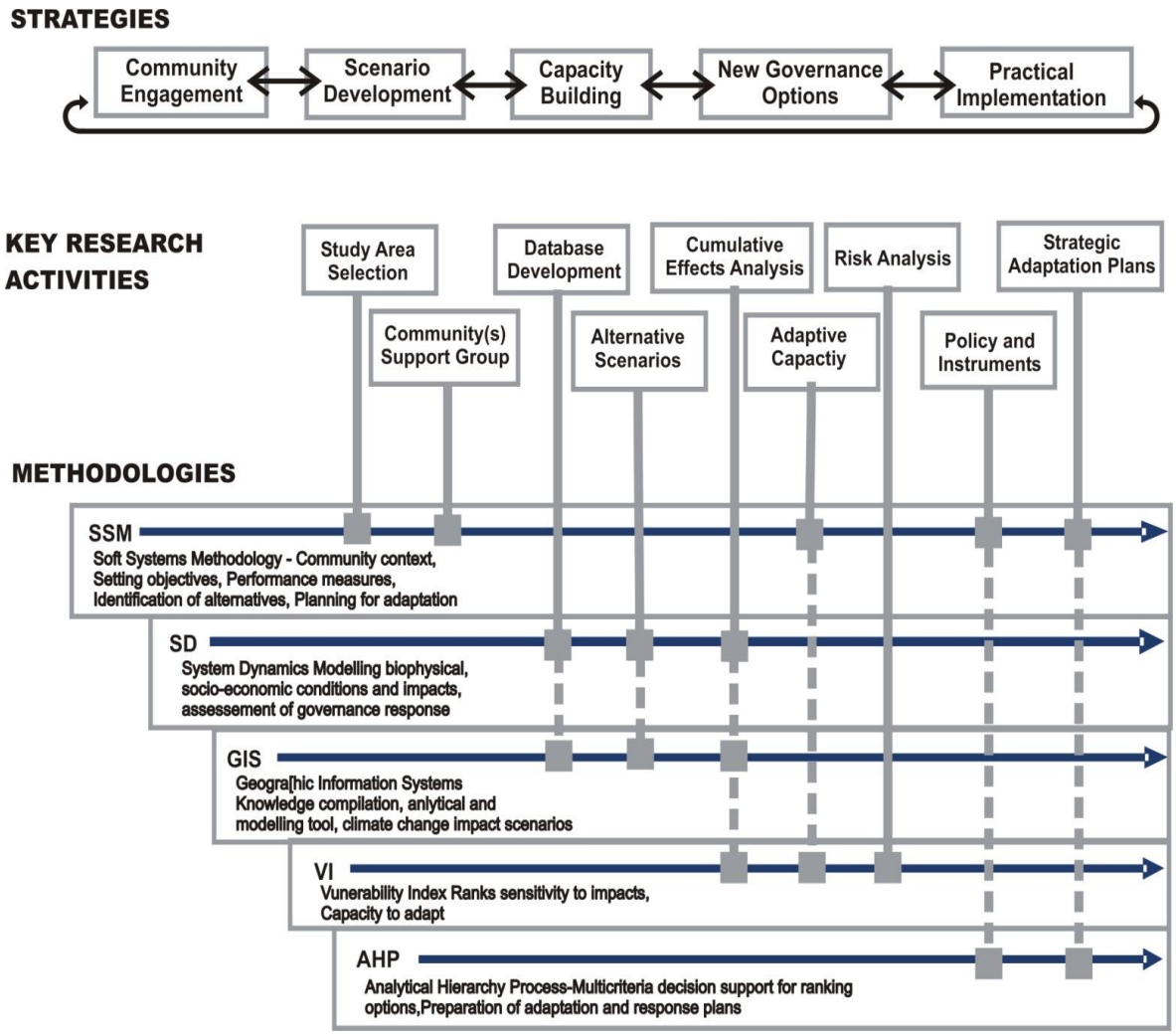
The research process (Figure 6) was an interdisciplinary collaboration that employed key research strategies, activities and methodologies. Information flowed electronically between

the central administrative sites (University of Ottawa and University of West Indies, St. Augustine) through the program website and out to the selected coastal communities. The website was the core of communication, data-sharing and knowledge exchange among researchers and community participants.

Baseline indices were updated regularly over the course of the project with changes to the value of the community vulnerability and adaptive capacity indicators reflecting ongoing project activities and recommended policy measures. Community groups assisted in the formulation of questionnaires, with meetings, reviewed recommendations and facilitated 'buy-in' by the wider communities, including taking ownership of local community meetings and workshops with the assistance of University researchers.

Local community workshops provided training in managing adaptation to environmental change, using the vulnerability index and adaptive capacity measures and building knowledge towards planning for change. Working documents from local workshops were prepared and disseminated through the project website to community leaders, practitioners and policy makers. Graduate students worked on specific project elements such as geomatics and information management, web database development, multicriteria decision making, policy evaluation, risk management, and were overseen by academic as well as community team members, with opportunities to gain experience working in practical application of research findings.

Figure 6 – Research Process



The various activities sought to provide a lasting impact on coastal communities' preparedness for environmental threats that will influence existing policy at the regional and national levels in the small island states in the Caribbean and in coastal Canada.

To this end, this project made formal linkages between the communities and their respective financial offices and funding sources since it is recognized that measures and policy recommendations will require government authorization and budgeting including the application of new technology and the reinforcement of community infrastructure.

5. Main Activities

From 2009 to 2015, this project presented a significant regional opportunity for researchers, students and impacted communities to engage in research to generate new knowledge and promote understanding of data on the vulnerability of various Caribbean States and the nature and scale of impact of change. The project also improved their understanding of the range of climate change adaptation strategies. During the project's six years, a wide variety of activities was completed.

a. Community Objectives

Project participants successfully:-

- Built closer collaborative relationships between the University of the West Indies and regional coastal communities;
- Established C-CHANGE Community-University Support Groups (C-USG) and Advisory Groups in each of the four sites where they were able to meet with stakeholders and share major findings of the research to build local capacity to implement adaptive strategies;
- Gathered information on resources, services and priorities, in conjunction with C-USG and Advisory Groups;
- Met with each community, on objectives, methodology, participants, and deliverables
- Strengthened community institutional arrangements (policy, guidelines, plans);
- Supported the Development of community adaptation action plans;
- Involved non-municipal/local government agencies or community members in the work of C-CHANGE;
- Developed community adaptation action plans;

b. University Objectives

Project participants successfully:-

- Carried out of field trips, in particular to the sites under investigation;
- Developed new university curricula to build capacity in Universities;
- Submitted for publication and published top-quality articles in well recognized international journals;
- Gathered information on resources, services and priorities, in conjunction with C-USG and Advisory Groups;

- Inventoried physical (infrastructure, topography, hydrography), economic, social, and institutional data in selected research sites;
- Hosted and/or participated in conferences on Climate Change in the Caribbean region, Canada and elsewhere; Developed GIS architecture;
- Carried out scenario analysis to determine the impact of sea-level rise on the sites under investigation;
- Implemented a comprehensive database of the vulnerability of the Caribbean States under study;
- Characterized and evaluated the impact of the climate change on the coastal states
- Created a vulnerability index for Caribbean States;
- Published press releases, various articles, book chapters and one book;

c. Joint Community-University Alliances objectives

Project participants successfully:-

- Assessed community adaptive capacity to environmental change;
- Developed environmental impact scenarios;
- Gathered information on resources, services and priorities, in conjunction with C-USG and Advisory Groups;
- Identified and recommended Policy Options to address Impacts;
- Calculated vulnerability/risk indices in each community;
- Mapped data and infrastructure with GIS;
- Created Model and Impact scenarios on the impact of climate change; sea level rise and surge tides for the sites under investigation;
- Strengthened community institutional arrangements (policy, guidelines, plans);
- Trained a large number of persons in various disciplines at the University of the West Indies at the undergraduate and graduate level, including the Ph.D.

6. Project Outputs

The project design, which focussed on enabling collaboration with, and knowledge transfer across and between, the major research partners, as well as community level knowledge transfer, benefitted a range of persons, including students, partners, and residents living in the communities under investigation.

a. Research Output

Table 2 shows the team's research production from 2009 to 2015. The main areas of research were vulnerabilty of coastal communities, climate change impacts on coastal communities, adaptive capacity of coastal communities, urban and regional planning, coastal engineering management, geography, geoinformatics and economics.

The team published seven (7) journal articles (there was collaboration between the Caribbean and Canadian teams for one published journal article); have eight (8) in submission; contributed two (2) book chapters (there was collaboration between the Caribbean and Canadian teams for one (1) book chapter); and presented thirty four (34) conference papers; prepared one (1) non-academic paper and published one (1) book.

In the Caribbean there were four (4) undergraduate degrees which were or are being completed. Seven (7) graduate students have completed, or are in the process of completing, studies, five (5) at the Masters level and two (2) at the Doctoral Level).

Table 1– Summary of Research Produced

Research production during the five years of the project	**Total number of Research Outputs**
Journal articles (published / accepted)	7
Journal articles (in submission)	8
Conference papers	34
Presentations (non-academic)	1
Books	1
Book chapters	2
Newspapers / other media	2
B.Sc	4
MA / MSc	5
PhD	2

Some fifteen (15) students received training at both the under graduate and graduate levels over the duration of the programme. As listed in Table 1, the students received high quality training and education and were successful in attaining:-

- Four (4) Undergraduate Degrees (two (2) completed, two (2) in progress)
- Nine (9) Masers Degrees (two (2) completed; seven (7) in progress)
- and two (2) Ph.D. students (both in progress)

The students came from different locations in the Caribbean. Of the fifteen students who received training, nine were women.

The students were offered training opportunities in the following multidisciplinary fields: Environmental Natural Resource Economics; Coastal Zone Adaptation to Climate Change; Urban and Regional Planning; Coastal Engineering Management, Geography, Geoinformatics, Economics of Climate Change, Sustainable Economic Development and General Economics.

Table 2 - C-CHANGE/C-CHANGE Students

Type of Study	Name	Area of Study	Qualification at time of award of Scholarship	Current Status
Under-graduate	1. Cerano Da Silva	B. Sc. Environmental and Natural Resource Management	Pursuing the B. Sc. Environmental and Natural Resource Management	Completed 2014 First Class Honours
	2. Farah A. Hosein	B. Sc. Geomatics	Pursuing the BSc. Geomatics	Completed 2012 Currently pursuing the M. Sc. in Geoinformatics
	3. Aria Laidlow	B. Sc. Environmental and Natural Resource Management	Pursuing the B. Sc. Environmental and Natural Resource Management	In progress Final Semester II 2015
	4. David Sobers	B. Sc. Social Policy and Development	Pursuing the B. Sc. Social Policy and Development	In progress, transferred to the B.Sc. in Youth Development
Graduate Students	1. Kyana Bowen	M. Sc. Urban and Regional Planning	Pursuing the M. Sc. Urban and Regional Planning	Completed 2012
	2. Tracey Beard	M. Sc. Urban and Regional Planning	Pursuing the M. Sc. Urban and Regional Planning	Completed 2013
	3. Keston Finch	M. Sc. Coastal Engineering Management	Pursuing the M. Sc. Coastal Engineering Management	In progress
	4. Hannah Fortune	M. Sc. Urban and Regional Planning	Pursuing the M. Sc. Urban and Regional Planning	In progress
	5. Alana Joseph	M. Phil. Geography	Pursuing the M. Phil. Geography	In progress
	6. Kira Lise Leung	M. Sc. Urban and Regional Planning	Pursuing the M. Sc. Urban and Regional Planning	Completed
	7. Nolana Lynch	M. Phil. Tropical Earth and Environmental Science	Pursuing the M. Phil. Tropical Earth and Environmental Science	In progress
	8. Amit Seeram	M. Sc. Geoinformatics	Pursuing the M. Sc. Geoinformatics	Completed 2014
	9. Demi Singh	M. Sc. Geoinformatics	Pursuing the M. Sc. Geoinformatics	Completed 2014
	10. Rudo Udika	M. Sc. Urban and Regional Planning	Pursuing the M. Sc. Urban and Regional Planning	In progress
Post Graduate Students	11. Sherry Ann Ganase	Ph. D. Economics	M.Sc (Economics)	In progress
	12. Dickson Osuala	Ph. D. Economic Development and Policy	M.Sc (Economics)	Thesis under examination

b. The Education and Learning Environment

A total of fifteen (15) courses were either introduced into the teaching programme of the University of the West Indies, or modified to take into account content related to the C-CHANGE project, across a number of Faculties. More than two hundred (200) persons

benefitted from the introduction and delivery of these courses and more will benefit in the future.

Table 3 - Course List

Course	Topics
ECON 6005	Climate Change Vulnerability and Adaptation in Developing Countries (Reading Course)
ECON 6010	Linking Vulnerability, Adaptation and Mitigation in SIDS: Climate Change and the Community of Grande Riviere, Trinidad
GEOM 2010	Information System and Geographic Information Systems, hardware and software systems, Spatial data issues - acquisition and input, data structures, data management, data processing, data manipulation, data analysis, spatial data quality, Designing and implementing GIS: data requirement, technical requirement,
GEOM 3050	Land technical, socioeconomic, political, and environmental concepts and theoretical issues from the perspective of a surveyor's role
GINF 6021	How GIS systems and spatial data are embedded in particular economic, political, social and legal structures affect the wider use of GIS
LAND 5006	GIS applications to social, political, economic and environmental issues
PLAN 6014 Planning in Coastal Zone	Climate Change Impacts on SIDS Natural Resources
PLAN 6011	Planning in the Coastal Zone and Climate Change Adaptation
PLAN 6025	Climate Change Impacts on Coastal and Terrestrial Ecosystems and Physical Planning Adaptation Measures
PLAN 6030	Climate Change, SLR, Flooding and Adaptation using Physical Planning measures
SALI 7000/8000	Research Dissertation
SALI 7001/8001	Directed Readings On Thesis Topic
SALI 7002/8002	Research design and management
SALI 7101/8101	Specialised research methods
SIDS in Nat Res Mgt	Critical Issues in Land use and Natural Resources Management

c. C-CHANGE Supported Special Projects

Over the years 2010 and 2011 six (6) special C-CHANGE-funded projects were executed. The projects focussed on Bequia, Georgetown and Grand Riviere:

Table 4 - Special Projects List

NAME	SPECIAL SUPERVISED C-CHANGE SUB-PROJECT
Demi Singh	1. Digitization of Spatial data for Georgetown, Guyana ○ Building spatial dataset with approx. 29800 building footprints ○ Street spatial dataset ○ Ward spatial dataset 2. Development of spatial database for digitized datasets for Georgetown, Guyana
Farah Hosein	1. Prepare GIS data related to Georgetown for final delivery to the CHPA in Georgetown, Guyana as discussed with Mr. Rawle Edinboro (Collaborator) at the C-CHANGE project retreat in Grande Riviere; 2. Link socioeconomic data to spatial data for Grande Riviere, and completing preliminary spatial analyses of socioeconomic phenomena 3. Complete preliminary work on the Georgetown dataset with regard to sea level rise modeling; and 4. Complete preliminary work on the GIS data and modeling for Bequia;

d. C-CHANGE-Related Leveraged Projects

Project co-applicants also provided support to other projects jointly funded with the Association of Universities and Colleges of Canada as well as the UWI School for Graduate Studies and Research.

Table 5 - – C-CHANGE Related Projects

NAME	PERIOD	FUNDING SOURCE	AMOUNT	Co-Applicants involved	OUTCOMES
Knowledge Transfer of Public Participatory GIS Innovation	JAN. 2012 – DEC. 2012	International Development Research Centre (IDRC) and *Association of Universities and Colleges of Canada*	CAD$14,775.00	M. Sutherland and S. Nichols. Applicant; Researcher	Public Participatory GIS for selected Caribbean sites
Development of Public Participatory GIS for Caribbean Coastal Communities	JAN. 2012 – DEC. 2012	University of the West Indies School for Graduate Studies and Research – Research and Publication Grant	TT$44,225.00	M. Sutherland. Applicant; Researcher	Public Participatory GIS for selected Caribbean sites

7. Project Outcomes

a. Collaboration between Researchers in the Caribbean and in Canada

1. Over the course of the project, the C-CHANGE research team based at the University of the West Indies were able to liaise and work with their counterparts from the Telfer School of Management of the University of Ottawa, the University of New Brunswick, the University of British Columbia and other Canadian Institutions. They also benefitted from contact with members of the SSHRCC and the IDRC, Canada. The team members were also able to extend the collaboration between research institutions located in the sites under investigation, particularly through the use of electronic database which formed the core resource for the identification, collation, analysis and dissemination of information in the communities and the impacts of pending climate change. There was a transfer of technology skills from Canada to the Caribbean on the development and use of a coastal GIS platform for the capture and display of project data. This was effected through the multidisciplinary nature of the project teams and their working relationships.

2. The alliances collaboratively developed adaptation and mitigation tools and methods, best practices, and appropriate policy recommendations. Using a multidisciplinary approach, this research incorporated aspects of sociology, economics, management science, and geomatics engineering. Leveraging the results of previous research, various levels of sea-level rise were modeled to identify potentially impacted community socioeconomic infrastructure. The models' results then provided support for socioeconomic impact assessment, the development of mitigation and adaptation strategies, and the development of appropriate policy recommendations.

3. Members of both the Caribbean team and the Canadian team met several times over the duration of the project and the joint team meetings were designed to ensure that site-based individual work plans were presented and discussed. Both researchers and students not only acquired new knowledge and perspectives and learned new technical skills and methodologies, but became more informed and capable in the communication and management skills needed to keep a large interdisciplinary team operating effectively. The students' knowledge and skills were enhanced as they presented their research to the team and at conferences and workshops.

4. The Public Participatory GIS (PPGIS) systems work led by Canadian co-applicant Dr. Sue Nichols (UNB) and her M.Sc. student, Titus Tienaah was done in collaboration with

Caribbean co-applicant Dr. Michael Sutherland to ensure the transfer of knowledge to researchers and targeted communities in both Canada and the Caribbean;

5. Four UWI undergraduate students participated in geomatics fieldwork involving the collection of primary data via hydrographic and topographic surveys. These data were used to develop a preliminary GIS predictive sea level rise model of Grande Riviere, Trinidad. This model was part of the methodology for assessing the socioeconomic impacts of that threat upon Grande Riviere. Apart from the technical work required to accomplish that task, the geomatics students learned the importance of interdisciplinary research, utility of their discipline to support socioeconomic research, and importance of acquiring community knowledge.

b. Data collection and community database

1. In 2011 a retreat was held in Grande Rivière and brought together the academic and community members of the project to share and discuss methodologies and project progress;

2. The identification, analysis, and evaluation of risks from climate impact scenarios was guided by structured database development of available community resource inventories including physical, economic, and social capital projecting the likelihood of real threats to local infrastructures, environments, economies and cultures and presented to community action teams to inform mitigation measures;

3. A DVD compilation of sea level rise in Grande Rivière was developed and used as an awareness instrument for both community members and policy makers;

4. The addition of valuable information to the data on the impact of climate change in developing countries which can also be applied to the Vulnerability Index and permits Caribbean states to identify mechanisms and adaptive measures to reduce their levels of vulnerability;

5. The identification of Climate Change Adaptation Strategies and policy prescriptions which may be replicated in other communities and sites in the Caribbean;

6. The exploration of engineering, physical planning and eco-design adaptation responses to minimise negative effects on the coastal environment and its community to make recommendations for building the coping capacities of coastal communities affected by climate change and physical development;

7. Building capacity at the community level through training to implement some adaptation measures;

8. The mapping output from the research used as a communication tool for building adaptation capacity among affected coastal communities.

9. In the first year, Canadian and Caribbean research teams establish the local C-CHANGE Community-University Support Groups. The Support Groups mobilised community engagement, gathered information and local priorities, and inventoried community resources, services, institutional and governance linkages. This information permitted the locally assisted development of environmental vulnerability indices for the community. Community spatial models were presented to the community to examine environmental impact scenarios including integrated econometric and socioeconomic impacts models from data projections for community discussion and review.

c. Visual Modelling

1. Spatial mapping and visualization were used to simulate and animate hypothetical situations for community discussion including exploring the impacts and response of adaptation and mitigation strategies to perceived and real threats.

2. Systems Dynamics (SD) techniques were used to describe and link the physical, economic and social baselines through visual spatial and temporal maps.

3. Sea level rise models based upon IPCC projections were constructed using hydrographic and topographic surveying techniques, and GIS. Informed by projected scenarios, communities gained understanding of possible beach loss and coastal inundation due to sea level rise, and its potential impact upon sea turtle nesting sites.

d. Vulnerability Modelling

1. Different models and frameworks were proposed over the years to measure vulnerability but this project differed in that it sought to capture or account for varying indicators within the SIDS of the Caribbean that aid in the estimation of their vulnerability.
2. A methodological framework for assessing vulnerability in SIDS, based on the Sustainable Livelihoods Approach (Hahn et al. 2009[2], Osuala et al. 2015[3]), and with emphasis on the Caribbean region, was developed;

[2] "The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique".

[3] "Perceptions of Risk associated with Climate Change: Causes and Implications for Adaptation in the Case of Georgetown, Guyana"

3. Micro-data on socioeconomic characteristics of each community was collected through a face-to-face administered questionnaire;
4. Vulnerability Indices (VIs), using this framework, were calculated for all four Caribbean sites as well as for sub-regions of all sites (except Grande Riviere, which was too small).
5. An examination was made of the level of risk that the critical facilities and properties in each community could face in the future by using projections of sea-level rise presented via spatial GIS models. The impact of these projected changes on sustainable livelihoods was calculated, allowing for the identification of appropriate adaptive measures through which vulnerabilities may be reduced.
6. Static and dynamic maps were used to provide visual presentations of both current vulnerability conditions as well as the vulnerability resulting from potential future scenarios of coastal environmental risks.
7. Studies were[4] completed assessing and analysing factors (social, economic and environmental) that impact vulnerability/resilience in Small Island Developing States with emphasis on the Caribbean region.
8. Using the case of Grande Riviere[5] as a specific example, the challenges of climate change associated sea level rise, beach erosion and physical development on leatherback turtle nesting and eco-tourism were analysed and recommendations made for building the coping capacities of coastal communities affected by climate change. A key finding was that when a projected minimum sea level rise scenario employing a GIS model is applied, the beach area, which is essentially the nesting habitat of leatherback turtles, would be altered. The mapping output from this research was used as a communication tool for building adaptation capacity among affected coastal communities and served to inform policymaking and regulatory stakeholders in the preparation of physical planning and design guidelines aimed at promoting sustainable coastal communities;

9. Generally, the results of these studies have important policy implications since policy- and decision makers will have to act to reduce and/or eliminate risk of exposure of specific areas of the community by implementing adaptation or mitigation measures and directing development away from future high-risk areas.

e. Adaptive Capacity and Resilience Modelling

[4] "Assessing Vulnerability to Climate Change in Small Island Developing States: A Proposed Methodological Framework"

[5] For example, "Climate Change and Physical Development Threats, Challenges and Adaptation Responses in Coastal Communities: Grand Riviere, Trinidad – April 2010"

Simulation exercises for a variety of policy options and exogenous shocks were conducted to examine how community vulnerability would be impacted. These simulations led to a series of (generally low-cost) recommendations of adaptation strategies to attenuate climate change impacts at the governmental, community and household levels. Some of these are

- Promote climate change awareness as a civic responsibility for nationals of the various countries to influence behavioral attitudes i.e. apathy to climate change.

- Improve efforts at mainstreaming climate change education and knowledge into the national school curriculum at all levels of education, which in turn builds human capacity.

- Incentivize participation in volunteer programs/schemes on raising climate change awareness this could be done in the form of or as part of a national youth service program.

- Partner and sponsor research into new trends, methodologies, processes by which climate change knowledge and information can be disseminated in the jurisdictions, fund workshops/training programmes for community based organizations, non-governmental organizations on how to effectively impart climate change knowledge.

- Create a database of autonomous adaptation measures on different scales i.e. household, community and ward, disseminate to residents of Georgetown coupled with a set of guidelines on how to respond in the event of flooding/coastal inundation brought about by sea level rise.

- Promote greater participation in flood insurance schemes by subsidizing premium payments for flood insurance policies. The further inland you are the greater the subsidies on your policy, this will likely encourage setting back of homes and relocation inland.

Proactive adaptation planning and implementation with respect to refurbishing coastal protection infrastructure and assets should commence urgently given that coastal protection projects take 30 years or more.

f. Implementation of local adaptation planning and action frameworks

Community Groups were identified and engaged in all four Caribbean sites: Georgetown (Guyana), Bequia (St. Vincent and the Grenadines), San Pedro (Belize) and Grand Riviere (Trinidad and Tobago). Groups at all sites readily agreed to interventions at the primary and secondary school levels. The GIS mapping of Georgetown was adopted for use by our partner organisation, the Central Housing

and Planning Authority of Guyana and the mappings of the other sites have been made available to the communities.

g. Creation and Communication of Knowledge

1. Papers and reports were made available to partners and community contacts through the via the project website. Within the academic community, research papers derived from the work were published and submitted for publication in both disciplinary specific academic journals and in journals that address broader interdisciplinary topics.

2. To enhance communication with communities, periodic working papers and community workshop reports were executed at the sites and directed at community leaders, practitioners and policy makers and focused on practical adaptation of information to matters of direct interest to these groups.

3. Students were trained in the identification and measurement of relevant phenomena, policy prescription, and modelling and analysis of the effects of rising sea-level and storm surges.

4. A Communication and Knowledge Dissemination Package for Climate Change Education and Awareness in Coastal Caribbean Communities was developed by PANOS Caribbean, Jamaica (2011) and used in regional communities to disseminate C-CHANGE's message. An average of 50-60 persons in each of the communities were exposed to C-CHANGE through this medium, in particular teachers and students of primary and secondary schools. The emphasis was on the climate threat to the Caribbean region and the need for greater awareness. A Professional communicator was employed at the sites, and she was accompanied by members of the C-CHANGE research team, who used the opportunity to make available results of the research. Copies of the training documents were left with members identified as leaders in the communities. In all cases, the communities agreed to support the notion of climate change on the syllabus of both the primary and secondary levels.
5. The Conference "Sustainable Development of Coastal Communities: Challenges and Solutions" held in Port-of-Spain, Trinidad in June 2011 increased national awareness of impact of climate change on coastal communities. A total of one hundred and five people participated in the conference. Presenters represented Canada, Guyana, Jamaica, Martinique, South Africa, Trinidad and Tobago and the United States.

h. Training

1. Training outcomes included: (1) academic training, and (2) community-based training of both professional and non-professional participants. Non-academic partners were introduced to GIS mapping and modelling and GIS maps of the various sites were prepared and made available to the communities. In the particular case of Georgetown, the community Partner was the Central Housing and Planning Authority of Guyana, which put our work to immediate use in Georgetown.

2. Formal courses were introduced or enhanced at the University of the West Indies, taking into account project results. Graduate students were also exposed to doing community based research and were able to practically apply theory and policy. Students were trained in the identification and measurement of relevant phenomena, policy prescription, and modelling and analysis of the effects of rising sea-level and storm surges.

8. Overall Assessment and Recommendations

Overall project assessment can be summarized as following:

a. Coordination and Governance

Overall project coordination and governance was impacted by several changes in Project Managers throughout the life of the project. This was all the more disruptive given the involved nature of the project:

- There we four research sites spread out all over the Caribbean, two of which are particularly cumbersome to reach (the islands of San Pedro and Bequia);
- This was community-based research, which required involvement of the community whose members (mainly of modest means), for the most part, were preoccupied with going about their daily business and who, notwithstanding tremendous goodwill, often viewed our interventions as intrusions;
- The research thrust was multi-disciplinary, which required the coordination of teams who, often, did not understand and even appreciate each other.

All this caused severe delays in some aspects of project execution and the collation and presentation of status data on the project.

The Core SALISES staff, whose responsibility was administrative and academic affairs management, was required to fill gaps created by changes in project staff, which burdened them and further slowed down project execution.

The University of the West Indies co-applicants, who all carried full teaching loads while simultaneously working on the project, influenced the timeframes and coordination and resulted in delays in the implementation of some project activities due to applicant unavailability.

b. Financial Management

The financial management of the project was complicated by SALISES having to rely on the main UWI Bursary to support financial disbursement, monitoring and control as well as financial reporting.

c. Transfer of Knowledge to Communities

While significant work was done with the communities in the investigation sites (see above), the transfer of knowledge was at times problematic. The project applicants were able through funding supplied to this project to maintain working relationships with community members.

In the context of the applicability and impact of UWI research within the Caribbean funds and personnel should be identified to engage in continuous community interaction and support.

d. Sustainability

The post-implementation sustainability of this project is a major challenge. While Community groups and local coordinators were engaged throughout the life of this project, there is a high probability that vulnerable communities may not have the financial and personnel capacity to maintain adaptation measures in the medium to long term and gains accruing to the project could be easily eroded.

We have every confidence that the community partners that worked with us during the project are in it for the long haul. They, nevertheless, have limited access to funds and spend a lot (most?) of their time going about their routine business and there is a risk that they may be discouraged. It is the intention of the research team to maintain the contact and to provide whatever back-up is necessary. We have supplied them with certain tolls that they are already finding useful and the contacts – indeed, the friendships – that have developed along the way will combine with the physical outputs provided to make the results sustainable for some time to come.

e. Recommendations

To consolidate the future of climate change research in the Caribbean, the following recommendations have to be considered:

1. Identifying opportunities to fund and support ongoing research to measure the impact of the outcomes of this projects and various mitigation strategies in the sites investigate for this project;
2. Offering new training opportunities at certificate and undergraduate levels to students of impacted communities across the region;

3. Assuring knowledge and skills transfer to communities across the Caribbean in island states which could benefit from the new knowledge created through this project;

4. Deepening the collaboration with Institutions and Governmental and Non-Governmental agencies to facilitate more widespread transfer of knowledge and the integration of research results into policy decisions with regard to adaptation to and management of climate change;

5. Identifying a mechanism whereby SALISES controls funds from grants may need to be explored to manage the financial aspects of projects to avoid long term procedures by the university proper. The project's activities suffered from some delays that influenced the performance and efficiency of the overall research program.

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