Managing adaptation to environmental change in coastal communities: Canada and the Caribbean

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Abstract

The impacts of the changing climate are nowhere more imminent or intense than in the coastal zone. Rising temperatures, thermal expansion of water, and subsidence of the land base are contributing to sea level rise, changing precipitation patterns, more frequent intense weather events, storm surges and flooding, salinisation of fresh water, coastal erosion, increased sedimentation of coastal waters, and pollution from flooded or destroyed infrastructure and storm runoff. Globally, the recent UN Conference on Climate Change in Copenhagen brought global media attention to the fact that not enough is being done to support mechanisms between our scientific knowledge and adaptation policies by mobilizing people, businesses, and institutions to prepare for the negative impacts of rising seas. As part of an international research initiative, this paper presents a framework, "C-Change", for integrating the multiple dimensions of the problems facing selected coastal communities in Canada and the Caribbean toward managing adaptation to the changing environment. Multiple dimensions in the coastal system include the bio-physical, economic, social and institutional arrangements of coastal communities. Criteria are given relative importance by the broad definition of participant groups within coastal communities: (1) governance and local decision makers; (2) private and public infrastructure services; (3) business and economic activity organizations; (4) citizens' groups; and (5) special interest or disadvantaged members (the poor, seniors, minorities). The methodology captures and profiles community data via a geographical information system that identifies sensitive areas to storm surge and sea level rise. The decision model compares among the participants alternative evaluations of community adaptation strategies in the face of simulated extreme weather conditions and provides a ranked group decision evaluation procedure to assist decision makers in their operational and strategic negotiations and evaluations. A selected set of coastal communities in Canada and the Caribbean are examined toward developing local strategic preparedness plans for community adaptation to the changing environment.

Keywords: coastal communities, environmental change, seal level rise, storm surge, GIS, system dynamics, soft systems, multicriteria decision analysis, community governance and decision making

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1. INTRODUCTION

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 (Harvey et al 2008, UNEP 2008, IPCC 2007a,b, IISD 2007, FAO 2007, Stern 2007). 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, Taylor 2007, Pelling and Hugh 2005, Pelling and Uitto 2001, Mahlung 2000, INC 2000,).

In Canada, despite the capacity to predict severe storm events and coastal vulnerabilities to sea level rise, there are concerns that not enough has been done to establish strategic linkages between scientific knowledge and institutions responsible for needed planning and adaptation for coastal communities on Canada's three oceans (Lemmen et al 2008, Weaver 2008). The September 2008 Report of the Standing Senate Committee on National Security and Defence states that "Canadians have no assurance that essential government operations will function during emergencies." (Canada 2008, p.6) Severe weather events, e.g., Hurricanes Katrina-August 2005, Ike-September 2008, and Juan-September 2003, have proven the vulnerability of coastal governance, industrial sectors, and social systems to severe storms and sea level rise. Hurricane Katrina flooded 80% of New Orleans and demonstrated the inadequate ability of governments to address impacts on humans and infrastructure damages. When Hurricane Juan hit Nova Scotia in September 2003 as a Category One storm, it resulted in eight Canadian deaths and over $200CAD millions in damage, and has been described as a "one hundred year storm" - the worst storm event to hit Halifax since 1893. Halifax was poorly prepared for such a storm event, as was evident in the time required to restore essential services in Juan's wake. Prior to Juan hitting Charlottetown, PEI, the city had expressed interest in planning for such an event (McCulloch et al 2002). However, despite considerable analysis having been done to model the potential impacts of storm surges, the community had not developed effective means to mobilize people, businesses, and institutions to prepare for the storm and its negative impacts. Well-intentioned government programs, e.g., Emergency Measures Organizations, are typically slow to reach impacted areas, and cannot be counted on to provide immediate help. 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 can both anticipate potential impacts and strategically apply limited resources to priority areas to reduce negative impacts (Mehdi et al 2006).

This paper introduces C-Change, an International Community-University Research Alliance (ICURA) research program for 2009-2014 that addresses the plight of coastal communities faced with pending environmental change. In this report, the C-Change community-based framework is described for evaluating storm surge and sea level rise impacts toward providing communities enhanced capacity to prepare for pending change to their coastal environments.

2. C-CHANGE OBJECTIVES

The C-Change develops local coastal community capacity to close the gaps between inevitable environmental change and the urgent need for local coastal communities to adapt their own efforts to anticipate and plan for climate impacts to their environmental, economic, social, infrastructure and cultural well-being. Community adaptation is acknowledged as the capacity of natural and human systems to adjust to global and local environmental change and to reduce adverse effects. This research seeks to improve planning for adaptation through the development and incorporation of new policy and management measures consistent with established planning theory and guidelines and the local context, through the use of tools and the identification and evaluation of practical local alternatives for coastal resource management.

The focus is on immediate and downstream consequences to coastal communities of the insidious effects of sea level rise and the potential catastrophic impacts of extreme weather events. Sale et al (2008) note that the keys to improving local capacity for planning adaptation and emergency preparedness lay in integrating local and traditional knowledge with available scientific, management, and institutional governance information. Similarly, this project addresses the vital need to inform and adapt municipal and private sector capacity to make needed changes to: (i) development priorities and practices, (ii) existing and evolving infrastructure, (iii) transportation and utilities systems, (iv) health and emergency services, (v) water and sewage distribution and treatment systems, and (vi) the management of environmental resource sectors in agriculture, aquaculture, and fisheries.

Anticipated and significant environmental impacts to coastal biodiversity will have a domino effect on coastal resources. Development of scenarios and measures to assist adaptation to environmental change can best be achieved through cooperation and sharing of knowledge, applied resources, and expertise between academic institutions allied with organizations in the coastal community in an output-driven, collaborative and applied research effort. As a collaborative community-university research program, C-Change creates alliances among:

a) selected coastal communities in Canada and the Caribbean,
b) postsecondary institutions to providing research and training resources,
c) community businesses, and
d) institutional and technical services leaders.

These alliances are aimed at developing strategies and making decisions to equip the coastal community in planning for sea level rise and for storm related emergencies. The research also establishes formal collaboration and mutual co-learning opportunities among the selected Canadian and Caribbean coastal communities on comparative research on policy implementation for adaptation to coastal environmental shifts. The research program also recognizes the fundamental need for capacity-building through its commitment to training of university graduates and community decision-makers and through the creation of new adaptive policy and management measures. C-Change objectives are summarized in Table 1 below.

No.	Community	University	Joint Community-University
1	***Establish formal Community-University alliances*** to assist in information gathering, priority-setting, decision making, reporting, and application of research deliverables.	***Develop academic alliances*** among university researchers in Canada and the Caribbean to share knowledge, resources and expertise on the adaptive capacity of coastal communities	***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	***Strengthen community institutional arrangements*** through the development of new management instruments, planning policy, guidelines, strategic plans, and decision support methods.	***Collaborate on global research*** and share the results of socioeconomic research with international links, e.g., UN, IPCC, through publication in journals, and participation in international conferences	***Mobilize knowledge and innovation*** to reduce coastal community risks through workshops, data and research collaboration within the Canada-Caribbean communities and among the academic participants.
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.	***Develop new curricula*** for Managing Adaptation to Environmental Change in Canada and in the Caribbean including joint graduate and undergraduate level courses in science, social science, and management	***Build capacity*** through training of graduate and undergraduate students, and local participants and decision-makers in the communities through workshops, seminars, and local field work and reports to the community.
4	***Prepare community action plans*** based on existing governance and local institutional authorities to advance preparedness for environmental shifts and emergencies.		***Develop impact scenarios, and prepare adaptation action plans*** in partnership with the priorities and concerns of the local community government, services, and community members.

Table 1. C-Change Research Program Community and University Objectives

3. COMMUNITY THREATS AND ADAPTATION

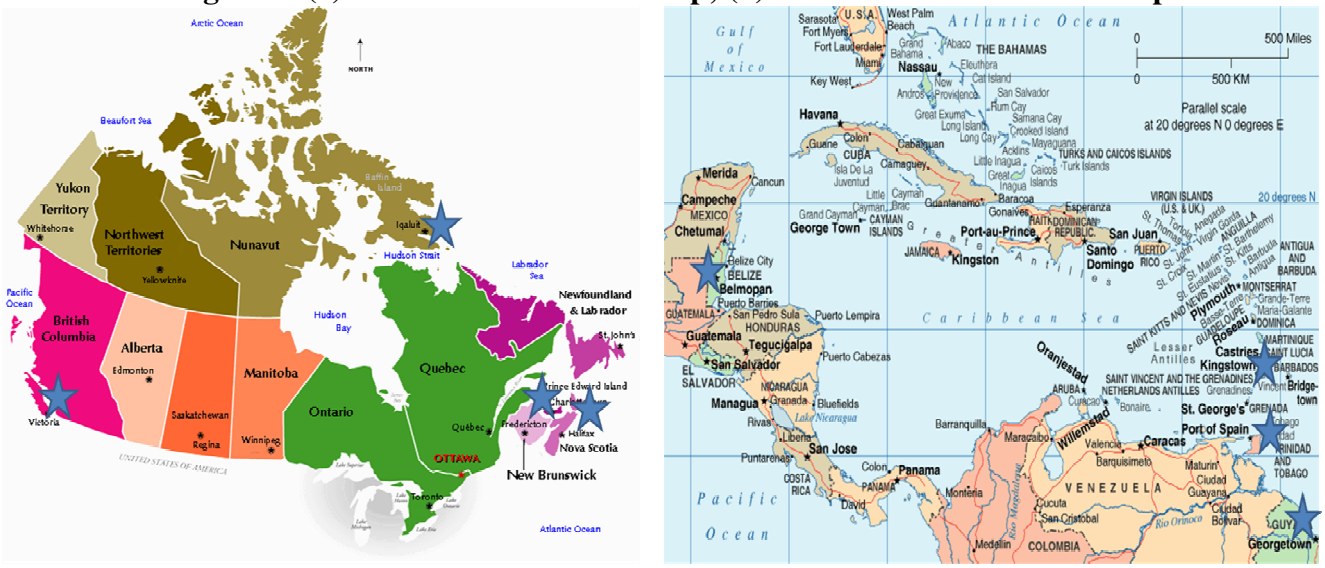
The eight C-Change coastal and twinned communities in each of Canada and the Caribbean are identified and characterized in Table 2 and Figure 1 maps below.

Community	Canada	Caribbean	Characteristics
1	Charlottetown Prince Edward Island	Georgetown, Guyana	Capital cities
2	Iqaluit, Nunavut	Belize Barrier Reef, Belize	Native homeland communities
3	Gibsons, British Columbia	Grand'Rivière, Trinidad and Tobago	Mainland coastal communities
4	Isle Madame, Cape Breton, Nova Scotia	Island of Bequia, St. Vincent & the Grenadines	Island communities

Table 2. Twinned Canada-Caribbean coastal communities

Communities are each defined broadly as a system comprised of: (1) governance and local decision makers (e.g., municipal governments); (2) private and public infrastructure services (planners and design professionals, utilities and services, insurance); (3) business and economic activity organizations (corporations, small businesses, boards of trade and commerce); (4) citizens' groups (environmental advocates, indigenous communities); and (5) affected individuals (especially special interest or disadvantaged members of the local society who are socially differentiated by poverty and across gender, class, race and age).

Figure 1. (a) Canada communities map; (b) Caribbean communities map



Coastal communities under threat in Canada and the Caribbean are susceptible to serious, immediate threats to infrastructure and or natural environments (e.g. tourism infrastructure, natural resources, habitats, species), and to local area residents (e.g. livelihoods, family structure, cultural assets, and vulnerabilities derived from poverty/gender issues). Table 3 summarizes the threats and vulnerabilities of the 8 C-Change communities under study.

4. C-CHANGE METHODS

The interdisciplinary C-Change research process adopts key research strategies, activities and methodologies. Figure 2 below illustrates the research process being applied, as described in further detail below.

Local C-Change Community Action Teams (C-CATs) mobilize community engagement, gather information and local priorities, and inventory community resources, services, institutional and governance linkages. This information is used to develop local measures of environmental vulnerability indices for each community. Community spatial maps are developed to display community data and resources. The spatial information is used to examine the impact of environmental scenarios using integrated econometric and socioeconomic community impacts models from community data trends. Baseline indices are updated over the course of the project with changes to the value of the community vulnerability and adaptive capacity indicators to reflect ongoing project activities and policy measures. C-CATs guide surveys and questionnaires, and facilitate 'buy-in' by the wider communities including leading local community workshops with the assistance of the C-Change Community Coordinator and researchers. Local community workshops provide training in "Managing Adaptation to Environmental Change" and use of vulnerability and adaptive capacity measures and build knowledge towards planning for change.

Community	Distinctiveness	Threats	Partnerships and Alliances
Charlottetown Prince Edward Island	Provincial capital city and coastal port; Population 60,000, centre of industrial and commercial activity; historic downtown	Impacts to infrastructure and historic sites from flooding associated with predicted SLR and storm surges	City council; provincial government, local university, businesses and services, UPEI
Georgetown, Guyana	National capital city and coastal port; centre of industrial and commercial activity, Population 215,000; largest city in region, 14' below sea level;	Breaching of the protective sea walls and dykes by storm surges, salt water contamination of drinking water supplies	Central government planning agency; local community groups; local businesses and enterprises
Iqaluit, Nunavut	Territorial capital city in Canada's high North. Population highly sensitive terrestrial and marine Arctic environment Eco-tourism including whale-watching; whale hunting permitted by native peoples using traditional methods; nearby shipping	Melting/destabilization of permafrost areas of shoreline leading to erosion and sedimentation and coastal hydrological and biodiversity changes - leading to impacts on ecosystems, indigenous cultures	Local contacts, team members with experience in working in these communities
Belize Barrier Reef	Island atolls on 300 km section of the 2nd largest reef in world - the Mesoamerican Barrier Reef System, World Heritage Site ;destination for half of region's 260,000 tourists, nearby shipping lanes	Impacts from SLR and storm surge on coral reefs, and on local tourism and fish and shellfish fisheries	Local contacts, team members with experience in working in these communities
Gibsons, British Columbia	Sunshine Coast coastal town, unique location with proximity to Vancouver, popular resort town, significant eco-tourism and hiking and camping area	Impacts from SLR and severe storms leading to beach erosion and risk of groundwater exposure to salinisation	Town council and planning committee support, Local contacts with tourism and environmental groups
Grand'Rivière, NE Coast, Trinidad and Tobago	Isolated village of fishermen and small crop farmers, popular local eco-tourism area, protected nesting area for giant leatherneck turtles; nearby shipping important agricultural areas	Immediate potential for impacts from sea level rise and severe storms	Local contacts with tourism and environmental groups
Isle Madame, Cape Breton, Nova Scotia	Local fishing and aquaculture area, eco-tourism, archipelago of small isolated coastal communities; historic settlement area for Acadians	Impacts from SLR and severe storms on unique transportation links and potential isolation due to infrastructure damage	Municipality Council, development association, DIMA, industrial, professional activities, businesses, trade & tourism, Univ Sainte-Anne
Island of Bequia	Island archipelago and coral reefs. Popular boating area for cruising yachts; marine, eco-tourism based on whale-watching; natural habitats, native peoples' traditional marine activities, nearby shipping lanes	Impacts from SLR and severe storms, unique transportation links, potential isolation due to infrastructure damage	Local governments, industrial, professional activities, businesses

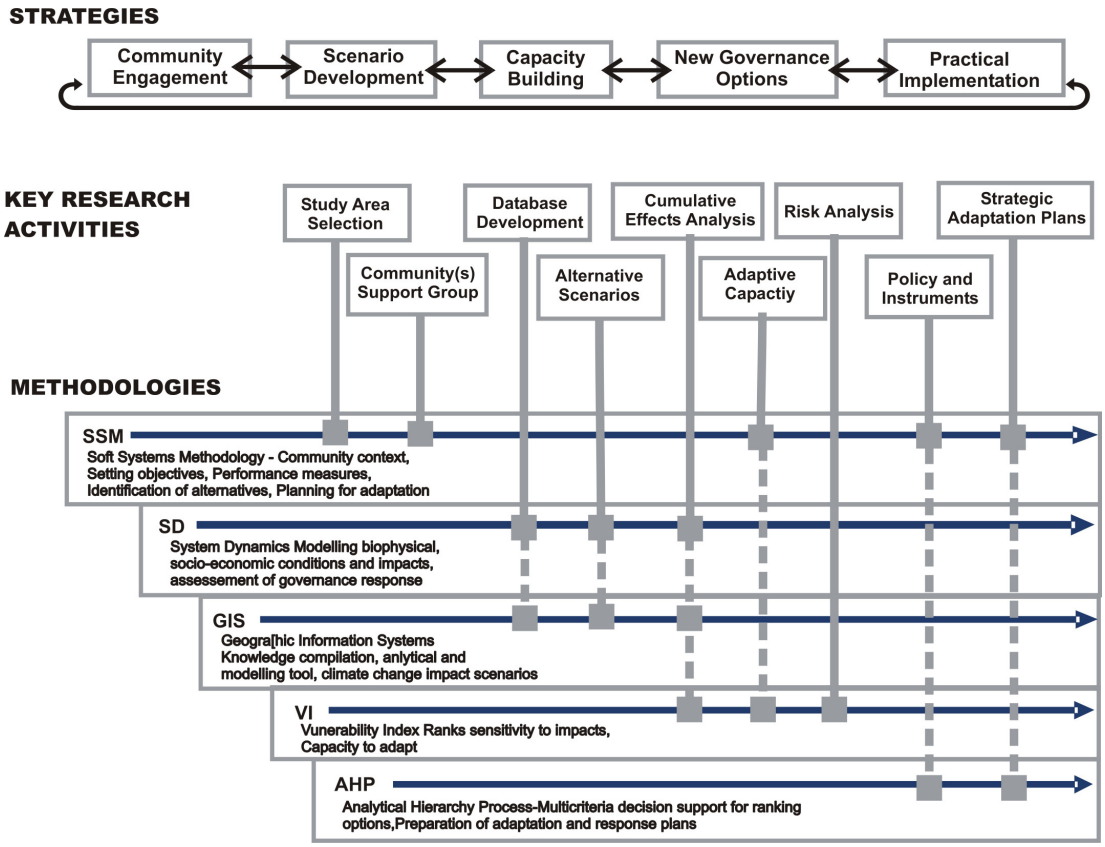
Table 3. C-Change Canada-Caribbean Communities – Threats and Vulnerabilities

The methodologies and tools noted in Figure 2 are described below and follow the typical in problem solving and risk management (Australia 2007).

1. ***Problem definition*** - Soft Systems Methodology (SSM, Checkland 1992) helps establish local priorities, to define the scope of the local research, to pinpoint local institutional arrangements, decision makers and affected organizations, to establish measurable performance indicators, and to develop decision alternatives. SSM addresses issues of

adaptation and sustainable development at the local community level by acknowledging that human problems are complex and issue-based, requiring inter-disciplinary collaboration to develop solutions, and are accomplished though accommodation by all community members rather than though consensus or optimization. SSM seeks 'common ground' through respectful and structured debate on management where the need is for a system of inquiry and adaptive learning, reacting to events and responding to behaviour rather than changing patterns of behaviour and their underlying causes (Senge 1990).

Figure 2. C-Change Research Process



2. ***Community profile database*** – the identification, analysis, and evaluation of risks from climate impact scenarios will be guided by structured development of available community resource inventories including physical, economic, and social capital. Data also include base maps, storm histories, topography, coastal hydrography, and cadastral data for assessing outcomes and projecting the likelihood of real threats to local infrastructures, environments, economies and cultures. Table 4 provides the Community Profile template developed for data collection.

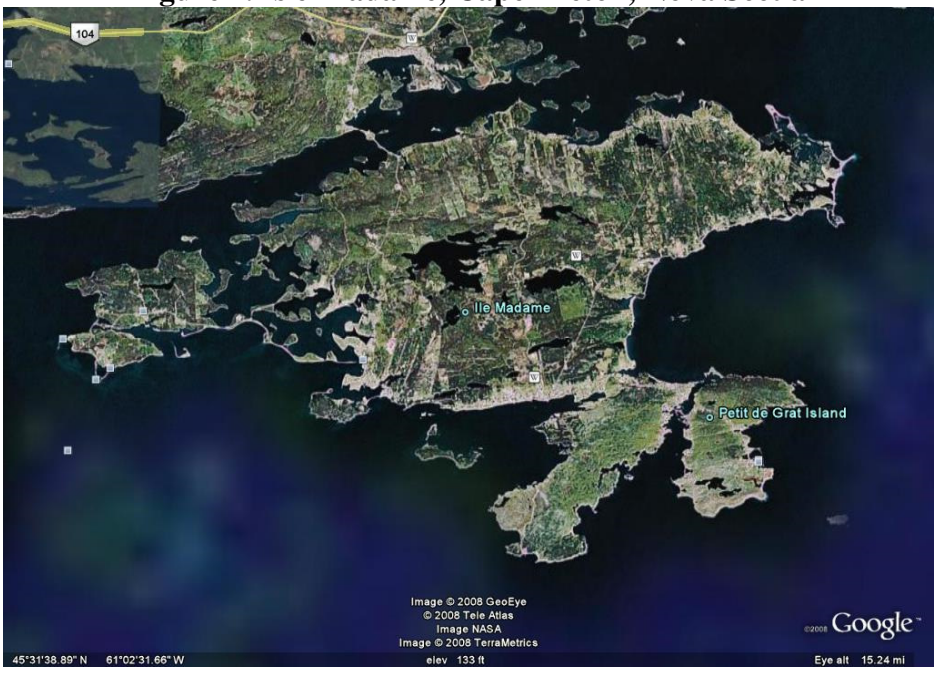
3. ***Visual Modeling*** - spatial modeling of integrated dynamics of the ecological, socioeconomic, and cultural subsystems are developed using GIS software including hardcopy maps, tables, graphs and images to support visual and manual analyses, e.g. augmenting readily available modelling software such as *Google Earth*. See also Figure 4 example below. Spatial mapping and visualization are used to simulate and animate storm events for community discussion

including exploring the impacts and response of adaptation and mitigation strategies to perceived and real threats. Systems Dynamics (SD) modeling using *Stella* and *Vensim* are developed for each community to describe and link dynamics changes in physical, economic and social baselines through visual spatial and temporal maps (Ahmad and Simonovic 2004, Hartt 2010, Pidd 2008, Sterman 2000).

No.	Dimension/ Categories	Data Sub categories
I	**Environmental**	a. Topography b. Hydrology c. Coastal Geomorphology d. Habitats and Species e. Land Cover f. Land Use g. Marine Use h. Climate i. Natural Resources
II	**Economic**	a. Employment and Earnings b. Occupation c. Industry Sector d. Industry Revenues ($) e. Real Estate Values ($)
III	**Social**	a. Population Statistics b. Language c. Health Status d. Education e. Employment f. Communication Resources
IV	**Institutional & Organizational**	a. Governance Systems b. Community dynamics c. Public Works d. Built Environment
V	**Cultural**	a. Places of cultural significance b. Community groupings c. Cultural events and festivals (dates, attendance numbers, area)

Table 4. Communities Data Profile Elements

Figure 4. Isle Madame, Cape Breton, Nova Scotia



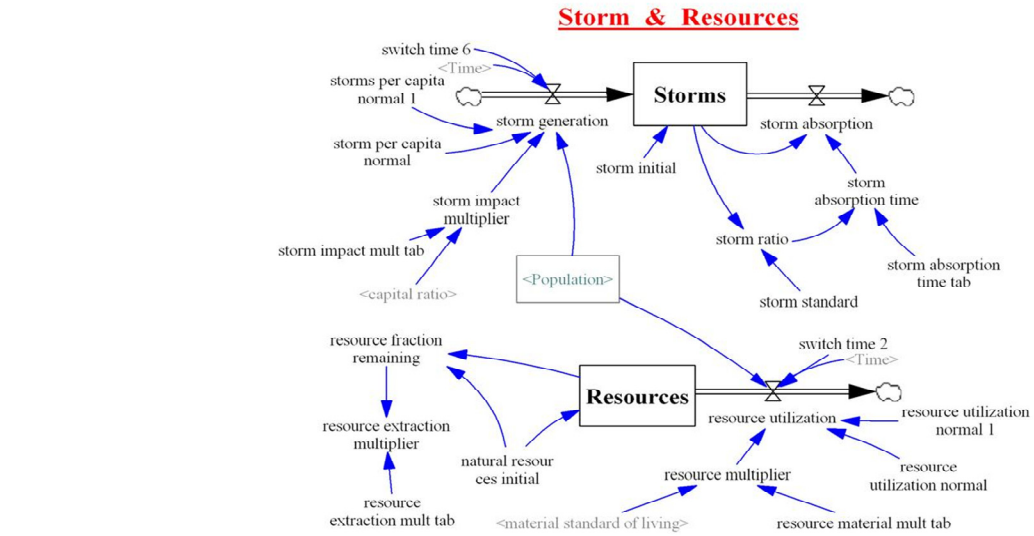
4. ***Vulnerability Modeling*** - community Vulnerability Indices (VIs) are produced using static and dynamic maps that present both current vulnerability conditions as well as potential future scenarios subject to coastal environmental risks. Coastal community vulnerability stems from detrimental impacts to natural systems that are exacerbated by factors such as a narrow economic base, dependence on trade, and susceptibility to external economic fluctuations (e.g. oil prices). VIs measure the sensitivity of coastal communities to storm incidences and are a criterion for the allocation of financial and technical assistance. The index of community vulnerability is designed to be simple, affordable, comparative, and transparent. C-Changes uses the UN/Commonwealth VI to identify risks as well as to assess community capacity of to adapt to changing conditions (Sale et al. 2008, Nicolls et al 2008). Socioeconomic VIs are modified from Briguglio (1995) and Adger (2006).

5. ***Adaptive Capacity and Resilience Modeling*** – communities' abilities to develop and implement strategies for environmental changes are determined as a function of: (i) technological options; (ii) available resources; (iii) institutional structure and decision-making; (iv) existing social infrastructure; (v) access to risk-spreading mechanisms; (vi) decision-makers' ability to manage information; and (vii) public's perception of the source and significance of the impact to its local manifestations (Yohe and Tol 2002). Adaptation is constrained by the resilience of the natural systems in evolution with human systems, i.e., by the ability to cope with external shocks (Gunderson and Holling 2002, Adger et al. 2005). Resilience refers to the coping ability or adaptation capacity of the affected community and ability of an affected community to recover from a damaging external impact. C-Change builds resilience in selected coastal communities by promoting planning and greater awareness toward evaluating and adopting measures to advance economic, environmental and social resilience in the face of the increasing pace of environmental change. C-Change researchers are constructing a Resilience Index (RI) (as a companion to the VI) adapted to coastal communities that is associated with local community adaptive policy (Briguglio et al. 2006) and applied to developing alternative policy options (Sutherland et al 2004).

6. ***Development and assessment of policy options*** - spatial analyses are used to produce cases of ecosystem shifts in local community ecosystems as the basis to project spatial and socioeconomic impacts. Storm event cases are derived from global and international scenarios (e.g., IPCC scenarios for sea level rise and storm frequency), as well as from local storm histories. Models are based on projections using the Systems Dynamics (SD) baselines as a starting point. The SD projection models complement the delivery of participant-based SSM that is in turn used as a negotiation tool to identify areas of agreement in which to investigate and prepare for future community environmental scenarios. SD is used as a dynamic simulation tool in conjunction with visual mapping tools for presentation of the environmental scenarios, estimated cumulative community effects, and impact evaluations for group analysis (Forrester 1973). SD software, (*Stella* and *Vensim*) has advanced iconic capability making model visualisation, development and sharing accessible to participants. Figure 5 presents a rudimentary example of a *Vensim* model sketch with feedback loops for storms and general resource linkages.

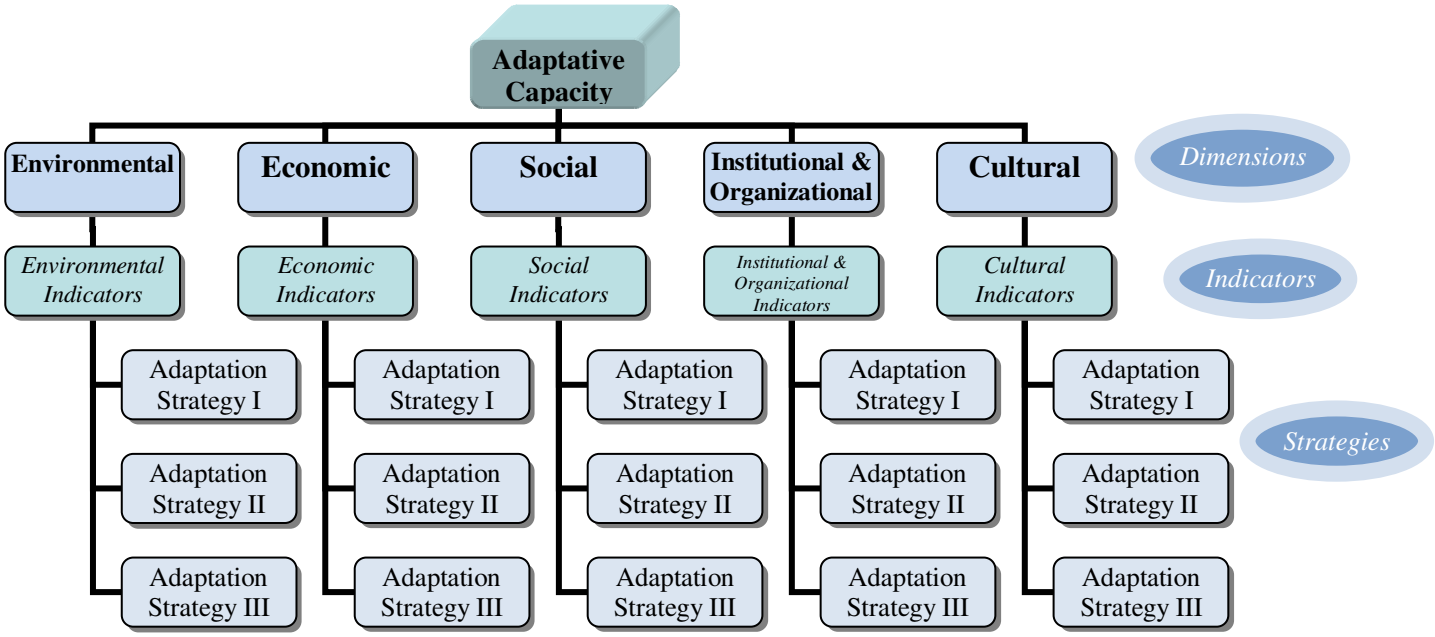
Figure 5. Vensim System Dynamics Model for Storm-Resource Interface

Model: C:\Program Files\Vensim\models\sample\EXTRA\Storms.mdl View: Storm & Resource



7. ***Evaluation of group decision making*** – evaluating and ranking alternative environmental mitigation strategies will be carried out using the Analytic Hierarchy Process (AHP, Saaty 1980) and the *Expert Choice* (v11) software package for multiple participants. AHP is adopted to evaluate community participants' perspectives on the importance of system dimensions (Table 4) that arise in C-CATs community discussions and within in the SSM prioritization exercise. AHP provides a structured decision framework that breaks down complex decision problems in a hierarchical structure (Figure 6 below). The hierarchy identifies the community goal and key components of the environmental ecosystem as well as its social, economic, cultural, and infrastructure and organizational dimensions. Participants' feedback on the relative importance among the criteria (dimensions) and sub-criteria (indicators) of the problem is used to determine trade-offs among problem objectives, e.g., reduce vulnerability and increase adaptive capacity, given evaluated policy alternatives (Michalowski and Szapiro 1992). Identification of specific alternative adaptation strategies subject to storm scenarios provides a means of ranking and evaluating strategy effectiveness as the basis for planned action (Zhao et al 2008, Lane 2007).

Figure 6. Analytical Hierarchy – AHP Framework



8. ***Local adaptation planning and action frameworks*** - consensus on action planning for mitigation of negative environmental impacts are developed and documented into a Community Adaptation Action Plan (CAAP). The CAAP is a coordinated and integrated set of policy and planning documents directed at community sectors: (1) governance and local decision makers; (2) private and public infrastructure services; (3) business and economic activity groups; (4) citizens' groups; and (5) special interest and affected individuals for preparedness for a relevant range of environmental shifts and coastal community emergencies. CAAPs provide basic local action checklists for community sectors and guidelines for community members to carry out in the event of storm surge activity.

C-Change seeks 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 research will make formal linkages between the communities and their respective financial offices and funding sources since it is recognized that measures and policy recommendations will require prioritization (amidst a highly competitive demand for local resources), government authorization, and budgeting including the application of new technology and the reinforcement of community infrastructure.

5. EXPECTED RESULTS AND DISCUSSION

C-Change research allies coastal communities' partners with academic researchers, research collaborators, and research associates. In addition to local adaptation plans and actions, the program is committed to investing the development of climate adaptation training programs and academic curricula for undergraduate and graduate students. The activity of the C-Change

research team and its key alliance with communities is expected to extend beyond the life of the five-year funding period to continue in the need for enhanced community capability and awareness of coastal environmental co-existence. Table 5 below summarizes outcomes of the C-Change project. Expected results are discussed in further detail below.

	Outcome	Description	Devices
1	**Creation and Communication of Knowledge**	the collation and integration of existing and new knowledge on managing adaptation to environmental change in coastal communities	• Website and social network • Newsletters • Working papers • Community workshop reports • Publications
2	**Co-Learning**	an electronic database that forms the core resource for the identification, collation, analysis and dissemination of information in the communities and the impacts of pending climate change	• Data depository and Metadata record • Developed software,examples • Training for use
3	**Decision Support Tools**	integrated models and state-of-the-art methods for environmental scenario analysis and multicriteria decision support tools for communities to improve their capacity to model, evaluate, and assess strategies for adaptation to change	• Case studies of local problem analysis • Developed software,examples • Training for use
4	**Monitoring and Evaluation Indicators**	performance indicators to assess the ongoing spatial and temporal status of coastal communities at risk from environmental change (including VIs and RIs)	• Community indices • Developed indices and use
5	**Training**	(1) academic training, and (2) community-based training of both professional and non-professional participants. Formal courses will be introduced at the partner universities in the Caribbean and in Canada	• Training manuals • Working papers • Community workshop reports • Publications
6	**Community Adaptation Action Plans (CAAPs)**	community templates as outcomes for the development of CAAPs specific to each community that will respond to a range of climate change scenarios	• CAAP Documents delivered with Community assistance • Example cases
7	**Governance Institutional Advice**	case studies as outcomes of the activities in and comparison among the participating communities in Canada and the Caribbean with respect to the successes and failures of local government institutional arrangements and the characterization of effective institutions for responding to the issues of pending environmental change	• International case studies • Publications

As an international initiative, C-Change team members rely on electronic communication tools. Apart from regular discussions among team members, these include, most importantly, the C-Change website (www.coastalchange.ca), and the companion C-Change Facebook Fan site (http://www.facebook.com/pages/Ottawa-ON/C-Change-Managing-Adaptation-to-Environmental-Change/282668675785). The website is also the depository for research documents and working papers, reports on meetings, community workshop reports directed at community leaders, practitioners and policy makers and focused on practical adaptation of information to matters of direct interest to these groups. The C-Change Facebook social networking site engages all community and team members and encourages public feedback and running commentary on the content and progress of the work. Research papers derived from the work will be submitted for publication in both disciplinary specific academic journals and in journals that address broader interdisciplinary topics (e.g., *Journal of Ocean and Coastal Management*, *Journal of Sociology*, *Canadian Journal of Fisheries and Aquatic Sciences*, *Climatic Change*).

The C-Change community data depository and electronic database forms the core resource for the identification, collation, analysis and dissemination of information in the communities and the analysis of impacts of pending climate change (e.g., Canada 2007, Forbes et al 2006, Nichols et al 2006, Environment Canada 2004,). Collected and generated information addresses comprehensively the change in both spatial and temporal contexts, especially as it is expected to affect environmental, social, economic, infrastructure and organizational, and cultural characteristics of the study areas and their supported communities. The local area databases build on existing and available sources and afford opportunities for sharing of learned experience and knowledge, including collaboration with other climate change initiatives that are taking place in both Canada and the Caribbean. Emphasis will be placed on transferring knowledge gained from existing academic and government research initiatives to practical application within the coastal communities.

Performance indicators including Vulnerability Indices, VIs and Resilience Indices, RIs assess the ongoing spatial and temporal status of coastal communities at risk from environmental change. These indices allow coordinated and ongoing community-based monitoring and review for current and projected future conditions. These indicators, are used together with multicriteria decision support tools to address environmental scenario analysis and decision strategy alternatives for communities to evaluate their capacity to adapt to change.

Formal training courses will be introduced at the partner universities in the Caribbean and in Canada. Graduate students participating in academic research will receive experience in the communities and in practical application of theory and policy. Students will also be trained in the interdisciplinary identification and measurement of relevant phenomena, policy prescription, and modeling and analysis of the effects of rising sea-level and storm surges.

Community Adaptation Action Plans (CAAPs) specific to each community will respond to a range of climate change scenarios. CAAPs will reflect locally-specific conditions and threats including operational planning documents for practices and mechanisms for emergency response. The CAAP template includes the local database framework and decision-support and scenario analysis tools, and is developed so as to be applicable to other coastal communities within the Caribbean, and across coastal Canada.

Finally, case studies will be written as outcomes of the activities in and comparison among the participating communities in Canada and the Caribbean. Special attention will be directed at "best practices" with respect to the successes and failures of local government institutional arrangements and the characterization of effective institutions for responding to the issues of pending environmental change.

The success of C-Change depends on its ability to develop the community-university alliance over the course of its tenure. The goodwill of all the C-Change community partners, the perspective of shared learning among the Canadian and Caribbean teams, together with the urgency of the climate change issue, are all positive indicators for enhanced capacity and awareness in coastal communities facing environmental change.

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