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Coastal Community-based Protocols and Guidelines for Adaptation Planning

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Abstract

According to the Intergovernmental Panel on Climate Change report , "Adaptation to climate change is defined as, an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). Adaptation is required due to the increase in the number of natural disasters and extreme changes in environmental conditions in coastal areas that are a function of sea level rise, floods, extreme heat, drought, and coastal storm surge from severe storms. To reduce the impacts of climate change risks in the future, coastal communities through local government initiatives are compelled to develop and implement grass roots community plans.

This study is part of an International Community-University Research Alliance (ICURA), "C-Change" that aims to develop community-based adaptation protocols based on best practices and through the evaluation of the scientific method of problem solving designed to help coastal communities be sustainable and to protect their local coastal environments. To this end, the thesis reviews the international development and application of adaptive strategies related to climate change and evaluates these global strategies for identification of best practices and application to coastal communities.

The objective of this research is to design and develop improved C-Change community adaptation frameworks by analyzing the applications of international protocols and local action plans with respect to the scientific method and of problem solving through using AHP (Analytic hierarchy process) as a tool, and by choosing best practices to provide guidelines for communities' climate adaptation plans for the C-Change ICURA coastal communities in Canada.

Keywords: Climate change, coastal communities, adaptation planning, planning protocols, Canada and the Caribbean.

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1 Introduction

This document presents research in the Master's Program in Systems Science of the University of Ottawa, in the form of a thesis in partial fulfillment of M.Sc. degree in Systems Science.

1.1 Background and Motivation

Global climate change has recently become one of the biggest concerns of world leaders. As discussed in Bali (COP13, 2007) and Kyoto (COP3, 1997) (UNFCC, 1998), governments under UN (United Nations) supervision agreed on developing a "road map" to secure the world against future climate change (Carpenter 2008). The agreements in these conferences provide direction to government to work more on protecting communities in their countries against climate change through activities like developing local action plans. Events such as the Boxing Day tsunami in Southeast Asia in 2004 and again in the Indian Ocean in 2006, and the Great Sea of Japan earthquake and tsunami in March 2011 are just some of recent examples among natural disasters happening all over the world. These events have cost thousands of lives and caused enormous social and economic repercussions (Thompson 2011).

In this situation, adaptation is a required process to manage the society at the individual, community, and country levels to develop resilience and capacity against the potential ravages of climate change. The concept of adaptation is not new. People always adapt to changes in their lives and the environment around them due to a variety of threats such as global warming, sea-level rise, hurricanes, and tornados (Schiermeier 2011). Nevertheless, policymakers require tools and adaptation protocols applied at the local level as a guide to make decisions about their communities' future adaptation plans utilizing available data and forecasting methods. In a more specific view of the Canadian perspective, negative impacts arising from recent severe storms such as Hurricane Gabrielle (2001), Hurricane Igor (2010), and sea level rise, storm surge, and hot weather are felt at all levels of Canadian society.

These natural disasters have affected communities socially and economically (Dorland, Tol and Palutikof 1999).

Under these evolving circumstances, developing community based adaptation frameworks requires policymakers to make clear steps in line with the community's specific priorities to simplify implementation and make them more effective.

In recent years, Canadian communities have developed several strategies to reduce the negative impacts of extreme climate changes effectively (Richardson 2010). It follows that organizations in different parts of the world are developing plans for climate change adaptation. These include groups such as ICLEI (Local Governments for Sustainability), and Cooperative for Assistance and Relief Everywhere, Inc. (CARE), in order to help communities play the essential role of planning, implementing, monitoring and evaluating current action plans and improving the milestones for the application of general adaptation plans.

1.2 Problem Definition

In the Natural Resources Canada 2004 adaptation report (Warren 2004), climate change impacts have been identified in different regions of Canada. To reduce the negative impacts of climate change and take advantage of new opportunities, Canadians must adapt themselves to the evolving situation. Climate change adaptation provides new opportunities for municipalities to prepare their communities against negative climate change impacts in the future, and use it to reduce costs and damages resulting from the changing coastal climate.

Canadian communities are familiar with the concept of adaptation and are beginning to recognize the impacts of climate change on their society. For example, communities have been developing local action plans relevant to their community's specific vulnerabilities. In Alberta, for instance, provincial government support for the Municipal Climate Change Action Plan (MCCAP) program has been assisting communities to develop local action plans in all municipalities toward reducing Greenhouse Gas (GHG) emissions, improving recycling and reuse, and increasing overall the level of community sustainability (MCCAC, 2009).

However, as a result of the changing natural environment and the increasing rate of climate hazards, coastal communities in particular face new challenges that require specific strategy development through understanding of their local and regional environmental changes and vulnerability in the future (FCM 2009). Coastal communities in particular have to consider factors' in developing future strategies such as the nature of climate change in their area, the considerations of climate sensitivity in their region, and society's capacity to adapt to the climate change.

Analyzing coastal communities in Canada with their wide range of different geographical, ecological and economic distributions, shows that for each single community in different parts of the country, the needs are to examine specific concerns and factors (Bruce et al. 2006).

1.3 Research questions and objectives

Based on the problem motivation and problem definition presented above, this research addresses the following focused questions:

1. What are the common adaptation protocols in place globally and applied locally to assist and direct communities to adapt to pending climate change?
2. How can community climate change adaptation protocols applied to coastal areas be effectively evaluated?
3. What is an efficient and effective framework for coastal communities to adapt with specific interest in the C-Change Canadian communities?
4. What are the community-based adaptation guidelines that can be identified for the C-Change Canadian coastal communities toward the development of community Action Plans?

In this study protocols are designed for managing community adaptation through the combination of useful steps of current global protocols, and exhibited and evidence-based best practices with applied emphasis to selected communities in Canada and the Caribbean region.

To respond to the research questions, the following objectives are designed for this study:

1. Identify the suite of specific protocol and adaptation processes currently in place through known international initiatives and local cases studies.
2. Define and apply the scientific method of problem solving as the multicriteria framework to compare and evaluate adaptation processes for international initiatives.
3. Apply the adaptation framework to determine best practices and gaps for coastal communities through current protocols, and communities' vulnerabilities.
4. Detail the key components and guidelines of coastal communities' climate change action plans including identifying roles and responsibilities, and operational activities of community members from best practices of evidenced-based examples.

1.4 Organization of thesis

The structure of this thesis document to follow is:

Chapter 2 – Literature review: review of different adaptation protocols, action plans, and their applications are presented including identification of the strengths and weaknesses of these processes.

Chapter 3 – Methodology: presentation of the adaptation evaluation procedure of the protocols and case studies through the framework of the scientific method of problem solving and identification of the multi-criteria structure for evaluating an ideal adaptation protocol to assist the coastal communities.

Chapter 4 – Analysis and Results: this Chapter presents the results of the evaluation methods applied to: (i) the suite of global adaptation protocols; and (ii) the C-Change selected coastal communities in Canada and includes recognition of best practices and characteristics of effective coastal community adaptation planning.

Chapter 5 – Community Action Plan and Guidelines: develops the plan for communities to enhance community preparedness against climate change. This chapter discusses responsible community organizations, and their duties and responsibilities, and household plans (72 hours) for the community, and presents the online action plan database demo for communities.

Chapter 6 – The final Chapter provides considerations for future research, critical analysis and limitations of the current research, and suggestions for further studies are highlighted.

The thesis also provides fully referenced documents in the detailed bibliography of the relevant literature and for community-based adaptation planning, as well as a complete list of appendices containing the complete evaluation data and results of the analyses.

2 Literature Review

This chapter presents and discusses the relevant published literature on adaptation protocols and relevant case studies in Communities Adaptation Planning. Section 2.1 introduces the global adaptation protocols, in which their specific processes are described and analyzed in detail.

In Section 2.2, related case studies together with applied action plans and methods to cope with climate change, as well as communities' specific vulnerabilities as a result of environmental issues are provided. Section 2.3 presents the literature related to the evaluation framework based on the scientific method of problem solving. Finally, Section 2.4 discusses methods for multi-criteria decision making and specifically, the Analytic Hierarchy Process (AHP).

In summary, this chapter discusses:

2.1. Global Adaptation Protocols

2.2. Case studies in adaptation

2.3. Scientific methods of problem solving

2.4. Multicriteria decision making (AHP)

2.1 Global Adaptation Protocols

In this section we discuss the important global protocols currently being used by local communities around the world, accompanied by a step-by-step analysis of each protocol in order to discover their developmental processes. All the analysis performed in this section will be in relation to the versatility of coastal communities' needs and concerns, especially in regard to Canadian communities' vulnerability and climate impact. The global protocols reviewed include: (1) ICLEI; (2) FCM-PCP; (3) CARE; (4) UNDP; (5) ECCP; and (6) C-Change all defined in further detail below.

2.1.1 ICLEI - Local Governments for Sustainability

ICLEI, the "International Council for Local Environmental Initiatives" was founded in 1990 (ICLEI, 2008). ICLEI, in collaboration with national and regional local government organizations, commits to support local government to run sustainable environmental development. The Council was established when more than 200 local governments from 43 countries assembled at the World Congress of Local Governments for a Sustainable Future, in the United Nations in New York in 1990 (Jackson, et al. 2008).

The aim of ICLEI is to provide technical consulting, training, and information services to support local governments in the local implementation of sustainable development. The main principle of ICLEI is that locally designed initiatives can provide an effective and cost-efficient way to achieve sustainability objectives on local, national and international scales. For reaching the goals of ICLEI, its Board developed a solid vision and mission for the organization. ICLEI's vision is to become:

- *"A growing association of local governments focused on sustainable development with worldwide presence, which has challenging positions, whose voice is heard, and which is attractive to be a member of, work for and partner with";*
- *"Be a powerful and flexible movement of local governments working together in networks for performance, supported by campaigns and strategic alliances";*
- *"Be an effective sustainability and environmental agency demonstrating creativity and excellence in developing advanced solutions and program design and execution".* (ICLEI 2008)

Furthermore, ICLEI's mission is to build and serve a worldwide movement of local governments to achieve tangible improvement in global sustainability with a special focus on environmental conditions through cumulative local actions (ICLEI 2008).

ICLEI assists communities to achieve their GHG reduction plan through implementing the CCP's (Cities for Climate Protection) five milestones, these five milestones present a method

for calculating GHG emissions, measuring and reporting emissions, and developing future emissions reduction targets (Jackson et al. 2008). The CCP milestones are described briefly in Table 2.1 below (Binder 2007; CCP Australia 2009).

Action plan

As described in Table 2.1, in the initial milestone, communities have to calculate their GHG emission consumption for the base year and the forecast year. In the second milestone, emission reduction targets for the existing emissions are to be set for the targeted period. In the next step (Milestone 3), the community develops its local action plan designed to achieve the emissions target set in the previous milestone. These local action plans are to be implemented by the community (in Milestone 4), with ongoing mitigation (emissions reduction) monitoring and target attainment verification of the results (Milestone 5).

The abovementioned five milestones illustrate a flexible and adaptable framework for analyzing available data in different levels of society (Federal, local government, municipality and etc.). This framework is applicable globally, in all communities (in developed or developing countries) as it satisfies the communities' needs through ICLEI's milestones (ICLEI 2008).

No.	Milestone	Description	Action Plan
1	***Conduct a baseline emissions inventory and forecast***	Based on energy consumption and waste generation, the community calculates greenhouse gas emissions for a base year and also for a forecast year. The inventory and forecast provide a benchmark against which the community can measure progress.	Baseline and forecast emissions profile
2	***Adopt an emissions reduction target for the forecast year***	The municipality establishes an emission reduction target for the community. The target both fosters political will and creates a framework to guide the planning and implementation of measures.	Reduction goal stated explanation of how developed
3	***Develop a Local Action Plan***	Through a multi-stakeholder process, the community develops a Local Action Plan that describes the policies and measures that the local government will take to reduce greenhouse gas emissions and achieve its emissions reduction target. Most plans include a timeline, a description of financing mechanisms, and an assignment of responsibility to departments and staff. In addition to direct greenhouse gas reduction measures, most plans also incorporate public awareness and education efforts.	Outline of actions and policies that have been implemented since the base year
4	***Implement policies and measures***	The community implements the policies and measures contained in their Local Action Plan. Typical policies and measures implemented by CCP participants include energy efficiency improvements to municipal buildings and water treatment facilities, streetlight retrofits, public transit improvements, installation of renewable power applications, and methane recovery from waste management.	Proposed actions and policies to be implemented
5	***Monitor and verify results***	Monitoring and verifying progress on the implementation of measures to reduce or avoid greenhouse gas emissions is an ongoing process. Monitoring begins once measures are implemented and continues for the life of the measures, providing important feedback that can be used to improve measures over time.	Commitment to monitoring and reviewing

Table 2.1: CCP Milestones. Source: (Binder 2007; CCP Australia 2009)

2.1.2 FCM-PCP

The Partners for Climate Protection (PCP) program is a network of Canadian municipal governments which are committed to reducing greenhouse gases and taking actions towards adapting to climate change (FCM 2009).

The PCP program is the Canadian component of ICLEI's global CCP network, which involves more than 900 communities around the world. PCP is in fact a partnership between the Federation of Canadian Municipalities (FCM) and the ICLEI – Local Governments for Sustainability.

PCP is based on the five milestone framework designed by the Cities for Climate Protection (CCP) campaign described above which is used to guide municipalities to reduce greenhouse gas emissions (FCM 2011). As mentioned above, these milestones have several benefits for communities, which include saving cost through increasing energy efficiency, developing local renewable energy sources, as well as creating new job opportunities through developing new markets for renewable energy technologies.

To achieve these benefits PCP developed its own five milestones as follows:

No.	Milestone	Description	Action plan
1	***Creating a greenhouse gas emissions inventory and forecast***	A greenhouse gas inventory brings together data on community and municipal energy use and solid waste generation in order to estimate greenhouse gas (GHG) emissions in a given year. The forecast projects future emissions based on assumptions about population, economic growth and fuel mix.	Start a community-wide composting program, and launch an awareness program on water conservation.
2	***Setting an emissions reductions target***	An emissions reduction target is established. The target is normally set, following the development of an emissions inventory and forecast or after the quantification of existing emissions reduction measures.	Use financial incentives to help residents reduce waste, and promote energy efficiency in the industrial sector
3	***Develop local action plan***	A Local Action Plan (LAP) is a strategic document that outlines how the municipality will achieve its greenhouse gas (GHG) emissions reduction target. The LAP covers municipal operations and the community. Municipal governments first develop and implement a plan for municipal operations. In doing so, they demonstrate leadership and provide a positive example for the community.	Create incentives for using public transit, and Use bylaws and development approval incentives to increase building standards and land use mix
4	***Implementing the local action plan or a set of activities***	The following items are key to the structure put in place for the implementation process: • Staffing and communications • Financing and budgeting • Project timeline • Stakeholder engagement	Support and encourage energy efficiency initiatives in the residential and private sectors, Develop and maintain infrastructure friendly to pedestrians and bicycles

5	***Monitor the progress and report the results***	Monitoring the results of the actions planned for in Milestone 3 and implemented in Milestone 4 determine whether: • Reduction measures are producing the anticipated results; and • Emissions reduction targets will be met. If actions are not producing the anticipated results or targets will not be met, the data collected provide information needed to evaluate and adjust activities.	Support community garden initiatives or urban agriculture using surplus land or by developing green roofs, Initiate commuter challenges to reduce vehicle use

Table 2.2: FCM Milestones Source: (FCM, 2011)

Since FCM-PCP is the Canadian component of ICLEI's CCP, FCM applied the CCP's milestones (1 through 5) for developing PCP's milestones for reducing GHG emission in Canadian communities.

Therefore, in the first step, the GHG emission inventory (household and corporate) is created and forecast projections made together with profiling the community's economic situation, population, and fuel consumption. In the next step, the GHG emission reduction targets are set, and are followed by developing a local community action plan. In Milestone 4, the developed local action plan is implemented. During and after the implementation, the process is monitored and results reported regularly for further analysis (FCM 2011).

2.1.3 CARE (Cooperative for Assistance and Relief Everywhere)

CARE is one of the world's largest private international humanitarian organizations (CARE International 2010). The main objective of CARE is to fight global poverty through helping people in poor communities. CARE programs are designed to improve basic education, prevent the spread of disease, increase access to clean water and sanitation, and protect natural resources in poor communities around the world to help people rebuild their lives (CARE International 2010).

In order to achieve the organization's goals, a clear vision and mission are defined which give CARE a unique guideline for developing future operating plans. The Vision of the organization is:

> "*To seek a world of hope, tolerance and social justice, where poverty has been overcome and people live in dignity and security. CARE International will be a global force and a partner of choice within a worldwide movement dedicated to ending poverty.*" (Caldwell 2002)

CARE's Mission is:

> "*To serve individuals and families in the poorest communities in the world, and drawing strength from global diversity, resources and experience. They promote innovative solutions and are advocates for global responsibility.*" (Caldwell 2002)

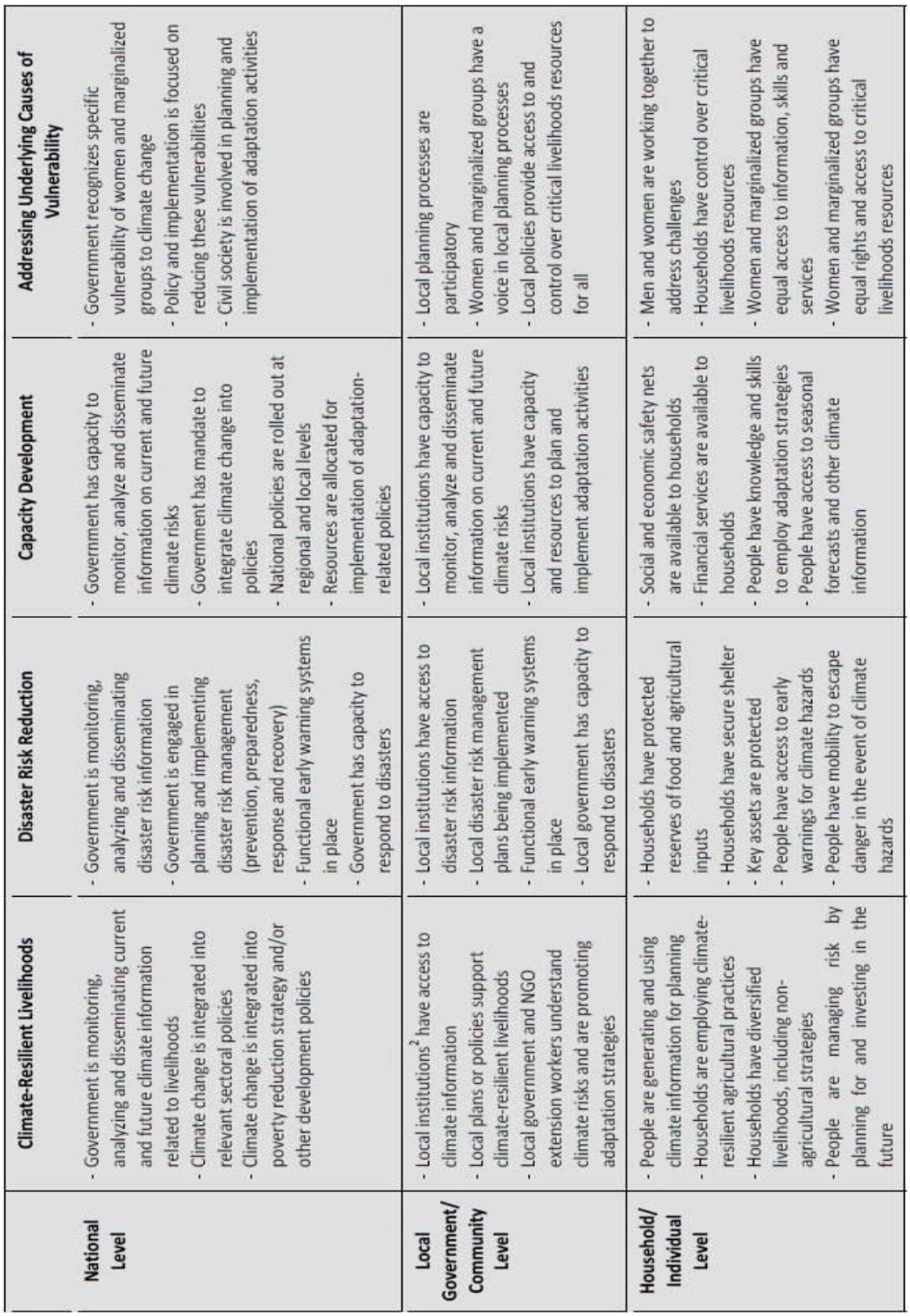
Along with their main objective of protecting the poor communities around the world, CARE has developed a Community-Based Adaption plan (the CBA). The CBA presents a range of main factors which should take place in different levels to run the adaptation plan effectively. These factors are related to four inter-related strategies as follows:

1. Promotion of climate-resilient livelihood strategies; like diversification of livelihoods, both within and outside of agriculture, and income generating strategies (CARE International 2010)
2. Disaster risk reduction strategies to reduce the impact of hazards on vulnerable households;
3. Capacity development for local civil society and governmental institutions; and
4. Advocacy and social mobilization to address the underlying causes of vulnerability (CARE International 2010).

Since CARE's objective is to develop frameworks to help communities in all different levels (household, local, federal and international), CARE introduced the following framework presented in Figure 2.1 (CARE International 2010). Unlike ICLEI and FCM which are community-based, CARE's adaptation process is more people-centered. The focus of the CBA is mainly on monitoring and evaluating the adaptive capacity of target populations rather than fixed factors and milestones for all projects (Caldwell 2002).

In order to cover the broader society, the CARE framework is developed in three different levels of community namely: National, Local, and Household. In all three discussed levels of the community, CARE's main concentrations are: (i) Climate-Resilient Livelihoods; (ii) Disaster Risk Reduction; (iii) Capacity Development; and (iv) Addressing Underlying Causes of Vulnerability. As explained in Figure 2.1, responsibilities and issues related to each of these factors are defined in all three levels. For instance, at the National level, Climate-Resilient Livelihoods relate to governments' responsibilities for analyzing and monitoring current and future climate information (Caldwell 2002). At the Household level, Disaster

Risk Reduction attracts society's attention about readiness to relocate during early hazard's warnings (Dazé, Ambrose et al. 2009).



	Climate-Resilient Livelihoods	Disaster Risk Reduction	Capacity Development	Addressing Underlying Causes of Vulnerability
National Level	- Government is monitoring, analyzing and disseminating current and future climate information related to livelihoods - Climate change is integrated into relevant sectoral policies - Climate change is integrated into poverty reduction strategy and/or other development policies	- Government is monitoring, analyzing and disseminating disaster risk information - Government is engaged in planning and implementing disaster risk management (prevention, preparedness, response and recovery) - Functional early warning systems in place - Government has capacity to respond to disasters	- Government has capacity to monitor, analyze and disseminate information on current and future climate risks - Government has mandate to integrate climate change into policies - National policies are rolled out at regional and local levels - Resources are allocated for implementation of adaptation-related policies	- Government recognizes specific vulnerability of women and marginalized groups to climate change - Policy and implementation is focused on reducing these vulnerabilities - Civil society is involved in planning and implementation of adaptation activities
Local Government/ Community Level	- Local institutions[2] have access to climate information - Local plans or policies support climate-resilient livelihoods - Local government and NGO extension workers understand climate risks and are promoting adaptation strategies	- Local institutions have access to disaster risk information - Local disaster risk management plans being implemented - Functional early warning systems in place - Local government has capacity to respond to disasters	- Local institutions have capacity to monitor, analyze and disseminate information on current and future climate risks - Local institutions have capacity and resources to plan and implement adaptation activities	- Local planning processes are participatory - Women and marginalized groups have a voice in local planning processes - Local policies provide access to and control over critical livelihoods resources for all
Household/ Individual Level	- People are generating and using climate information for planning - Households are employing climate-resilient agricultural practices - Households have diversified livelihoods, including non-agricultural strategies - People are managing risk by planning for and investing in the future	- Households have protected reserves of food and agricultural inputs - Households have secure shelter - Key assets are protected - People have access to early warnings for climate hazards - People have mobility to escape danger in the event of climate hazards	- Social and economic safety nets are available to households - Financial services are available to households - People have knowledge and skills to employ adaptation strategies - People have access to seasonal forecasts and other climate information	- Men and women are working together to address challenges - Households have control over critical livelihoods resources - Women and marginalized groups have equal access to information, skills and services - Women and marginalized groups have equal rights and access to critical livelihoods resources

Figure 2-1: CARE's Framework for CBA (Dazé, Ambrose et al. 2009)

2.1.4 UNDP (United Nations Development Program)

The United Nations organization has developed a global network called “The United Nations Development Program (UNDP)”, to support the changing and connecting community development process in communities around the world with the aim of exchanging the knowledge, experience and resources toward raising society’s quality of life (United Nations Development Programme 2012).

Climate change adaptation is one of the UNDP’s missions to secure the organization’s goals and to reduce climate change impacts. The UNDP developed its adaptation program through principles similar to those for developing economic sustainability and livelihoods in the face of climate change, especially in developing countries (United Nations Development Programme 2012).

Since climate change adaptation is part of the mission of the UNDP, the organization has developed an adaptation policy framework named “UNDP-GEF” (Global Environment Facility) through the following four principles:

2 *“Identify development priorities;*

3 *Determine current and future climate risks and projected impacts on development;*

4 *Identify and design adaptation opportunities; and*

5 *Implement and integrate climate change risks into ongoing processes and practices, including monitoring and evaluation.”* (UNDP-GEF 2012)

The Vision of the UNDP adaptation policy is defined as follows:

> *“Climate change requires us to “do development better”. Greater progress is needed to develop national capacity to support cross-sectoral policy processes as the foundation for sustainable adaptation in coming decades. But better development is only part of the challenge – we must also “do development differently”. To reduce climate change risks, systemic changes to planning and practice are therefore crucial”* (UNDP 2007).

In order to deliver its expertise and knowledge to local communities, the UNDP has developed an Adaptation Policy Framework (APF) on behalf of the Global Environment Facility (GEF). The APF connects the climate change issue to development sustainability and environmental factors. The APF is developed around the following four main principals:

1. *"Adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change;*
2. *Adaptation policies and measures are assessed in a developmental context;*
3. *Adaptation occurs at different levels in society including the local level; and*
4. *Adaptation strategy and the process by which it is implemented are equally important."* (UNDP-APF 2012)

The defined process of the APF can help communities develop their adaptation project and action plans in all scales including the local and national levels (Droesch et al 2008). Table 2.3, presents the milestones, description and action plan components of the UNDP's APF.

The APF (Adaptation Policy Framework) works as a link between climate change adaptation, sustainable development and environmental issues. It is structured in the following steps of Table 2.3.

No	Milestone	Description	Action Plan
1	***Scoping & Designing an Adaptation Project***	Clarify objectives and scope of the policy, plan, or project; Establish a stakeholder process; Review available information on vulnerability and adaptation; Outline the policy, plan, or project	Promote tighter linkages from assessment, upstream policy and institutional change activities to investment and financing of solutions
2	***Assessing Current Vulnerability of Development Objectives to Climate***	Assess current climate risks and impacts (relevant to the policy, plan or project); Establish current socio-economic conditions; Assess current vulnerability of the relevant system; Assess current adaptive capacity/adaptation; Assess current policies related to climate risk and vulnerability and policy needs.	Complement efforts at the national level by facilitating action at the provincial, municipal and community levels. Balance the emphasis placed on adaptation and mitigation
3	***Assessing Future Climate Change Risks to the Development Objective***	Identify relevant climate variables and assess trends Assess socio-economic trends Assess trends in natural resources and environment, including anthropogenic drivers of environmental stresses; Assess barriers to adaptation to climate risks and opportunities for adaptation.	Diversify the funding sources that countries can access and enable them to effectively combine and sequence the different sources

4	***Formulating an Adaptation Strategy***	Synthesize previous steps, studies and existing adaptation options; Identify policy, plan or project options for adaptation, characterize costs, benefits, and barriers of each; Prioritize and select policy, plan or project options for adaptation; Formulate an adaptation strategy;	Broaden public-private partnerships with the private sector, and engage new actors
5	***Continuing the Adaptation Process through Monitoring and Evaluation***	Incorporate adaptation policies and measures into development plans; Implement the adaptation strategy and institutionalize follow-up; Review, monitor and evaluate effectiveness of policies and measures;	Mainstream Climate Change into core development processes, reaching out to non-environment sectors

Table 2.3: UNDP-APF Framework. Sources: (UNDP 2008; UNDP-APF 2012)

The UNDP's APF framework is applied comparably to the other protocols discussed previously (ICLEI, FCM, and CARE). The APF milestones start with designing the adaptation project, in terms of the community and clearly defined stakeholders, participating organizations, and all the needed information including the community's vulnerabilities. Therefore, when all the information has been provided, the APF implementation team can work on current vulnerabilities and assess the situation (via a socio-economic analysis) in the community and design initial objectives and frameworks (UNDP-APF 2012). Once the status quo current situation has been analyzed, the implementation team analyses the future expected risk and climate hazards in the community. Next, the team conducts an assessment of the community's natural resources, and the social and economical situation to find out future opportunities and risks. After all these analyses have been carried out, and information classified as current situation and future conditions, the expected adaptation framework is formulated. The APF requires that the community prioritize the options and steps regarding to the community's needs and vulnerabilities, and develop related adaptation strategies. At the project implementation stage, the final step is the monitoring and results validation analysis for future implementations (UNDP-APF 2012).

As points are mentioned in the action plan column of Table 2.3, UNDP try to help communities through involving new players (public and private organizations) in the implementation part of the framework, because as much as different parts of the community get involved in the project, more people feel responsibility for the results. Other benefits of new partners' involvement in the project are the financial aspects of the project. Since more organizations involved in the project lead to additional funding sources so that the community can achieve its targets faster.

2.1.5 EU Commission-ECCP (European Climate Change Program)

The European Commission launched the European Climate Change Program (ECCP) in June 2000 as part of EU's strategic identification and development of implementing the Kyoto Protocol (European Commission 2010).

The first phase of the project run during 2000 to 2004, and involved all stakeholders including all EU departments, industry and environmental agency representatives, and all EU members working and cooperating together (European Commission 2010). The EU continued the second phase of the project (ECCP II) launching it in October 2005 with the GHG emission reduction targets set for 2030.

These abovementioned projects ECCP I and II show how the EU plans to combat the negative impacts of climate change. As a first objective, the European Commission seeks to reduce greenhouse gas emissions as well as considering other options in the future phases of the ECCP (EU-ECCP 2003). The initial steps considered by the EU Commission regarding emissions reduction are to:

- *"Continually improving the energy efficiency of a wide array of equipment and household appliances;*
- *Mandating increased use of renewable energy sources, such as wind, solar, hydro and biomass, and of renewable transport fuels, such as biofuels;*
- *Supporting the development of carbon capture and storage (CCS) technologies to trap and store CO2 emitted by power stations and other large installations;*
- *Launching the European Climate Change Program (ECCP) in 2000, led to the adoption of a wide range of new policies and measures, including the Emissions Trading System, the EU's key tool for reducing greenhouse gas emissions from industry cost-effectively.*
- *Developing a comprehensive EU adaptation strategy that strengthens Europe's resilience to climate change."* (EU-ECCP 2003)

The ECCP's main objective is to control the global temperature increase and reduce GHG emissions. In order to achieve this goal they developed the controlling milestones as follows:

- *"Monitoring the emissions of the six Kyoto greenhouse gases and removals by sinks,*
- *Annual GHG inventory reporting to the European Commission*
- *EC GHG inventory is the sum of GHG inventory of each of the 15 Member States(UK, Austria, Sweden, Belgium, Finland, Luxemburg , Germany, Italy, Greece, Denmark, France, Netherland, Spain, Portugal, Ireland)*
- *Member States report their respective data to the UNFCCC(United Nations Framework Convention on Climate Change)*
- *Implementation and annual reporting of national programmes (including policies and measures) and emission projections to the Commission and*
- *Evaluation of progress and reporting to the European Parliament and Council by the Commission."* (Müller and Jol 2012)

  As part of the EU future plan for the ECCP's implementation, all involved organizations have to report annually and update their action plans continuously, so they can update the general framework and develop a plan to achieve the EU targets of the Kyoto Protocol into the future, and reduce the GHG emission in participant countries (Müller and Jol 2012).

2.1.6 C-Change

C-Change is an International Community-University Research Alliance (ICURA) project Managing Adaptation to Environmental Change in Coastal Communities conducted between Canada and the Caribbean communities for the period 2009-2015. C-Change links community members and university researchers from Canada with members of the Caribbean community in support of research on coastal adaptation to environmental change, including the impacts of the storm surge and sea-level rise on susceptible coastal communities (International Community-University Research Alliance (ICURA) 2007).

The main mutual objectives of the ICURA between the community and the university are:

- *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.*
- *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.*
- *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.*
- *Develop impact scenarios, and prepare adaptation action plans in partnership with the local community government, services, and community members.* (International Community-University Research Alliance (ICURA) 2007)

C-Change developed a research process to achieve its main objectives (as mentioned above). This process is developed in 5 steps as follows:

1. Community Engagement - Canadian and Caribbean research teams establish local C-Change Community-University Support Groups. The Support Groups mobilize community engagement; gather information and local priorities, and assess community resources,

services, institutional and governance linkages. This information permits the locally-assisted development of community profiles including environmental vulnerability indices for the community as a function of the storm and impact scenarios.

2. Scenario development - Community spatial models are developed with the assistance of the community to examine environmental impact (i.e., storm) scenarios including integrated econometric and socioeconomic impact models from data projections for community discussion and review.

3. Capacity building - Baseline indices are updated regularly 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 the recommended policy measures.

4. New governance option - C-Change community partners participate in questionnaires and meetings toward providing indication of local priorities and issues. Local community workshops provide training in "Managing Adaptation to Environmental Change" including decision support aids, the use of the local vulnerability index, and adaptive capacity indicators and build knowledge towards planning for change. Working documents from local workshops will be prepared and disseminated through the project website to community leaders, practitioners and policy makers and new local governance arrangements will be proposed to further prioritize coastal environmental issues.

5. Practice implementation - Graduate students from the C-Change international university network will work on specific project elements such as geomatics and information management, web database development, multi-criteria decision making, policy evaluation, risk management, and will be overseen by academic as well as community team members, with opportunities to gain experience working towards the practical application of research findings.

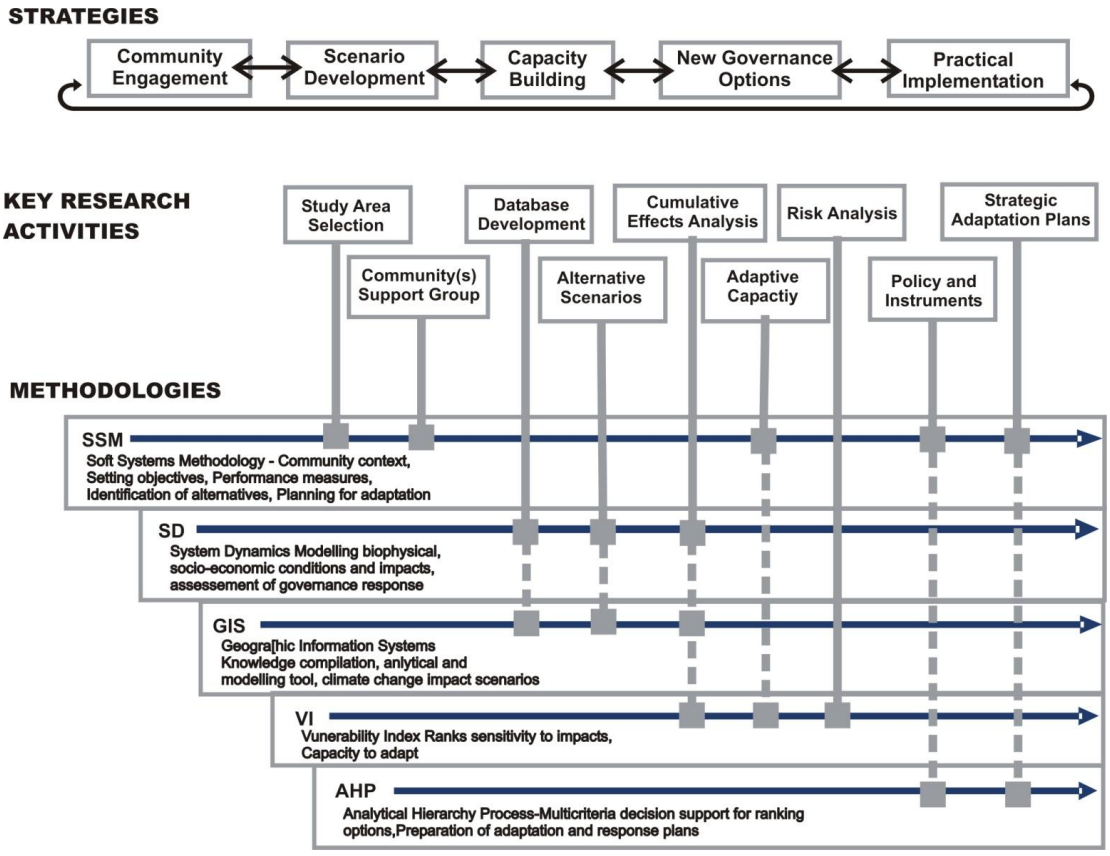


Figure 2-2: C-Change Research Process Map. Source: (International Community-University Research Alliance (ICURA) 2007).

Figure 2.2 presents C-Change's main strategies for achieving the abovementioned objectives through: (1) Community engagement, (2) Scenario Development, (3) Capacity Building, (4) New Governance options, and (5) Practical implementation. Strategy implementation in partner communities is carried out through: Study area selection, development of Community support groups, Community profiling and database development, Cumulative effects analysis of environmental change, Alternative scenarios preparation, Adaptive capacity, Risk Analysis, and preparation of a Strategic adaptation plan.

In order to implement these activities C-Change uses the following tools: SSM (Soft System Methodology), SD (System Dynamic Modeling), GIS (Geographic Information systems), VI (Vulnerability indices), and the AHP (Analytical Hierarchy Process) in support of local governments needs for multicriteria decision making. AHP, as used in this thesis, is reviewed in the last part of this chapter. Further information on the four C-Change Canadian

communities is provided in detail in Chapter 4 of this thesis. These four Canadian coastal communities (Gibsons, B.C., Iqaluit, NT, Charlottetown, P.E.I., and Isle Madame, N.S.) are presented there and reviewed with respect to the comparative analysis of their adaptation processes.

Table 2.4 shows the summary of the discussed international protocols, with a brief discussion about each protocol's goals, objectives and action plans. Although each of these protocols is working in different areas, and their main objectives are different than others, all of these protocols are working similarly toward developing and implementing adaptation strategies for pending climate change. Some of the protocols, e.g., CARE, focus on developing communities, while others, e.g., UNDP, ICLEI, develop worldwide general frameworks for adaptation to climate change. Consequently, comparing and combining these protocols' adaptation frameworks and related experiences helps to understand and to develop a more ideal adaptation framework for coastal communities as the objective of this research.

Protocol	Description	Goals and Objectives and Action Plans
ICLEI-CCP	International association of local governments that made a commitment to sustainable development	Build capacity, share knowledge, and support local government in the implementation of sustainable development at the local level. Profile baseline and forecast emissions. State GHG reduction goals and explanation of how to achieve. Outline policies and implement local Action Plan highlighted by Commit to regular monitoring and reviewing. This action plan developed in five steps: Incorporate background information, and goals, Choose actions to achieve these goals, Identify staff responsibilities for actions, Set priorities, timelines, and budget figures (where possible) for actions, and establish a monitoring and review process and timeframe.
FCM-PCP	Network of Canadian municipal governments that have committed to reducing greenhouse gases and acting on climate change	The Infrastructure Risk project's goal is to help Canadian municipal governments assess the vulnerability of their communities, specifically municipal infrastructure, to current and potential future climate risks and natural hazards. Design and complete the foundation work necessary to develop case studies. Part of this foundation work includes facilitating interaction between municipal staff and researchers working on science-based regional climate change projects. Present a summary of baseline emissions forecasts and targets, a set of existing and proposed emissions reduction actions, implementation strategies, including the resources involved; and input from stakeholders.
CARE	One of the world's largest private international humanitarian organizations fighting global poverty through helping the people in poor communities	In cooperation with its partners, CARE seeks to increase the skills, experience and resources in communities to develop and implement CBA projects and in the same time combine it into projects in climate-sensitive areas. CARE contributes to the learning process about adaptation especially in developing countries to educate the society about adaptation concepts. CARE helps vulnerable communities against climate change hazards threaten their communities, and educate people about the adaptation process.

		Care address the Climate-Resilient Livelihoods, Disaster Risk Reduction, Capacity Development, Addressing Underlying Causes of Vulnerability with contribution of local partners (NGOs), and communities
UNDP	Global development network based in the United Nations to change and connect countries to help people have better lives through education and transfer of experience and expertise, and resources	UNDP programs identify development priorities, determine current and future climate risks and projected impacts on development identify and design adaptation opportunities, and implement and integrate climate change risks into ongoing adaptation processes. UNDP seeks to support the changing and connecting process in communities around the world to exchange their knowledge, experience and resources toward raising society's quality of life. UNDP-APF promotes tighter linkages from assessment, upstream policy and institutional change activities to investment and financing of solutions, complements efforts at the national level by facilitating action at the provincial, municipal and community levels, balances the emphasis placed on adaptation and mitigation, diversifies the funding sources that countries can access and enable them to effectively combine and sequence the different sources, broadens public-private partnerships with the private sector, and engages new actors, mainstreams Climate Change into core development processes, reaching out to non-environment sectors

European Climate Change Programme (ECCP I and II)	The European Commission launched European Climate Change Program (ECCP) at June 2000 as part of EU's strategic identification and development of implementing Kyoto Protocol.	ECCP's main objectives are to: Improve the resilience of social and economical systems as well as ecosystems across Europe and in other parts of the world, and Reduce their vulnerability to the impacts of climate change. ECCP seeks to develop a comprehensive EU adaptation strategy that strengthens Europe's resilience to climate change. The strategy includes: Annual GHG inventory reporting to the European Commission, Monitoring the emissions of the six Kyoto greenhouse gases and removals by sinks, Implementation and annual reporting of national programmes (including policies and measures) and emission projections to the Commission, and Evaluation of progress and reporting to the European Parliament and Council by the Commission
C-Change	International Community-University Research Alliance (ICURA) project, "Managing Adaptation to Environmental Change in Coastal Communities: Canada and the Caribbean"	C-Change community and university objectives are to: Identify the short and long term vulnerabilities, Mobilize knowledge and innovation, Build capacity Develop impact scenarios, and Prepare adaptation Action plans. The C-Change research process includes the steps of: Community Engagement, Scenario development, Capacity building, New governance option, Practical implementation.

Table 2.4: Summary of Adaptation Protocols description

2.2 Case studies

This section of the literature review provides a review of case studies that demonstrate how different communities in different regions of Canada are addressing climate change adaptation (National Round Table on the Environment and the Economy 2009). Each of the Canadian communities' case studies is designed to improve awareness of climate change impacts through designing specific methods and action plans for the communities. The case studies analyzed in this chapter reflect the actions taken in specific communities across Canada, and as such, are relevant to different communities in different comparable regions in Canada and abroad. These actions help these communities in the decision making process to improve the community's long term preparation level against climate change impacts and reduce the future potential risk.

In the community case studies for Vancouver, Toronto, Halifax, Edmonton, Sudbury, and Dawson Creek are all presented and described in detail in the Natural Resource Canada publication "Adaptation to Climate Change – An Introduction for Canadian Municipalities" by Richardson (2010). This publication was prepared as a source of local application of Canadian examples of community adaptation. This publication is cited considerably in the literature review as an excellent source for current adaptation practices of relevance to the thesis.

Communities are applying the FCM protocol locally. Case studies illustrating these community applications are described in detail in the Natural Resource Canada publication Adaptation to Climate Change – An Introduction for Canadian Municipalities" (Richardson 2010).

Figure 2-3: Map of Canada, Source: (EmbassyWorld.com Inc 2012)

The locations of these cities are identified in Figure 2.3 Map of Canada, above.

2.2.1 Metro Vancouver Integrated Stormwater Management Plan (ISMP)

Metro Vancouver known as the Greater Vancouver Regional District (GVRD), is located on the west coast of Canada (Figure 2.3), and comprises within its boundaries 24 member municipalities including Richmond, Langley, and Surrey (Metro Vancouver 2010). Figure 2.4 presents an aerial view of the GVRD with indicated municipalities. For these municipalities, one of the main climate related concerns is about how changes in stormwater runoff quality and quantity impact the region's many urban and rural salmon and trout streams. The municipalities of Greater Vancouver in collaboration with provincial and federal environmental agencies including Environment Canada, and Fisheries and Oceans Canada, developed the Stormwater Interagency Liaison Group (SILG), and formed in 2002 the

Integrated Stormwater Management Plan (ISMP) under its provincially approved liquid Waste Management Plan (Richardson 2010).

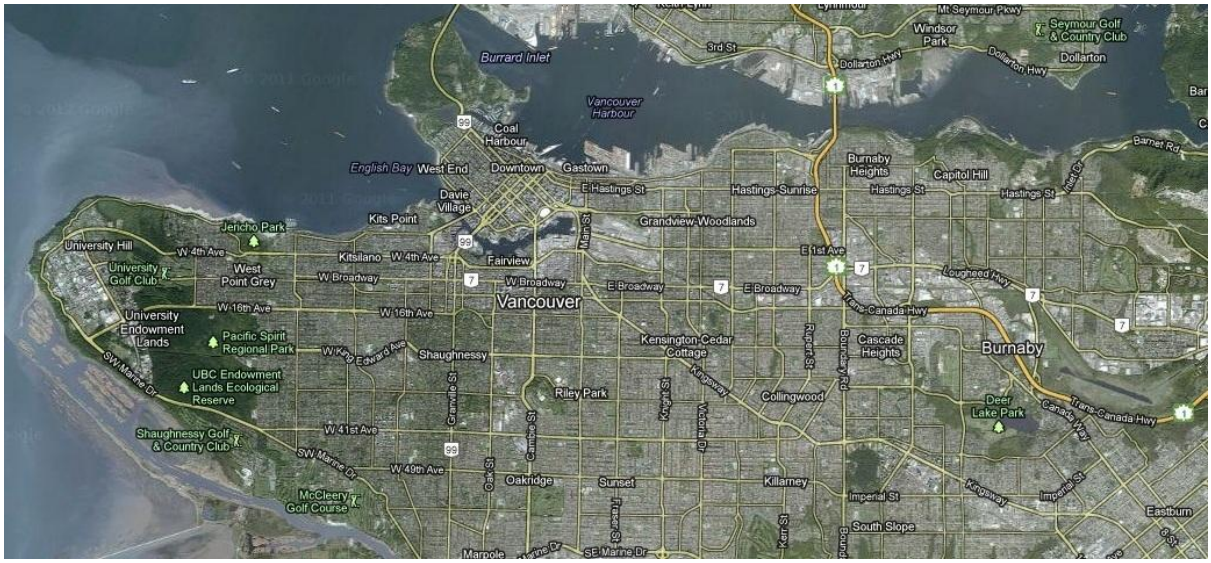


Figure 2-4: Aerial Photo of the Greater Vancouver Regional District (GVRD). (Source: Google Map, 2012)

Through this co-ordination, they prepared a template in the ISMP for developing watershed-specific, flexible and adaptive strategies for protecting communities from localized flooding, and for integrating a wide range of water management issues, including watershed health, land use planning, engineering, community values, and climate variability and change. For developing and implementing the ISMP plan, the Metro Vancouver strategic group developed seven steps as follows:

1. *"Secure political interest and support.*
2. *Identify watershed problems and opportunities.*
3. *Develop objectives and alternative scenarios.*
4. *Collect meaningful data and refine scenarios.*
5. *Evaluate alternatives and develop component plans.*
6. *Develop an implementation program.*
7. *Refine the plan through adaptive management."* (Richardson 2010).

Many Metro Vancouver municipalities have translated the ISMPs into actions since 2001 under the Liquid Waste Management Plan (LWMP) (Metro Vancouver 2001). Under this plan, municipalities are expected to apply the plan on all levels of their society until the 2014 deadline. For better understanding of the ISMP plan, SILG developed the Template for Integrated Stormwater Management Plan (TISMP) in 2002, and updated it in 2005. In this template, 35 different analyses and assessments were carried out including: data collection and review; field assessments to supplement watershed knowledge, and identify values developed to help the municipalities to implement their ISMP plan (Metro Vancouver 2012).

Among the strategies of the ISMP in Still Creek, they are developing a specific Hydraulic model to assess their Hydraulic structure as well as to assess impacts of channel implementation on flow conveyance. These actions take place under the following strategies of the overall ISMP: (i) Develop and Implement Watershed-scale Rainwater Facilities and (ii)Plans to Reduce Flooding and Flood Impacts within the Still Creek Corridor, and (iii)Improve Integration of Drainage Infrastructure Management and Maintenance Practices among Vancouver, Burnaby and the GVRD.

In conclusion, the ISMP provided the participant municipalities with the methods to develop their local framework to increase their preparedness against environmental risk the their water infrastructure systems in the future (Richardson 2010).

2.2.2 Toronto

The City of Toronto (Figure 2.5) implemented an Extreme-Cold Weather Alert in 1996 and a Heat Health Alert in 2001 to alert the city's most vulnerable populations of extremes temperature that the City has been experiencing in recent years (Richardson 2010). Since the main target of the plan is elderly people and children, the city provides education services to make them aware about the weather problems and what they have to do during those particular time periods to reduce the risk of health issues. The steps followed by City of Toronto officials include the following actions:

- *"Contacting local media to inform the public that a heat alert has been issued,*

- *Notifying community agencies and other response partners of the alert status, in order for them to implement agency specific protocols,*

- *Operating, through the Canadian Red Cross, a heat information line from 9 a.m. to 9 p.m. for those in need of assistance or with heat-related inquiries,*

- *Distributing bottled water through the Canadian Red Cross, targeting vulnerable people and providing water to agencies that work with vulnerable groups,*

- *Distributing Toronto Transit Commission (TTC) tokens through selected drop-in centers to the homeless, so they can reach cooling centers, and*

- *Opening seven designated cooling centers (one open for 24 hours) at public locations, such as community centers and civic centers, during an Extreme Heat Alert* (The City of Toronto 2012) (Richardson 2010).

The Toronto Public Health (TPH) agency reviewed this plan and subsequently increased the number of cooling centers and transit tokens distributed to people in need of transportation to a cool place (Richardson 2010 p.22).

In addition, the city developed other additional plans like the Green Roof Bylaw. : The City of Toronto is applying the Bylaw as a requirement for new building permit applications to have a construction of green roofs in their new developments. in order to "increase awareness of problems related to extreme heat, contributed to the development of a new program and

measures to combat the urban heat island effect, and helped facilitate the partnering of various city departments" (The City of Toronto 2012) (Richardson 2010).

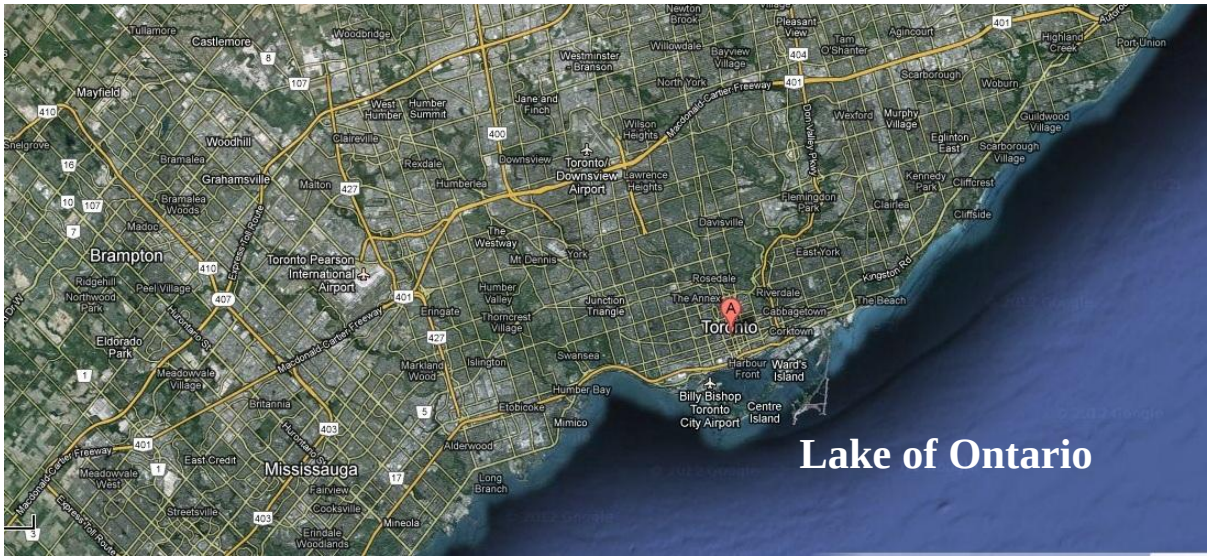


Figure 2-5: Aerial Photo of the Toronto (Source: Google Map, 2012)

Through this plan and participation of public organizations and NGO's (like: Toronto police services, Office of emergency management, and Street health), and the attention of the rest of the society, the City of Toronto expect to reduce the numbers of victims of recurring hot weather extremes during the summer in future years.

2.2.3 Halifax ClimateSMART (Sustainable Mitigation and Adaptation Risk Toolkit)

In September 2003 and February 2004, the Halifax Regional Municipality (HRM) launched ClimateSMART (Sustainable Mitigation & Adaptation Risk Toolkit) to help develop climate change mitigation and adaptation into municipal planning and decision-making. The objective of this Toolkit is to assist the municipality in dealing with its current problems related to the rising sea level, and increased storm intensity with waves and storm surges (Richardson 2010).

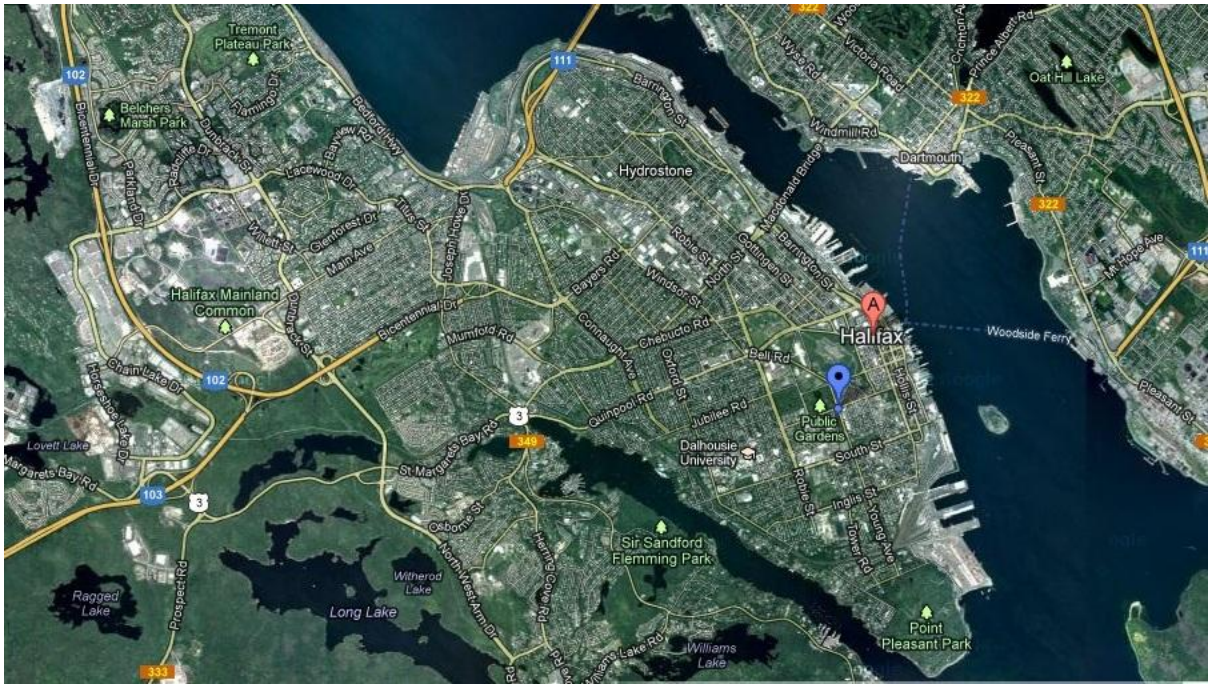


Figure 2-6: Aerial Photo of the Halifax Regional municipality

To achieve their objectives of the study of storm impacts on the HRM, scientists developed water run-up scenarios. In doing so, the process to define these scenarios included milestones as follows:

- *"Analyze historical sea-level rise*

- *Document observed historical stormwater levels and impacts on coastal areas*
- *Project future sea levels and stormwater levels in Halifax Harbour*
- *Apply high-resolution mapping of possible future flood levels for planning purposes."*(Richardson 2010)

In the first step of the Toolkit, scientists calculated the sea level rise and land rise in past decades. Next, Halifax historical storm data were analyzed to find out the highest sea level rise in the past 90 years, the frequency of storms, and the effects of land rising. Through all these analyses, 3 storm scenarios were developed for upper, middle, and lower range for sea level rise during the period of 2000-2100. In the lower range, Scenario 1, 16cm were forecast from the community's historical data, and 57cm were modeled as the upper level based on the IPCC's fourth assessment in 2007 (IPCC 2007). Finally, 1.3m was suggested from more recent literature (Richardson 2010).

All the above mentioned scenarios were analyzed using GIS software to simulate the situation out to 2100 based on each of the 3 seal level rise scenarios.

After this analysis, the HRM Council chose the Scenario 2C as the most likely scenario for Halifax harbor. Figure 2.7 below presents a picture of the flood impacts to 2100 versus the present day shoreline from the Scenario 2C sea level rise (Natural Resource Canada 2010).

Maps of projected sea-level rise are a powerful visual tool for communicating potential flood impacts to policy-makers, land owners and the general public.

SCENARIO 2C

Relative sea-level rise 2000–2100	=	0.73 m above 2000 level (still water)
Add 1 in 50-year stormwater level	=	1.74 m (tide plus storm surge)
Stormwater level in 2100 relative to geodetic datum	=	2.67 ±0.17 m
Add wave run-up	=	+1 to +2 m

Figure 2-7: Halifax Harbour Water Level Flood Impacts from Scenario 2C.

Community decision makers began plan implementation based on the Scenario 2C results. The plan included the following steps to be carried out by the HRM:

- *"Further consultation with property owners and other stakeholders to obtain feedback on options and strategies*
- *Modeling exercise to accurately predict the impact of heavy wave action on harbour-front properties*
- *Development of a risk assessment database containing information on the vulnerability of harbour-front properties*

- *Creation of measures that could include minimum ground elevation for new development, engineered solutions such as raising sea wall heights, and land use and development regulations for flood-prone areas"* (Richardson 2010).

By implementing this plan, council expects to reduce the effects of sea level rise in the next 100 years. The plan also calls for updating measurements by monitoring and assessing the plan from time by time (Richardson 2010).

2.2.4 Edmonton

According to Natural Resource Canada book's (Richardson 2010) report, the City of Edmonton's (Figure 2.8) one of the major challenge, is the scale and intensity of drought-related tree deaths. Edmonton's policy is to replace each and every fallen tree, but recently, the City has been unable to keep up with the rate of the recent losses (600-900 tree deaths annually).

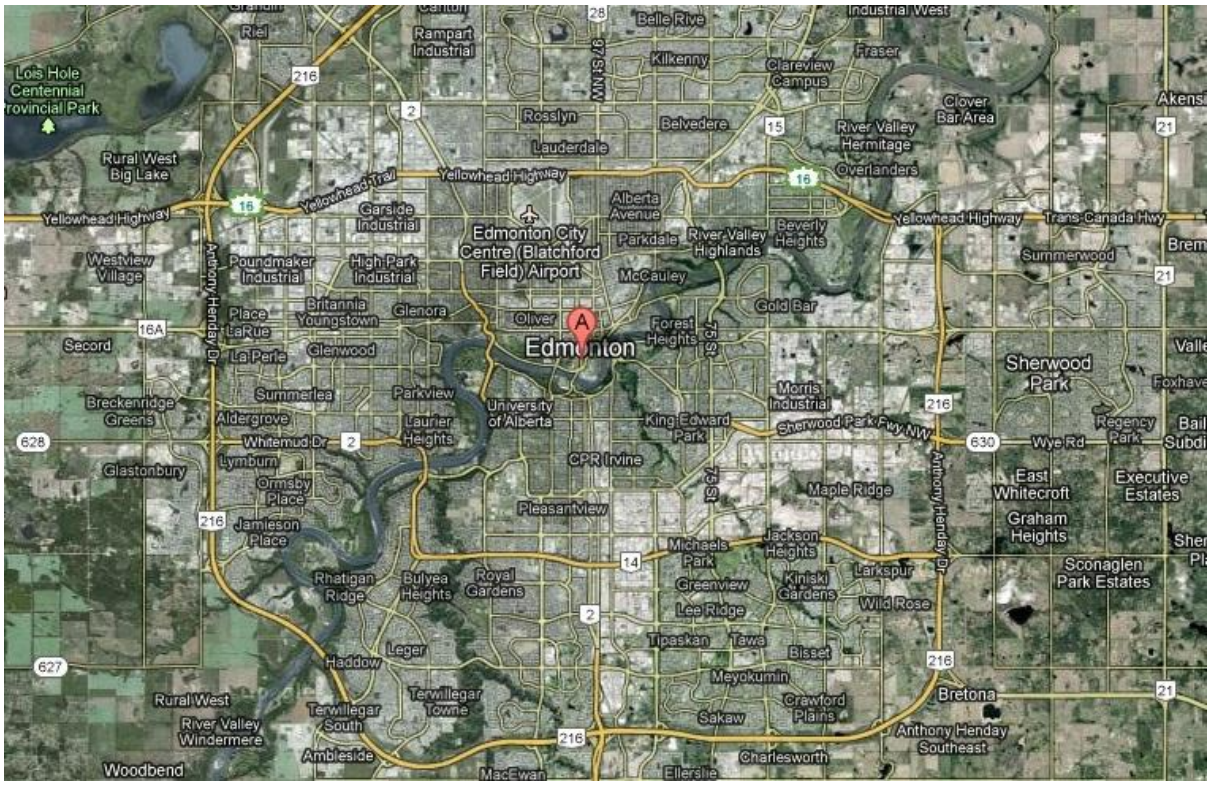


Figure 2-8: Aerial Photo of Edmonton (Source: Google Map, 2012)

The changing climate threatens the health and viability of Edmonton's urban trees through the instances of: drought, insect infestations, disease and storms. It is estimated that if the summer drought conditions continue year over year, the City will need to increase its replanting efforts and reconsider which trees have to be replanted in order to reduce the number of losses. The City's other main consideration is the wave coming from the south of invasive pests and diseases that are seizing mostly green ash and American elms (Richardson 2010).

These threats led the City to develop the first Urban Forest Management Plan (UFMP) in 2006. The Plan's vision is "*to have a diverse and sustainable urban forest that enhances the beauty of Edmonton and contributes to the wellbeing and quality of life for future generation*" (Wheeler 2010).

The main objectives developed for this plan were:

- *"To provide Edmonton with a comprehensive plan for effectively managing, sustaining and ensuring the growth of the City's urban forest*
- *To educate the general public, other city agencies, neighboring communities and community partners about the importance of the urban forest, forestry issues and management best practices; and*
- *To protect native forest and tree stands in conjunction with the city's Office of Natural Areas, which is responsible for the natural areas and the Natural Connections Strategic Plan."* (Wheeler 2010)

For capturing these objectives, the City developed strategies such as creating an inventory of the urban forest, and at the same time developing a replacement strategy for trees lost, reviewing existing planting strategies, as well as creating a fire and disaster management plan and disease control plan for more preparation against future climate change affects (Richardson 2010).

2.2.5 Sudbury

The Regional municipality of Sudbury is located in Northern Ontario (Figures 2.3 and 2.9) (EmbassyWorld.com Inc 2012)(Google Map 2012), and includes seven separate municipalities (Sudbury, Capreol, Nickel Centre, Onaping Falls, Rayside-Balfour, Valley East, and Walden, (Wikipedia 2011) . In 1993, Sudbury was chosen as a one of 11 Ontario municipalities to be studied to identify barriers and develop solutions to implementing energy efficient activities for the Ontario municipal sector named as the Ontario Municipal Energy Collaborative (OMEC). The project "Energy Management and CO2 Reduction" was developed in Sudbury and coordinated by ICLEI (Eszes 2000), and sponsored by the Ontario Ministry of Environment and Energy(Ontario Ministry of Environment and Energy 2012).

In 1995, the Region signed a partnership agreement with ICLEI to develop a strategic energy plan in a payback period of seven years to decrease the municipality's energy usage and reduce implementation cost in the energy sector. The objective was to use ICLEI's expertise to increase their knowledge in environmental management (Eszes 2000).

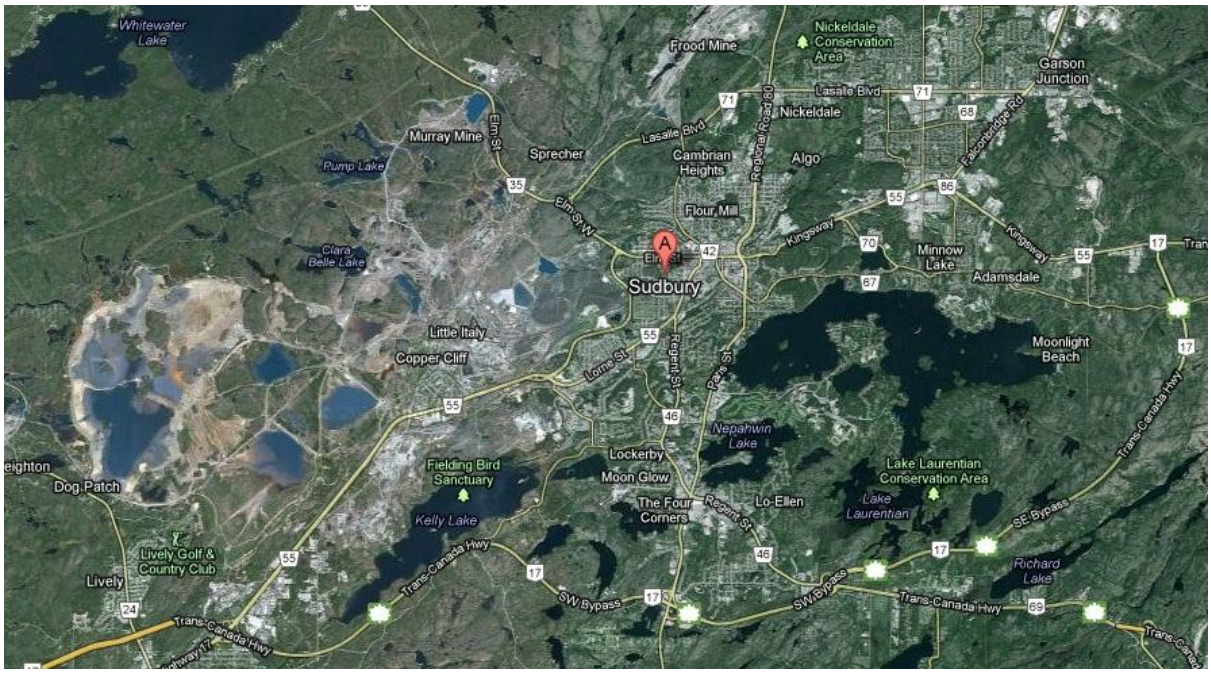


Figure 2-9: Aerial Photo of Sudbury (Source: Google Map, 2012)

As part of the implementation of this project, the municipality engaged the public and the private sector (Greater Sudbury 2012) including regional staff, councilors, provincial utilities, local utilities, and external consultants to contribute to an auditing plan for existing energy use, to measure potential energy and cost savings in the community, and to analyze the economic and environmental benefit of this project (Eszes 2000). This project cost $6.4 million dollars in total, and by implementing the project, the Region expects to save $1.1 million in energy saving per annum, and a CO2 emission reduction of 28%. The annual savings they expected will return the costs of the project in 5.8-years (Eszes 2000).

After finalizing the "Energy Management and CO2 Reduction" project in 1997 (Eszes 2000), the Regional Municipality of Sudbury joined ICLEI's Cities for Climate Protection Campaign (CCP) to implement its plan within the context of the CCP campaign milestones (Eszes 2000).

On the other hand, since 2003 the community has been developing the local action plan for sustainability known as the "EarthCare Sudbury Action Plan" for increasing the resilience and livability in the community and for controlling continuously the GHG emission and the ecosystem's overall health (Greater Sudbury 2010).

2.2.6 Dawson Creek

Dawson Creek is a city located in northeastern British Columbia. Dawson Creek has a population of more than 11,000 people. The city is located in a strategic junction of several railways and highways, and this strategic location is the main reason of the city's economic prosperity (FCM 2001).

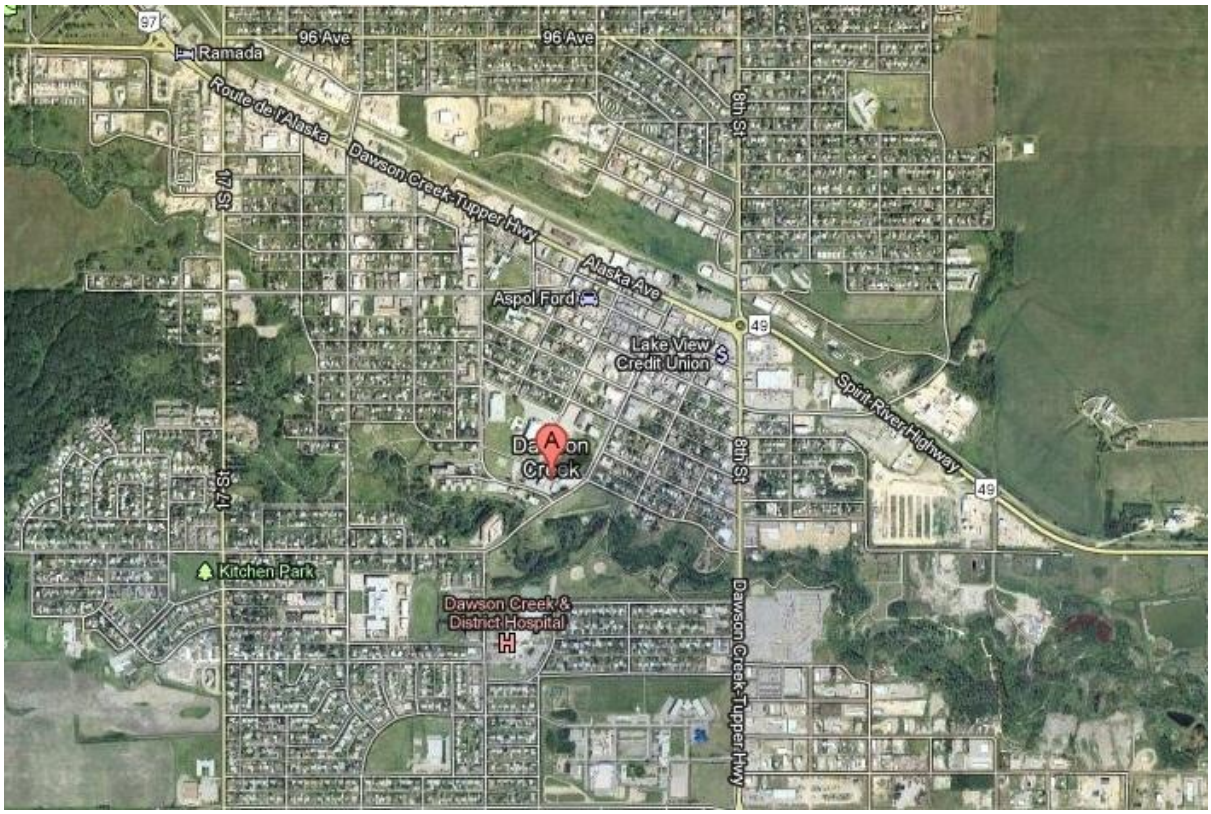


Figure 2-10: Aerial Photo of Dawson Creek. (Source: Google Map, 2012)

Dawson Creek expects growth of 1,000 residents annually through to the year 2021 as a consequence of its economic potential. And, through this additional population, the city expects significant development in commercial and industrial sectors in the growing city. To achieve the city's expected future population growth goals; it had been applying its strategic plan known as the Official Community Plan (OCP) and the Capital Workers Plan. Now the

City of Dawson Creek has developed a Comprehensive Environmental Development Plan (CEDP) that provides an up-to-date long-term strategy to deliver municipal infrastructure service in an efficient, cost-effective and environmentally responsible way (FCM 2001).

The first priority in this plan is water service improvement. Therefore the city is promoting water conservation, managing stormwater flow, and reducing the environmental impacts of wastewater.

This plan was developed in three steps. In the first step the city gathers data for completing the supply and demand requirements to recognize the current used lands and the potential of remained lands to meet the project's demand.

Next, the project team prepares the infrastructure report to analyze how water, sanitation, sewer, storm drainage and roads could affect the project's annual growth demand. The third step is to prepare a financial report, and to present the financial improvement strategies in an environmentally responsible and cost-effective way (FCM 2001).

The result of the CEDP's implementation demonstrated that the existing wastewater system was sufficient for forecasted growth, but it recommended stronger guidelines for new subdivisions to minimize erosion, runoff, and environmental impacts of urban drainage (FCM 2001).

Table 2.5 shows the summary of the discussed communities, with a brief discussion about each community’s issues, goals and objectives, processes, and actions. Although shows how each of these communities in different area, dealing with their specific climate issues through working on developing and implementing adaptation strategies for pending climate change by using International protocols milestones (Table 2.4) or developing local action plans. Consequently, comparing and combining these communities’ experiences helps to understand and to develop a more ideal adaptation framework for coastal communities.

Community	Issue	Goals and Objectives	Process	Action
Metro Vancouver **NRCan, 2010**	How changes in stormwater runoff quantity and quality impact the region's many urban and rural salmon and trout streams	Develop effective plans to protect communities from flooding and results in no net loss to environmental quality	ISMP	Secure political interest and support, Identify watershed problems and opportunities, Develop objectives and alternative scenarios, Collect meaningful data and refine scenarios, Evaluate alternatives and develop component plans, Develop an implementation program, Refine the plan through adaptive management
Toronto **NRCan, 2010**	Populations at risk from extreme heat weather	Help public health agencies identify heat stress conditions that are likely to be harmful to human health so they can implement appropriate health services.	Toronto Hot Weather Response Plan	Increase awareness of problem related to extreme heat, contributed to the development of new program and measures to combat the urban heat island effect, and helped facilitate the partnering of various city departments
Halifax **NRCan, 2010**	Rising sea level, increased storm intensity and associated waves and storm surges	Help to mainstream climate change mitigation and adaptation into municipal planning and decision making.	ClimateSMART	Further consultation with property owners and other stakeholders to obtain feedback on options and strategies, Modeling exercise to accurately predict the impact of heavy wave action on harbour-front properties, Development of a risk assessment database containing information on the vulnerability of

				harbour-front properties, Creation of measures that could include minimum ground elevation for new development, engineered solutions such as raising sea wall heights, and land use and development regulations for flood-prone areas
Edmonton **NRCan,2010**	Urban tree threaten by recent drought, insect infestations, disease and storms	Having a diverse and sustainable urban forest that enhances the beauty of Edmonton and contributes to the well-being and quality of life for future generations Provide a plan, effectively managing, sustaining and ensuring the growth of the City's urban forest, educate the general public about the importance of the urban forest, and forestry issues, protect native forest and tree stands in conjunction with	UFMP	• To provide Edmonton with a comprehensive plan for effectively managing, sustaining and ensuring the growth of the City's urban forest • To educate the general public, other city agencies, neighboring communities and community partners about the importance of the urban forest, forestry issues and management best practices • To protect native forest and tree stands in conjunction with the city's Office of Natural Areas, which is responsible for

		the city's Office of Natural Areas		the natural areas and the Natural Connections Strategic Plan.
Sudbury **ICLEI, 1995**	The cost of energy usage, increasing level of CO2 emission	Reduce greenhouse gas emission	Energy Strategic Plan	Saving energy cost and reduce CO2 emission, and The municipality engaged the public and the private sector, and external consultants to contribute to an auditing plan for existing energy use, to measure potential energy and cost savings in the community, and to analyze the economic and environmental benefit of this project
Dawson Creek **FCM,2001**	Community development plan for designing community's facility for future growth	Provides a long-term strategy to deliver municipal infrastructure services in an efficient, cost-effective and environmentally responsible way	CEDP	Gathering data for completing the supply and demand requirements to recognize the current used lands and the potential of remained lands to meet project's demand, the project team prepares the infrastructure report to analyze how water, sanitation, sewer, storm drainage and roads could

				affect the project's annual growth demand, to prepare a financial report, and to present the financial improvement strategies in an environmentally responsible and cost-effective way

Table 2.5: Case Studies Summary

2.3 The Scientific Method of Problem Solving

Management science is the method designed to help solve management problems scientifically. Management science is very wide in scope so that the developed techniques can be used in different fields of business, e.g., economics, finance, marketing, accounting, etc., to satisfy similar kinds of problem solving needs, such as improving the process and efficiency of organizations as well as increasing the success rate of implementation.

The problem solving approach is the logical and scientifically-based approach of management science to solve management related problems and help to make better decisions. This method has become known as the "scientific method of problem solving" (Taylor 2001).

As shown in the Figure 2.11, this method is generally developed in five steps as follow:

(1) Observation

(2) Problem definition

(3) Model construction

(4) Solution, and

(5) Implementation

The scientific method of problem solving is explained briefly, and then AHP, the Analytical Hierarchy Process, a tool to implement a specific scientific-based method of problem solving with respect to multicriteria decision problems is discussed in more detail below and with specific reference to this research.

In this study for designing an ideal protocol for the coastal communities' adaptation frameworks, existing protocols are reviewed and the experience, effectiveness, and results of these approaches relative to management science and problem solving are examined. To this end, the scientific method of problem solving is presented as the evaluative framework in which to evaluate adaptive frameworks for problem solving. The steps of the scientific method of problem solving are used as specified in the figure below (Taylor 2001).

The approach starts with observation, and it continues with problem definition and model construction, which leads to the production of model solutions. The approach is finalized with implementation of the solution results and monitoring and review of the ongoing impacts.

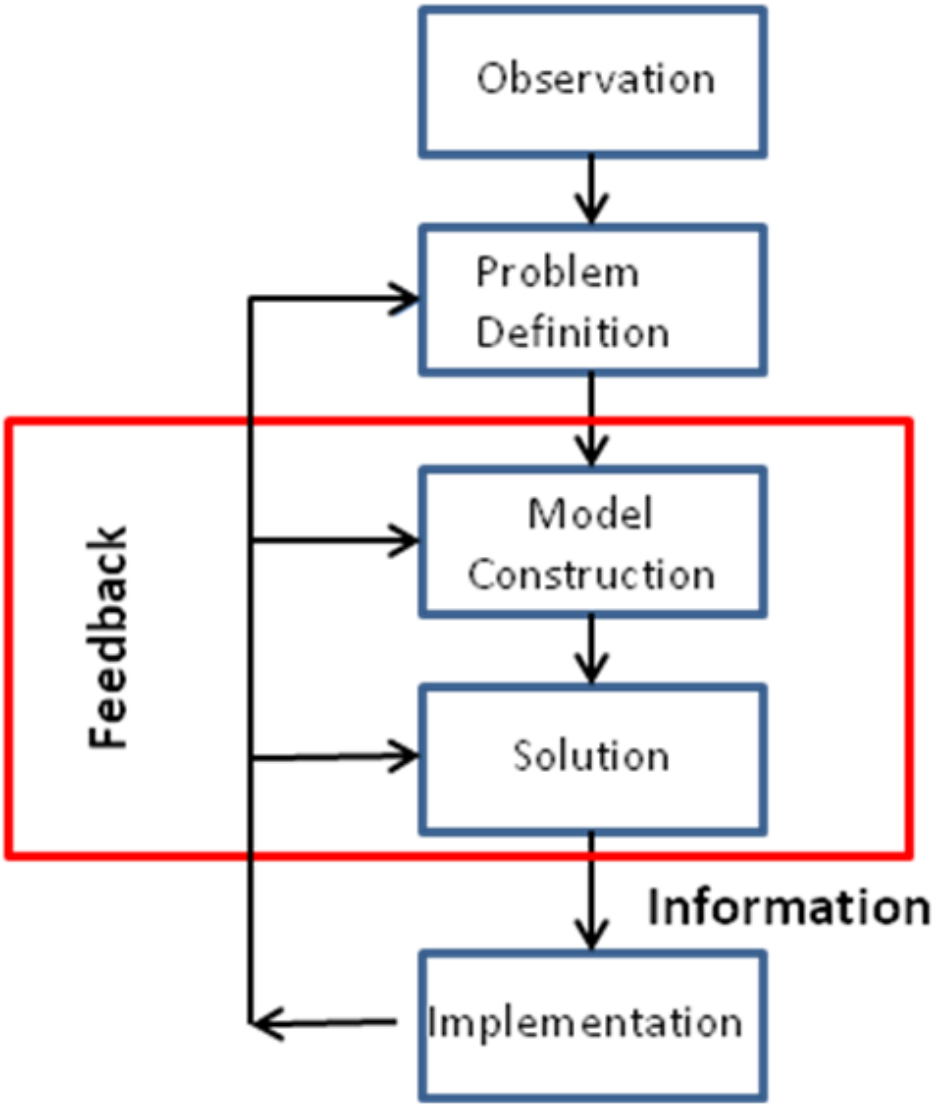


Figure 2-11: The Management Science Process (Taylor 2001)

As shown in Figure 2.11, the hierarchy for the scientific method of problem solving is broken down into 5 main steps, as explained below.

1) Observation. This is the initial step of the scientific method of problem solving hierarchy (Taylor 2001). The main concern is the identification of the problem in the system through observing the system. Therefore problems could be identified as soon as the occur in the system.

2) Problem definition. The step after identification of the problem is problem definition. Since the previous steps shows the problem exists, team has to take action to define the problem clearly. This step demonstrates how clear definition of problem leads the organization to resolve the problem as soon as it occurs again in the future.

3) Model construction. The third step in the scientific method of problem solving is the construction of a mathematical model; this model will be notion of organizations current problem.

4) Solution. The fourth step is developing the solution. In this step the defined problem in step (2) is solved through the model developed in step (3).

5) Implementation. The final step and criterion is the implementation of the recommended solution to the defined problem. This is the developed model, or the solution for the existing problem.

2.4 The Analytic hierarchy process (AHP)

Multiple criteria decision making (MCDM) is developed to help decision makers make decisions in complex, multiple objective problem situations. In these problems, a number of alternatives are evaluated with respect to multiple criteria to find a preferred ranking of the alternatives. There are several methods available for solving MCDM problems including: simple scoring methods, ideal point approaches, and structural problem hierarchical methods (Lane 2010). In this study, AHP is selected as an effective MCDM procedure to apply in the case due to its ease of use and understanding as well as its ability to combine subjective and objective measures without concern for scaling problems (Zeleny 1998, Xu 2001).

The Analytic hierarchy process (AHP) is a multicriteria decision making (MCDM) support method for analyzing problems that may be described by quantitative and qualitative measures. AHP is used as a decision making tool to solve unstructured problems since 1977, and make supportive decisions that involve complicated and conflicting multiple criteria (Saaty 1980).

As part of the decision making process, AHP assists decision makers in analyzing complex problems in the form of a simple structured hierarchy format enabling decomposition of the problem into a plain hierarchical structure (Lane 2007). AHP's approach gives weights to the multicriteria factors that then enables evaluation of decision options that contribute differently to these criteria (Saaty 1980).

As shown in Table 2.6, AHP's capability of qualitative analysis exposed by the following five components, namely: possible epithets of equal, Somewhat more, Much more, Very much more, and Absolutely more important (Lee, Yoon et al. 2007).

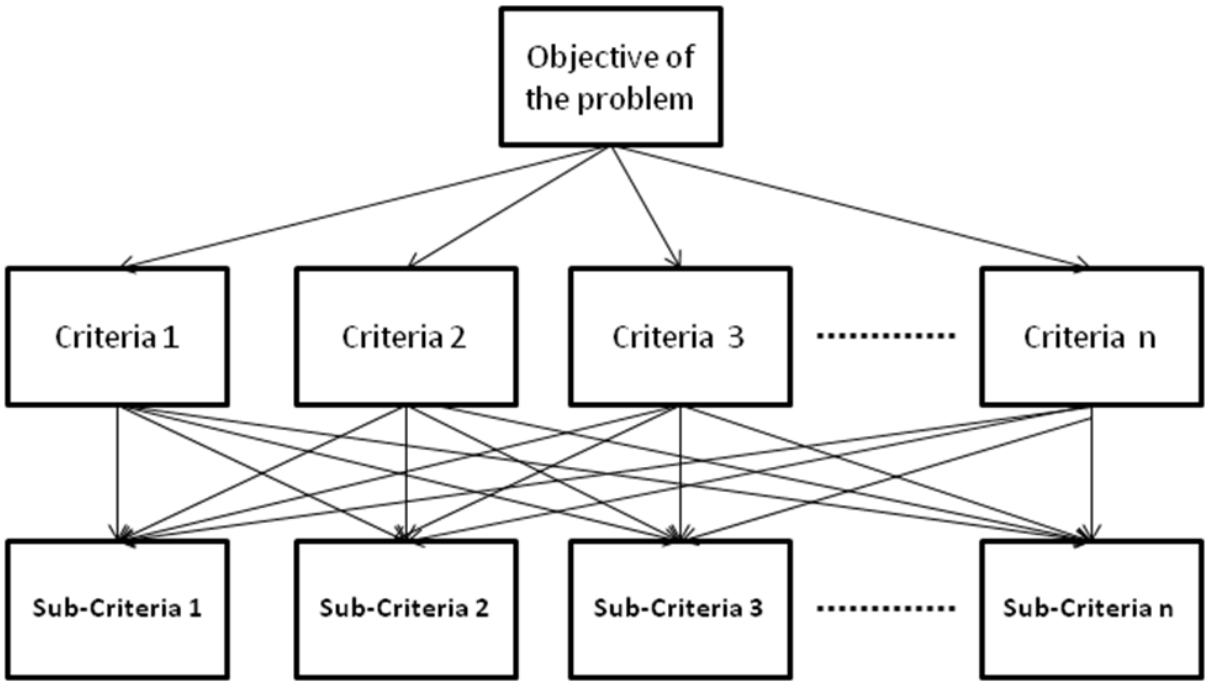


Figure 2-12: Structure of hierarchical Structure of AHP model, Source: (Lee, Yoon et al. 2007)

The AHP defines four steps for its process method as:

1. "Decomposition - In the first level, the objective and goals of the project are placed in a hierarchical structure. Main criteria and sub-criteria are placed in the second and in the third levels of the hierarchy, respectively (as shown in Figure 2.12). This structure allows for additional measurable sub-categories of indicators to be created as needed.

2. Prioritizing - In this step decision makers provide a pairwise comparison on a Likert scale between criteria in each level (Table 2.6).

3. Synthesis – The decision maker weights each criterion in each level based on the pairwise comparison analysis done in the previous step.

4. Sensitivity analysis – In this step, decision makers make an overall assessment among different alternatives based on gathered criteria through the given weights established in previous steps." (Lee, Yoon et al. 2007)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

Table 2.6: Saaty's AHP Rating Scale. Source: (Lee, Yoon et al. 2007)

For example, in the case of 3-criteria comparisons there are 3 pairwise comparisons to review. These are captured in the relative scale values, W_i/W_j, where *i* is not equal to j, and *i*,*j*=1,2,3.

The resulting 3x3 matrix (see below) has a characteristic eigenvector that is determined and scaled to 1 so that the resulting elements of the vectors are considered as the weights w_j^* of importance of each criterion (Saaty 1980).

$$\begin{pmatrix} w1/_{w1} & w1/_{w2} & w1/_{w3} \\ w2/_{w1} & w2/_{w2} & w2/_{w3} \\ w3/_{w1} & w3/_{w2} & w3/_{w3} \end{pmatrix}$$

Across the levels of the hierarchy the overall weight for each alternative *k* is determined by the score of each alternative, a_{ik} with respect to the criteria, *i* by multiplying the respective criterion weight, w_i, *i*=1,2,3, and a_{ik}, *k*=1,2,…,n where n is the number of alternatives. Then:

$$A_k = \sum_{i=1}^{n} w_i^* a_{ik}$$

where Alternative overall scores, A_k are scaled to obtain the overall alternative relative ranking.

In conclusion, AHP helps decision makers to understand their ranking of available alternatives with respect to each alternative's contribution to the multiple criteria and their relative importance to the decision maker (Lane 2007).

2.5 Summary of literature review

In this chapter, the international protocols in the area of community adaptation frameworks to climate change such as those that developed by ICLEI, FCM, UNDP, ECCP, and C-Change are analyzed, and their milestones and steps are presented. Case studies of selected Canadian communities, their climate related issues, and vulnerabilities as well as their local action planning targeting adaption of the communities to changing climate are analyzed.

The scientific method of problem solving is defined, and the usage of problem solving steps is presented and discussed. The AHP model is introduced as a tool to deal explicitly with multicriteria problems and the provision of decision support, as needed in this research on adaptation frameworks for coastal communities.

In the next chapter, the Methodology used in this study is presented and the modeling and research process established through using the background literature will present. The criteria taken from the protocols will be compared pairwise by applying the AHP's Expert Choice software, and the highest ranked protocols chosen in order to fulfill this study's objective of developing an ideal protocol for adaptation frameworks applied to coastal communities.

3 Methodology

This chapter presents the research methods used in this thesis. These methods are based in part on the analysis of the literature discussed in the previous chapter as adapted for the current research.

The aim of the research methods is to develop procedures to discover a "best practices" framework using the scientific method of problem solving in order to assist coastal communities to develop and implement their own efficient adaptation plans for the management of their changing coastal environments. The framework provided in this chapter explains the basis and process of analyses done in order to meet the final research objectives. Specifically, this chapter explains the research process for the assessment of the international adaptation protocols as discussed in Chapter 2, and the application of AHP for ranking the protocols with respect to the scientific method of problem solving. The chapter also describes the method of research analysis of the Canadian C-Change communities also applying the steps of the scientific method through AHP.

In the following, subsection 3.1 presents the phases of the research process. Subsection 3.2 details the criteria and subcriteria of the scientific method of problem solving, and subsections 3.3 to 3.5 present the details of the Phases 1 to 3 of the research process. Subsection 3.6 provides a summary of the research methods.

3.1 Research Process

Three phases are defined for the application of the methodology process. These phases are:

Phase1. Evaluation of International adaptation protocols (as presented in Chapter 2) through using AHP formulated with a hierarchy, defined by the scientific method of problem solving. This phase includes ranking and comparison of the application of the scientific method of problem solving to the adaptation protocols, and identification of best practices.

Phase2. Application of the scientific method of problem solving to the C-Change communities through the evaluation of the scientific method of problem solving via the AHP model defined in Phase 1. This phase involves ranking and comparison of results among the Canadian C-Change communities and the identification of best practices among communities. It also includes a "gap analysis" of the communities and critiques of C-Change communities' work to date.

Phase 3. Development of Community Guidelines for adaptation. This phase identifies the roles and responsibilities of community members in the event of an environmental threat to the community as well as the determination of Community Action plans for the preparation of community groups.

These ordered phases apply the research methods at each step in the process. The following sections present the research methods:

- Defining the scientific method of problem solving as well as defining and describing the specific steps of the scientific method of problem solving.
- Formulating the AHP multicriteria decision support model based on the steps and understanding of the scientific method of problem solving, and developing the AHP model using the Expert Choice Software.
- Evaluating the performance and sensitivity of the international protocols and the communities for comparison and contrast as a means of identifying "best practices" in adaptation framework and problem solving.

3.2 Scientific Method of Problem Solving

As discussed in Chapter 2, the scientific method of problem solving is used to identify defined research problems in this study. The scientific method of problem solving hierarchy, presented by Taylor (Taylor 2001, Figure 2.11), is applied to develop this study's framework as the approach of this research problem is to evaluate alternative approaches to manage adaptation as defined in Chapter 1.

As shown in Figure 3.1 below, the hierarchy for the scientific method of problem solving is broken down into 5 main steps, as explained below.

1) *Problem Identification*. This initial step of the scientific method is defined as a top-level criterion of the multi-criteria problem formulation of the AHP hierarchy. This criterion contains four relevant variables that are defined as sub-criteria. The following sub-criteria for this criterion are developed and applied to the AHP hierarchical formulation: (1.1) Problem Definition, (1.2) Affected Clients, (1.3) Declaration of Objectives, and (1.4) Constraining Factors.

2) *Data*. This step identifies the second top-level criterion and the relevant factors defined for it. These factors are: (2.1) Availability, (2.2) Measurability, (2.3) Cost and Issue, (2.4) Data Management and (2.5) Profiling Risk/Priorities. This criterion demonstrates how required information in the community is available and how these available data are measurable. If the reliable data were not available, then this criterion determines how much it would cost to find and process relevant data in the project. Other issues related to data are managing the data in the community, for example, updating data in specific time periods and prioritizing the data systematically. This step demonstrates how we could find relevant data in each step of the project accurately.

3) *Model building for problem solving*. The third step in the scientific method of problem solving is the construction of a mathematical model. As a criterion in the AHP hierarchy, model building has four subordinate factors defined as: (3.1) Static/Dynamic Modeling, (3.2) Relevance of Model Objective(s), (3.3) Model Communication and (3.4) Deterministic/Probabilistic Modeling. The objective of defining these factors is to show that the analysis done in modeling develops a model designed to meet the project's main objectives.

4) *Testing/Sensitivity/Validity*. The fourth step is model testing and validation. The factors for this criterion are: (4.1) Analysis in Place, (4.2) Robustness and (4.3) Feedback for Adjustment. This process requires us to analyze the data in each step and update the system with feedback on the robustness of each phase.

5) *Monitoring and Control*. The fifth step in the scientific method is the ongoing monitoring and control of the recommended problem resolutions. This criterion has the following

factors: (5.1) Advantage and Ongoing Verification of Objectives, (4.2) Switching Capabilities of Objectives, and (4.3) the Control Process. In this step the system has to be monitored and updated to control the process to make sure implementation and the results of actual indicators of the system parallel the defined objectives.

6) *Implementation.* The final step and criterion is the implementation of the recommended solution to the defined problem. For this criterion, two sub-criteria of the model are defined: (6.1) Evidence of Results, and (6.2) Guideline of Decision Method for Preparedness.

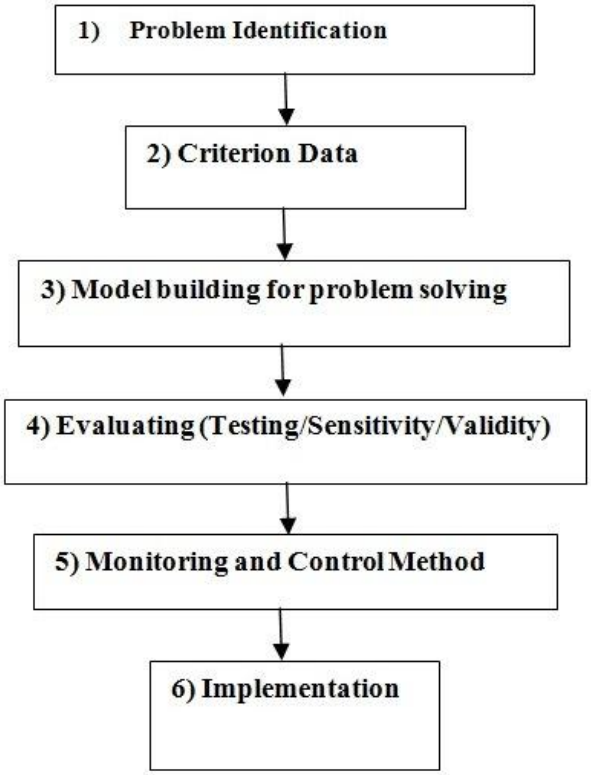


Figure 3-1: Steps of the Scientific Method of Problem Solving based on Figure 2.11 (Taylor 2001)

In the following, the framework of Figure 3.1 is developed into the applied hierarchy in AHP and implemented into the Expert Choice Software (Expert Choice 2004).

3.3 Phase 1: Evaluating Adaptation Protocols by AHP

Since the goal of this study is to develop a framework for coastal communities, so the hierarchy model is developed through using scientific methods steps to meet the project's objectives. Using AHP, the approach for assessing the adaptation protocols was established. According to AHP, weights and ranking of the criteria are developed in each level of the process as shown in Figure 3.2. Next, pairwise comparison was completed among the criteria and subcriteria at each level.

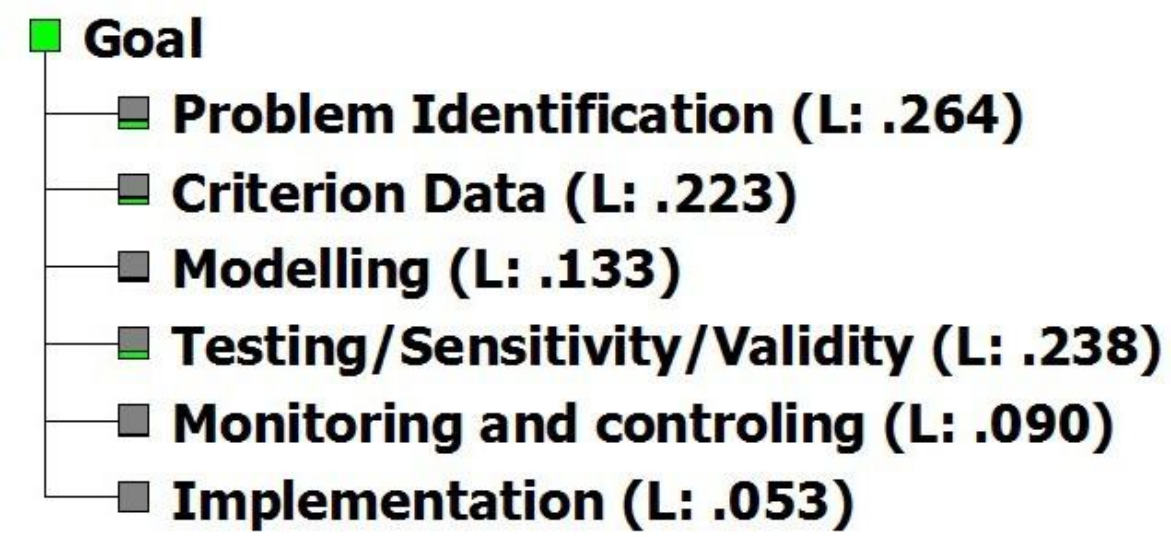


Figure 3-2: Tree view- Expert Choice output. Source: (Expert Choice 2004)

As shown in Figure 3.2 Problem Identification, Data, Modeling, Testing, Monitoring, and Implementation were defined as top-level and main criteria as the steps of scientific method of problem solving presented in subsection 3.2. Figure 3.3 shows the main criteria including their subcriteria elements also as noted in subsection 3.2 above to form the complete AHP formulation of the scientific method of problem solving in Expert Choice format.

Figure 3-3: Detail AHP hierarchy model for the Scientific Method of Problem Solving formulation. Source: (Expert Choice 2004)

All top level criteria and the sub-criteria levels were evaluated by pairwise comparison by following Saaty's nine point scales (as shown above in Table 2.6). These evaluations were made independent of the problem alternatives (to follow) and provide the basis for evaluating these alternatives (protocols and communities) and their own valuations.

The pairwise comparison values for the top level criteria and within lower level subcriteria were determined by the researcher based on the literature related to the scientific method, and the relative importance applied to the steps of the process. The results and defense of these pairwise comparisons are discussed in Chapter 4.

The AHP method, through the use of the Expert Choice software provides relative weights for each criteria and sub-Criteria. The assignment of the pairwise comparison value was applied while maintaining the consistency level under 0.1 for each criterion comparison in each level.

It is noted that the Figure 3.3 hierarchy is applied to both Phase 1 (international adaptation protocols), and Phase 2 (C-Change community comparison).

3.4 Phase 2: Application of scientific methods to C-Change communities

In Phase 1, the developed hierarchical framework (Figure 3.3) is used for comparing the analyzed international protocols (Chapter 2). Therefore the same steps and milestones of the evaluation of the international protocols are applied in the scientific method steps as developed in AHP. Weights are assigned for each criterion in comparison to other criterion in the same level as well as in relation with the higher level criteria. The final feedback from this application develops the final framework for applying best practices.

After all these analyses have been applied for the international protocols, the final framework is applied in Canadian C-Change communities (Isle Madame, Gibsons, Iqaluit, and Charlottetown) to discover how problem solving in the communities are ranked and compared. Therefore, in this part, communities will be analyzed and criteria will be weighted and compared regarding to communities' specific situation and needs. Through the result of this analysis, the researcher can determine how to assist the community developing its local

action plan and guideline. Through this analysis of the applied protocols in Canadian communities, selecting the preferred elements of the adaptation framework is developed.

3.5 Phase 3: Development of Community Guidelines for adaptation

Through the analysis done in Phase 2, guidelines are developing for the C-Change coastal communities. These guidelines define the roles and responsibilities of the key community leaders involved at all levels, including the governments (federal, provincial, local government, and municipality), and households. The Municipality's responsibilities and all other participant organizations duties are generally discussed, then households' emergency kits assessed. Consequently, the Community Action Plan is developed for all community members through information provided in this guideline. This Action Plan covers and manages the activities taking place in the community during storms, hazards or other natural events when the community is called upon to implement a preparedness plan.

3.6 Summary of the Chapter

In this chapter, the application of the scientific method of problem solving and its break down as a multicriteria hierarchical problem is presented. The AHP formulation using Expert Choice is explained.

The phases of the research process are provided. In Phase 1, the International protocols are analyzed and their specific elements compared through the AHP problem solving formulation of the scientific method of problem solving. In Phase 2, the best practices application among Canadian C-Change communities is developed. And finally, in Phase 3, the Community Action Plans guidelines are developed.

In next chapter, the results of the research process are presented. The AHP Expert Choice software is applied to identify best practices from the ranked protocols and the coastal communities.

4 Analysis and Results

This chapter presents the applied analysis and results of the research methods and process presented in Chapter 3. This chapter includes the following sections:

4.1) preparation of the AHP formulation of the scientific method of problem solving by developing the pairwise comparisons of the importance of the method for adaptation frameworks thereby establishing the weighted hierarchy for general application of the formulation

4.2) evaluation and comparison of the applied scientific method of problem solving of the International protocols for managing adaptation through the application of the AHP model for Multi-Criteria decision making by applying the Expert Choice software (Expert Choice 2004) (Phase 1 analysis)

4.3) identification of 'best practices' among the International protocols for managing adaptation result from the sensitivity analysis of the AHP model (Phase 1 results) ;

4.4) evaluation and comparison of the applied scientific method of problem solving of the C-Change Canada communities for managing adaptation through the application of the AHP model (Phase 2 analysis); and

4.5) Gap analysis of the ranked C-Change Canada communities including lessons applied from the best practices of the International protocols for managing adaptation resulting from the sensitivity analysis of the AHP model (Phase 2 results).

Lastly, the results of these analyses are provided as an aid to the determination of contents for the community adaptation action plans and guidelines (Phase 3). These guidelines, presented in Chapter 5, are the consequence of the action plans, best practices, and observations about the international adaptation protocols, as applied to the C-Change Canada communities. As such, the guidelines presented in Chapter 5 provide the recommended template for applied adaptation planning and implementation for the C-Change Canada communities based on the construction of the scientific method of problem solving and its expected implementation in practice.

In this chapter, the AHP Expert Choice software is used as a decision making support tool to rank alternatives in a multicriteria setting and to determine best practices in adaptation planning and action. The results of this structured comparison of international protocols permits prioritization of the specific criteria that are required and are most effective in practice toward satisfying the adaptation needs of coastal communities such as the C-Change ICURA project communities in Canada.

4.1 Preparation of the AHP Weighted Hierarchy

This section presents the pairwise comparison estimates for the general scientific method of problem solving problem as formulated in section 3.3 and Figure 3.3. The weighted hierarchy of Figure 3.3 is determined by comparing: (i) each two criterion in a pairwise manner; and (ii) each two subcriteria also in a pairwise mode as discussed in sections 2.4 and 3.3 above. The following Tables 4.1 to 4.7 provide the hierarchy pairwise comparison information that is used in this thesis to define the weighted hierarchy for the scientific method of problem solving problem formulation.

Table 4.1, shows the values were assigned between each pair of the first level criteria in pairwise comparison. As shown in the table, there are noted differences between the Modeling and the Testing criteria, and Testing is set as being more important than Modeling in terms of Saaty's 1-9 Likert scale (Table 2.6). As discussed in Taylor's management science process in Figure 3.1, the Modeling exercise is carried out prior to Testing or model validity and model parameter sensitivity analysis take place. The purpose of Testing is to analyze model issues and difficulties as well as address these by adjusting the model accordingly to make necessary corrections. This troubleshooting stage helps to improve the developed model. Therefore in the analysis of Table 4.1, the Testing/Sensitivity/Validity criterion is given more relative importance with a score of +4 relative to the Modeling criterion score due to the importance of the Testing, Sensitivity and Validity analysis of the model.

In another case, as shown in the Table 4.1, Modeling received a higher score of +4 in comparison to the Implementation criterion. Higher score assign for modeling compare to implementation because in general for any project successful model must construct for

successful implementation. Therefore the pairwise comparison done between the Modeling and Implementation criteria, the Modeling criterion received the higher score (+4).

Similar arguments were applied to developing the set of scores for the 15 pairwise comparisons done among all 6 first level criteria, as provided in Table 4.1 and Appendix A - Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and Subcriteria Weights.

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Problem Identificatio	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Criterion Data
2	Problem Identificatio	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Modelling
3	Problem Identificatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Testing/Sensitivity/V
4	Problem Identificatio	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Monitoring and contr
5	Problem Identificatio	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Implementation
6	Criterion Data	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Modelling
7	Criterion Data	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Testing/Sensitivity/V
8	Criterion Data	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Monitoring and contr
9	Criterion Data	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Implementation
10	Modelling	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Testing/Sensitivity/V
11	Modelling	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Monitoring and contr
12	Modelling	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Implementation
13	Testing/Sensitivity/V	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Monitoring and contr
14	Testing/Sensitivity/V	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Implementation
15	Monitoring and contr	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Implementation

Table 4.1: Pairwise Comparison the relative importance with respect to: Goal. Source: Expert Choice 2004.

After the first level criteria pairwise comparisons are complete as shown in Table 4.1, pairwise comparison of the 6 pairs of the 4 second level subcriteria of Problem Identification is presented in Table 4.2. As shown in Table 4.2, all the Problem Identification subcriteria are assumed to have equal importance in this project. For example, it is argued that the Problem definition and Constraining factors subcriteria are assigned a comparison score of "1", it means both of these subcriterion are assumed to have the same relative importance in order to fulfill the goal of the project. Identical scores are given to all subcriteria under the Problem Identification criterion which assumes the same level of importance for identifying the problem as a first step in defined model in Figure 3.1 for all these four subcriteria.

1	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Affected Clients (How
2	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Declaring objectives? (
3	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu
4	Affected Clients (How	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Declaring objectives? (
5	Affected Clients (How	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu
6	Declaring objectives? (	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu

Table 4.2: Comparison the relative importance with respect to Problem Identification (Expert Choice 2004).

Table 4.3 shows the comparison and relationship between each pair of subcriteria under the Criterion Data. Unlike the result of Table 4.2, Table 4.3 experiences a more diverse result meaning that the degrees of relative importance here are very different between each of the subcriteria. For example, the Cost and Issue subcriterion is assumed to be stronger than the Availability subcriterion and therefore received a higher relative score (+8) compared to the Availability subcriterion. This score was assigned because data available specifically in this study was crucial and would otherwise be costly for the organization. The Cost and Issue subcriterion is assigned to be slightly more important (at +2) compared to the Profiling Risk subcriterion. In general, cost and risk are analyzed in parallel in most cases, and, since in some cases organizations (e.g., municipalities) have to take some risk to implement vital projects (related to society's safety, or infrastructure, for example), then Cost and Issue criterion become the basis for strategy comparison and accordingly are assigned a higher score compared with Profiling the risk.

Similar arguments where applied to developing the set of scores for the 10 pairwise comparisons of the 5 secondary level subcriteria for Criterion Data, as provided in Table 4.3 and Appendix A - Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and subcriteria Weights.

1	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Measurability
2	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost and Issue
3	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
4	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
5	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost and Issue
6	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
7	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
8	Cost and Issue	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
9	Cost and Issue	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
10	Data Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie

Table 4.3: Comparison the relative importance with respect to Criterion Data (Expert Choice 2004).

Table 4.4 shows below the 6 pairwise comparison scores assigned to the 4 subcriteria under the primary level criterion “Modeling”. In this case, it is argued that the Static/Dynamic Sub-Criterion is assigned the lowest score (at scores of “8” and “3”) compared with each of the other subcriteria for Modeling. The other 3 subcriteria pairs are less different and more comparable (with scores of “2” and “3”) in their pairwise comparison scores. The logic behind this scoring method for example, assigns more importance with respect to whether the specific project is Deterministic or Probabilistic compared to being Static or Dynamic.

Similar arguments where applied to developing the set of scores for the 6 pairwise comparisons of all four second level subcriteria for Modeling, as provided in Table 4.4 and Appendix A - Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and subcriteria Weights.

1	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Relevance to objective
2	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication (interpı
3	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil
4	Relevance to objective	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication (interpı
5	Relevance to objective	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil
6	Communication (interpı	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil

Table 4.4: Comparison the relative importance with respect to Modeling (Expert Choice 2004).

The Testing criterion has just three related second level subcriteria. The assigned pairwise comparisons show that Robustness is almost equal with both other Testing subcriteria (Analysis in place, and Feedback for adjustment), but the Analysis in place subcriterion is judged to be slightly more important than Feedback for adjustment. The argument about this assigned score accounts for the notion that in Testing, we need to consider carefully Analysis in place as being assigned a higher score because in the field, the first thing that needs to be tested toward project implementation is the analysis in place prior to carries out the rest of the testing procedures.

Similar arguments were applied to developing the set of scores for the 3 pairwise comparisons of the three second level Sub-Criteria for Testing, as provided in Table 4.5 and Appendix A - Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and subcriteria weights.

1	Analysis in place	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Robustness(is there fle:
2	Analysis in place	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Feedback for adjustmer
3	Robustness(is there fle:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Feedback for adjustmer

Table 4.5: Comparison the relative importance with respect to Testing (Expert Choice 2004).

The Monitoring criteria have three subcriteria, and the three pairwise comparison scores are shown in Table 4.6. Monitoring is assumed to experience a similar phenomenon to the Testing criterion (Table 4.5) in comparison between its subcriteria. In Table 4.6, the pairwise comparison assigned to Switching capabilities are assigned almost equal value as are the other two subcriteria in this group, namely, Control process, and Advantage and ongoing objectives. However, Advantage and ongoing objectives is noted as being slightly more important than Control process. The logic here is that for Monitoring the process, Advantage and ongoing objectives are more important than controlling the process, and therefore the

Monitoring step with Advantage and ongoing objectives criterion can be shifted among the other two subcriteria.

Similar arguments were applied to developing the set of scores for the 3 pairwise comparisons of the three second level subcriteria, as provided in Table 4.6 and Appendix A - Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and subcriteria weights.

1	Advantage and ongoinc	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Switching capabilities f
2	Advantage and ongoinc	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control Process
3	Switching capabilities f	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control Process

Table 4.6: Comparison the relative importance with respect to Monitoring (Expert Choice 2004).

The last pairwise comparison is between the single pairwise comparison of the Implementation criterion's two Sub-Criteria, namely, Evidence of result, and Guideline of design model (Table 4.7). The study's main objectives suggest that the Guideline of the design model is moderately more important than Evidence of results with a score of "3"). This is because without the Guideline of design model, the Evidence of results does not make sense.

1	Evidence of results	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Guideline of decision m

Table 4.7: Comparison the relative importance with respect to Implementation (Expert Choice 2004).

After providing the pairwise comparison values for the scientific method of problem solving AHP hierarchy formulation, these given values are used to weight the relative importance of

the overall hierarchy for general application to alternative adaptation frameworks and, in particular, for evaluating the international protocols of Phase 1 of the research process.

After all the pairwise comparisons have been assigned between the criteria at all levels (Figure 4.1), the weighted hierarchy model can be developed to form the complete weighted AHP formulation of the scientific method of problem solving in Expert Choice format. In Figure 4.1, final weights are given to each criterion in all levels. The weights are scaled to 1 across the first level criteria, and for each set of second level Sub-Criteria. For example, the Problem Identification's Sub-Criteria weight summation across its four Sub-Criteria yield: 0.221+0.257+0.239+0.283 = 1.000.

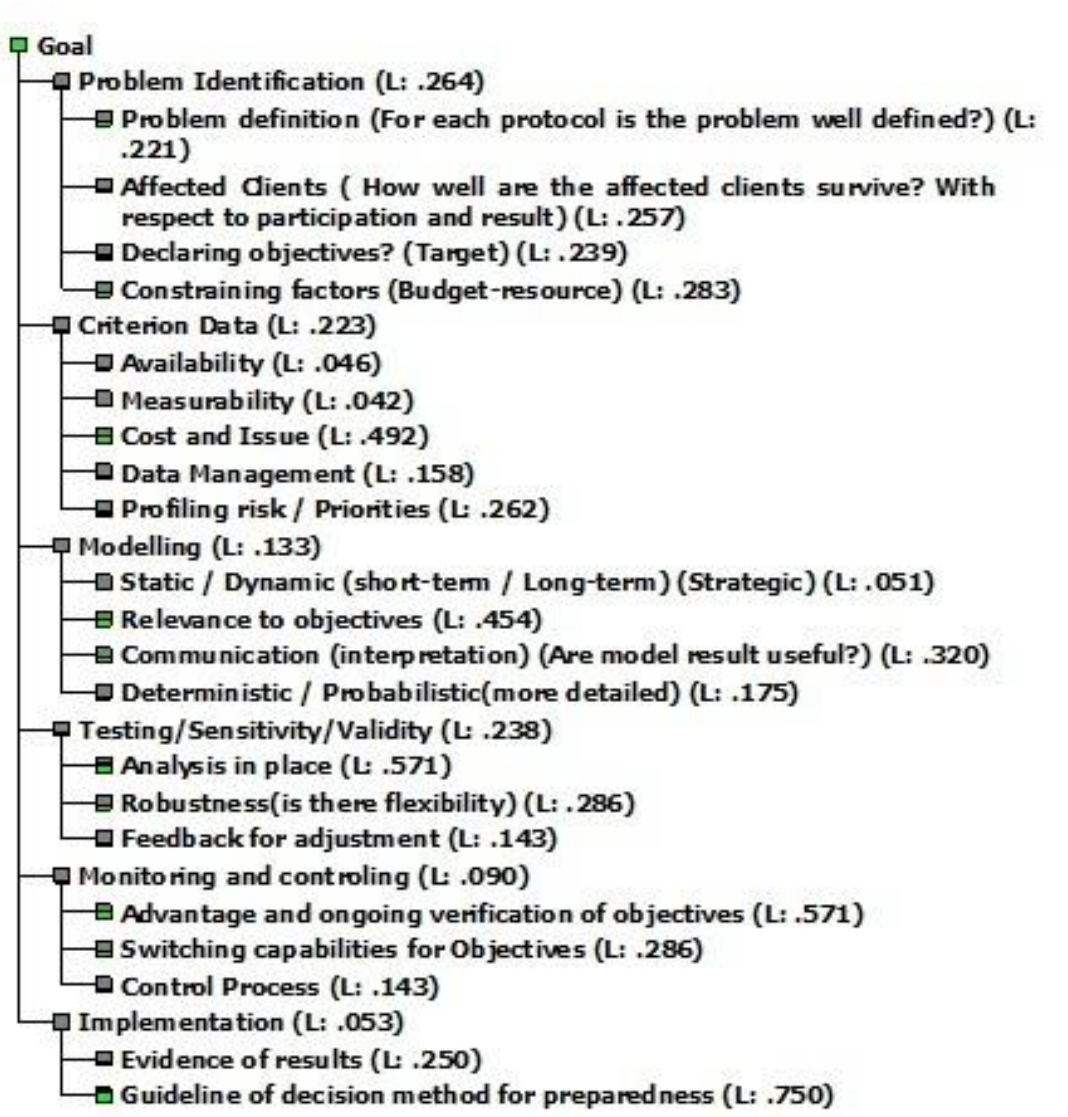


Figure 4-1: Detail AHP hierarchy model for the Scientific Method of Problem Solving formulation with assigned weight. (Source: Expert Choice 2004)

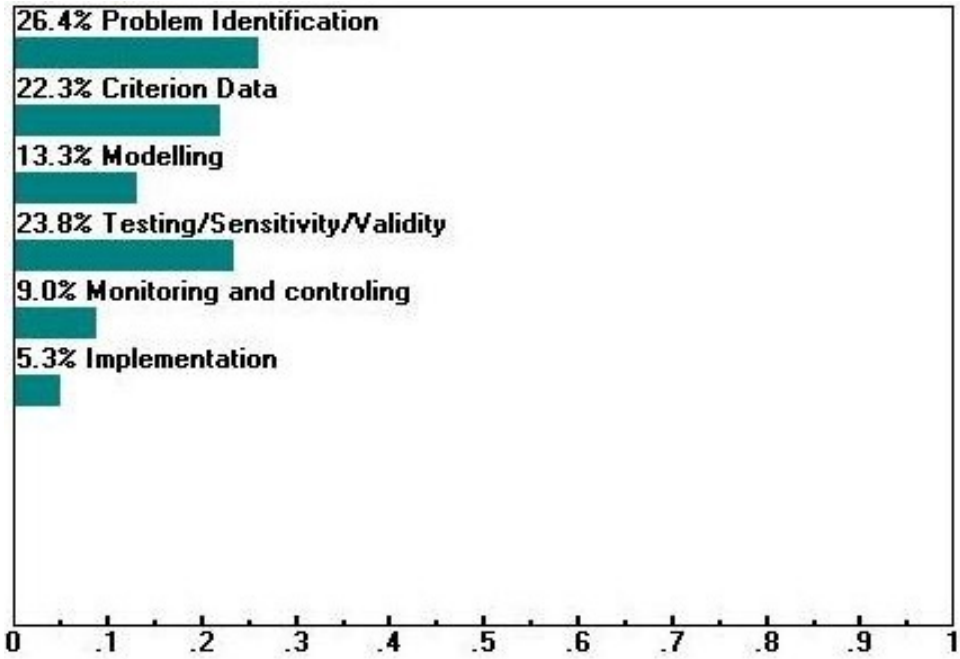


Figure 4-2: Main Criteria's final scores. Source: (Expert Choice 2004)

Figure 4.2 shows the weighted importance of the first level elements of the defined hierarchy from the pairwise comparison scores. In this Figure, the importance of 3 criteria: Problem identification, Criterion data, and Testing/Sensitivity/Validity are more heavily weighted than other elements and account for a combined 72.5% of the hierarchy total weight (of 100%). Hence, we can conclude these factors are relatively more important than other factors in regard to the decision of managing community adaptation frameworks.

4.2 Phase1. Evaluation of International protocols for managing adaptation

In this initial step, the International protocols for managing adaptation presented in Chapter 2 are analysed one by one and their criterion data for the scientific method of problem solving assessed. This is achieved by scoring each protocol independently with respect to the

measures and indicators associated with the subcriteria at the lowest level hierarchy elements of the AHP model (Section 3.3, Figure 3.3).

As presented in the review of Chapter 2, the international protocols for managing adaptation are as follows:

1) ICLEI - the International Council for Local Environmental Initiatives
2) FCM - the Federation of Canadian Municipalities
3) CARE - Cooperative for Assistance and Relief Everywhere
4) UNDP - The United Nations Development Program
5) EU-ECCP - The European Commission's European Climate Change Program as part of EU's strategic identification and development of implementing the Kyoto Protocol.

The scores for the 5 international protocols are presented below in Table 4.8 for the 3 Sub-Criteria of the Problem Identification first level criterion. The derivations and assignment of the protocol scores are discussed further below.

	INCR	INCR	INCR
Alternative	**Problem Identification Problem definition (For each protocol is the problem well defined?) (L: .221)**	**Problem Identification Affected Clients (How well are the affected clients survive? With respect to participation and result) (L: .257)**	**Problem Identification Declaring objectives? (Target) (L: .239)**
☑ ICLEI	9	8	8
☑ FCM	5	2	5
☑ Care	4	4	6
☑ UNDP	9	9	9
☑ EU Commission	3	7	7
C-Change	2	3	9

Table 4.8: Data Grid scores (protocols). Source: (Expert Choice 2004)

In Table 4.8, the score given for the Problem Identification criterion and the Sub-Criterion Problem definition of the hierarchy for each protocol asks the question whether the adaptation problem is well-defined. As shown in Figure 4.8, regarding the scores given to each protocol, it is obvious the response to this question is different among these introduced protocols, especially between ICLEI and the EU Commission (ICLEI score is 9 versus a score of 3 for the EU Commission). For this particular example, these scores are given because ICLEI's considerable experience in defining specific milestones for its different types of client communities. On the other hand, EU Commission's framework developed to help the broader EU countries reduce GHG emissions and adapt to climate changes is much less specific in terms of problem definition. As such, this protocol is relatively new, and the EU with less experience than ICLEI, is still proceeding in the initial phases of defining the project problem. Therefore the EU Commission receives a lower weight (3). The Affected client Sub-Criterion comparison between the same two protocols shows different results. In this case the score assigned to ICLEI and EU Commission are almost same (ICLEI = 8, EU Commission = 7). The reason for these scores is because both protocols supported very well the affected clients, even though the variety of communities supported by ICLEI are very diverse than the communities supported by EU Commission.

Other examples analyze the third subcriterion under Problem Identification - Declaring Objectives. Analyzing the score assigned to protocols under this subcriterion in Table 4.8 shows all protocols received more or less similar scores in this case and the lowest score is 5 for FCM. The logic behind these results assumes that these protocols are trying to follow their target and their main purposes and therefore these protocols receive high scores. Care and FCM were assigned lower scores compared with other protocols because these two protocols are still dealing with new communities that are continuing to develop their priorities and are facing issues, developing their frameworks, and receiving further feedback from them.

The score given to all criteria (Data Grid Scores) for the International Adaptation Protocols analysis are presented in Appendix C – "Protocol's Data Grids".

Another important element affecting the scoring process is about utility scores and it's shown through gray areas in Table 4.8. Since the graph (Appendix B) in this study is not linear and regarding to the first level criteria have to make curves (Figure 4.3). These curves affecting the value of scores given for each protocol through the following system:

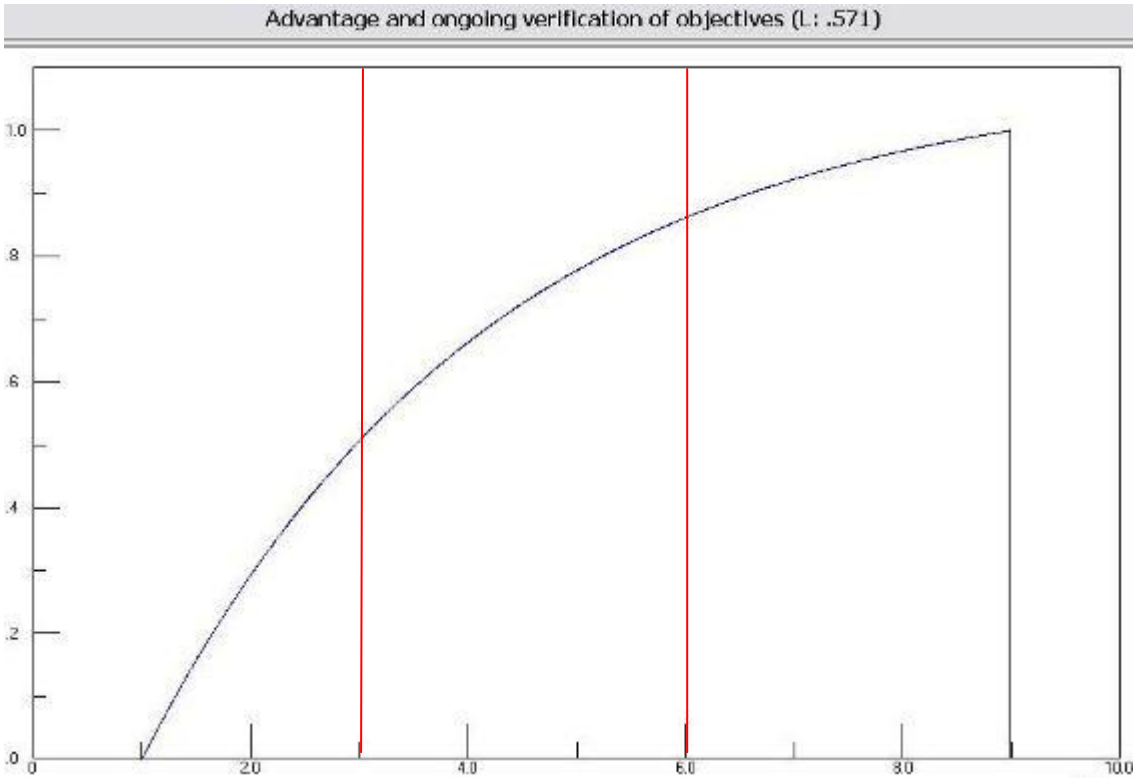


Figure 4-3: Utility Curve

In Figure 4.3 the curve is divided in different parts and all scores higher than 6 can be considered acceptable. The marginal utility for this case decreases as we proceed from the minimum to maximum anchor points.

The marginal utility for this case (Figure 4.3) decreases as we proceed from the minimum to maximum anchor points. This implies that gains made (in utility) are expected to fall as the scores increase, e.g., if the score is very low (3), the gains in utility from moving to 4 or 5 are higher than the gains in utility moving from a higher utility (7) to 8 or 9. This interpretation reflects decision makers' understand of the problem.

After scoring the protocols for each subcriterion, the most important criteria are classified through their weighted priorities of the hierarchy that follow from Figure 4.9 regarding each community's specific criteria.

The overall scores for each protocol are calculated through the summation of weighted scores given to the criteria of the AHP scientific method formulation (Figure 4.2), i.e., Problem identification, Criterion data, Modeling, Testing, Monitoring, and Implementation

Figure 4.4 provides the final score for each protocol after the abovementioned calculation is done for each protocol. Regarding the result shown in Figure 4.3, the scores for ICLEI (22.3%) and UNDP (22.6%) are higher than the other protocols due to their extent of activity. These two protocols have expanded their scope in all kinds of communities: e.g., rural, urban, in developing and developed countries.

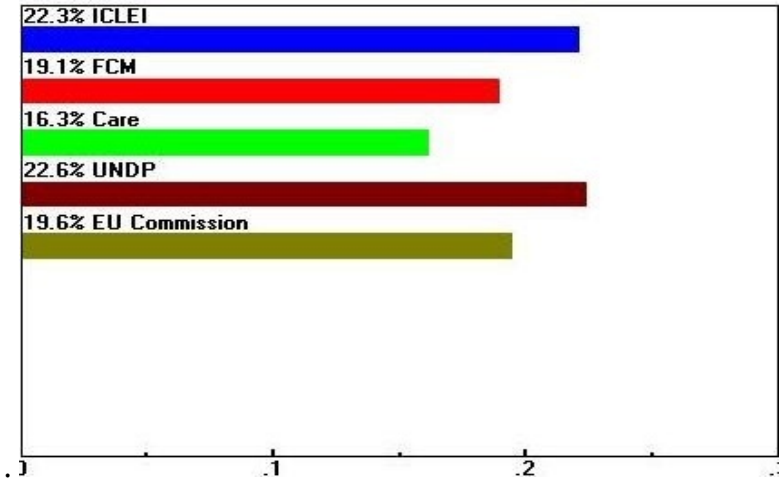


Figure 4-4: International Protocols final AHP overall scores. (Source: Expert Choice 2004)

AHP Sensitivity Analysis

After doing the analysis for the International protocols as above, the next step is the Sensitivity Analysis to show the robustness of the results. Figure 4.5 shows that in the first level criteria comparison between ICLEI and FCM, ICLEI scored more than FCM, i.e., ICLEI is dominant in all criteria in comparison with FCM. In some criterion, e.g., Problem Identification and Modeling and Testing, this dominance is much more obvious than in other criteria. In other cases, such as Monitoring and Implementation, the dominance is very low,

but through looking at the overall comparison at the bottom of the figure, it is concluded that ICLEI is dominant in comparison to FCM. Therefore ICLEI is expected to be a more appropriate overall protocol for application to the C-Change coastal communities (Phase 2). See also Appendix D- "Protocols AHP output-Sensitivity Analysis".

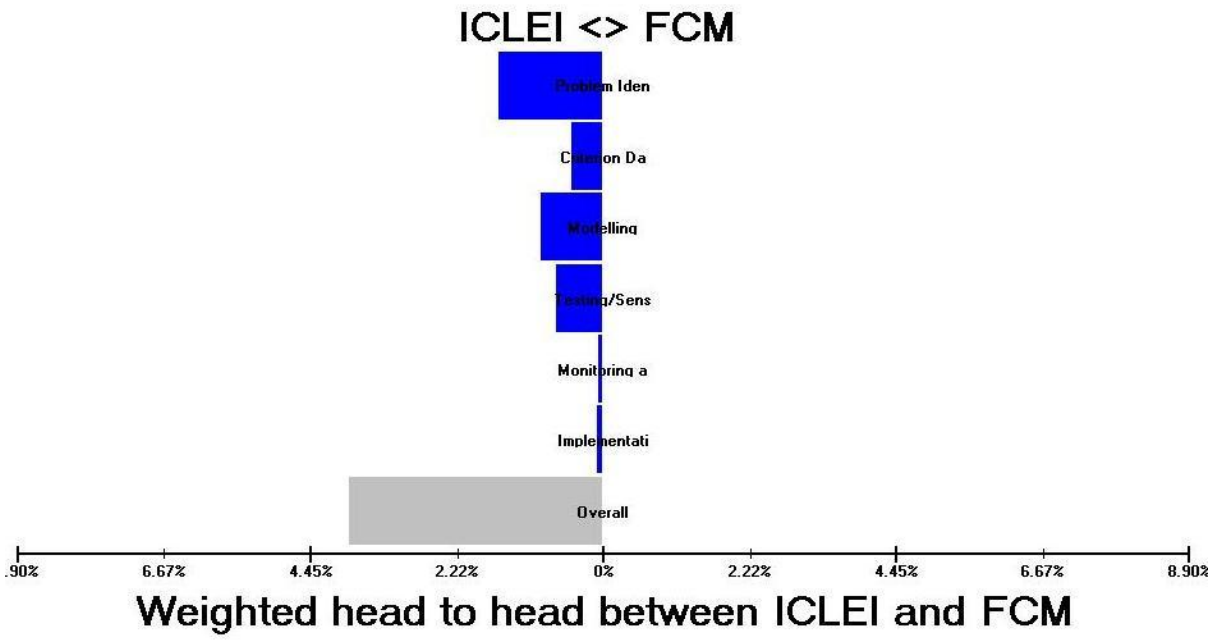


Figure 4-5: Weighted head to head Protocols Comparison. Source: (Expert Choice 2004)

In the final point of discussion about the International protocols rankings, the analysis of all protocols and the first level criteria is presented in Figure 4.6. This Figure shows the scores given to each criterion with the related International Protocols.

As shown in figure 4.6, ICLEI and UNDP are dominant in all criteria comparisons. This dominance is more obvious in some criterion such as Modeling. Dominance is reduced over other protocols in criterion such as Implementation. Overall for all criteria, the analysis of ICLEI and UNDP maintain their dominance and are assigned higher scores compared to other protocols.

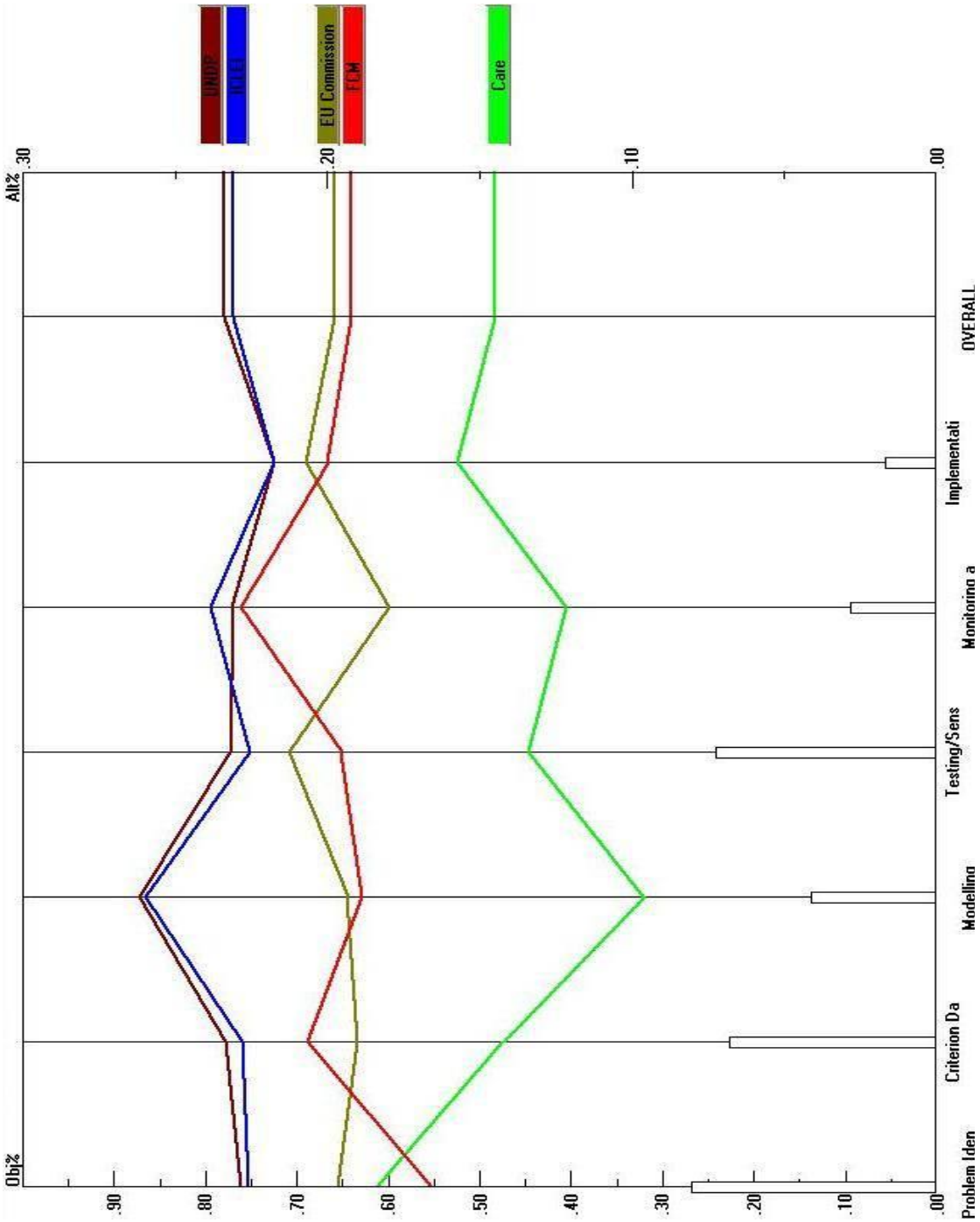


Figure 4-6: Protocol's comparison, Source: (Expert Choice 2004)

Moreover, as shown in figure 4.6 UNDP and ICLEI are very close to each other and both of them have a much higher score than other protocols in all criteria. The highest score belongs to the Modeling criterion and again, ICLEI and UNDP received highest score among all protocols with respect to the Modeling criterion, and CARE assigned 3, the lowest score. Furthermore, the lowest score for all protocols is in Implementation criterion due to progress of implementation of all these protocols. Therefore, changing Implementation score assigned to these protocols could make a significant change in overall result of this analysis.

In summary, in this part (Phase1) all the international protocols introduced in Chapter 2 are assessed and the scientific method of problem solving steps are applied in AHP Expert Choice software to do pairwise comparison between the criteria of these protocols in all levels to obtain best practices. Regarding the results obtained from AHP and analysis done among these data, ICLEI and UNDP are chosen as the best practices. These two protocols get the highest rank in all criteria and it is as a result of years of experience in the field, and developing and implementing their framework in partnership with different group of communities in developed and developing countries.

In the next step (Phase 2), the AHP hierarchy for the scientific method of problem solving is applied among Canadian C-Change communities to find the best case practice and hereby develop a preferred and model framework for coastal communities.

Moreover, as shown in the above Figures 4.4, and 4.5, UNDP and ICLEI have much higher scores than other protocols in all criteria. The highest score belongs to the Modeling criterion and again, ICLEI and UNDP received the highest scores among all protocols with respect to the Modeling criterion, while CARE assigned 3, the lowest score. Furthermore, the lowest score for all protocols is in Implementation criterion due to progress of implementation of all these protocols. Therefore, changing the Implementation score assigned to these protocols could make a significant change in overall result of this analysis.

4.3 Identification of 'best practices'

This step discusses the identification of 'best practices' among the International protocols for managing adaptation resulting from the sensitivity analysis of the AHP model (Phase 1 results) from section 4.2. Regarding the results obtained from the analysis done in Phase 1, ICLEI and UNDP are chosen as models of "best practices". These two protocols obtained the highest rank in all criteria. This is attributed to their years of experience in the field, and for developing and implementing their adaptation frameworks in partnership with different groups of communities in developed and developing countries. This result is relative to the overall data since both of these protocols are dominant, and receive the highest weights among all analyzed protocols.

The reason these two protocols are chosen as 'best practices' include:

- These protocols support a variety of communities in different regions of the world.
- ICLEI and UNDP are implementing their framework on developing and developed countries, in urban and rural areas.
- ICLEI and UNDP have proven methodologies and reliable databases with a variety of successful cases.
- Both of these protocols develop in the communities through training local authorities and transferring knowledge and experience to the community.
- Helping the communities to develop their own framework through using their basic reliable framework.

Moreover, ICLEI and UNDP are chosen as highest ranking protocols that demonstrate best practices in delivery of community based adaptation. These protocols contribute to the specific elements of the constructed model framework. Analyzing all aspects of these protocols in comparison with the other international protocols indicates where the preferred protocols make specific gains on others. The result of the analysis of best elements chosen through pairwise comparison provide the ranked protocols with better performance with

respect to problem solving. As well, insight gained from the hierarchical structure and scoring of the protocols permit direct comparison of the different protocols and communities.

In summary, in this part (Phase1), all the international protocols introduced in Chapter 2 are assessed according to their treatment and experience of applying the scientific method of problem solving within the adaptation framework. Regarding the results obtained from the AHP analysis, ICLEI and UNDP are chosen as models of "best practices". These two protocols obtained the highest rank in all criteria as a result of years of experience in the field, and developing and implementing their framework in partnership with different groups of communities in developed and developing countries.

In the next step (Phase 2), the AHP hierarchy and the scientific method of problem solving steps will be applied among Canadian C-Change communities to find the best case practice and hereby develop the characteristics of a preferred framework for coastal communities.

4.4 Phase 2 - Application of scientific methods on C-Change communities

Phase 2 is part of ICURA C-Change project. The ICURA's main goal is to develop climate change adaptation capabilities among coastal communities in Canada and the Caribbean through connecting the communities with research groups in universities throughout Canada and the University of the West Indies network in the Caribbean (International Community-University Research Alliance (ICURA) 2007). Therefore, the related goal defined for this study is to develop a preferred adaptation framework for coastal communities to assist them in adapting to coastal climate changes and to apply the developed framework to compare the C-Change Canadian communities. Hence, the analysis of Phase 1 among the international adaptation protocols through applying the scientific method of problem solving and the AHP's hierarchy, these developed methods are now applied, in Phase 2, among the four Canadian C-Change communities.

The Canadian C-Change communities are analyzed below with respect to their social, economic, cultural, and environmental profiles. Then, the four communities are compared regarding their estimated ability to present the scientific method of problem solving through applying the AHP hierarchy as before.

4.4.1 Isle Madame, Nova Scotia

Figure 4-7: Aerial Photo of the Town of Isle Madame (Source: Google Map, 2012)

Isle Madame is located in the south-eastern part of Cape Breton Island in Nova Scotia, Canada. The island archipeligo consists of three main island communities: Isle Madame proper, Petit-de-Grat to the east, and Janvrin's Island to the west. Isle Madame is in fact part of Richmond County and is separated from mainland Cape Breton Island by a narrow channel named Lennox Passage to the north (International Community-University Research Alliance (ICURA) 2007) (Figure 4.7).

Storm surge and sea level rise are considered as the biggest coastal environmental issues facing Isle Madame. Since most of the infrastructure (roads, water treatment, wharves) are built close to shore, it makes the community more vulnerable to storm surge (from more frequent severe storms) and pending sea level rise (Pakdel 2011).

4.4.2 Gibsons, British Columbia

Figure 4-8: Aerial Photo of the Town of Gibsons (Source: Google Map, 2012)

The Town of Gibsons is a growing coastal community which is located in southwestern British Columbia on the Strait of Georgia. Gibsons is 64km north of Vancouver, in the area known as British Columbia's Sunshine Coast. The community is accessible by ferry through Vancouver and by air.

Average annual temperatures for Gibsons (and the Sunshine Coast area) are slightly higher than that of Vancouver (13 versus 12 degrees Celsius) and, Gibsons has on average more frost free days (334 versus 329 for Vancouver). Winters are relatively mild and lots of rain makes this area green and blooming year round (United Nations Development Programme 2012).

In 2009, Gibsons earned an international recognition when it was named the "Most Liveable Community under 20,000" in a world-wide competition by the UN-backed International Awards for Liveable Communities. In 2005, Gibson's was recognized with the Berkley Springs International Water Tasting Award as the Gold Medal Winner (United Nations Development Programme 2012).

The Town of Gibsons addresses climate issues by developing the community energy and emission plan to reduce the energy usage in the community and GHG emissions as well. The community targets to reduce the energy consumption and GHG emission until 2031. Gibsons designed the following action to achieve their reduction goals (Epp 2010):

- *"Support Energy Efficient Land Use Practices*
- *Reduce Dependence on Single Occupant Vehicles*
- *Enhance the Green Building Sector*
- *Expand Local Renewable Energy Opportunities*
- *Reduce and Reuse Solid Waste as a Resource*
- *Strengthen the Local Economy*
- *Manage Brownfield Sites*
- *Foster a Culture of Conservation in the Community"*

This plan is designed to be updated during the implementation phase since reporting and monitoring are done continually (Epp 2010).

4.4.3 Iqaluit, Nunavut

Figure 4-9: Aerial Photo of the Town of Iqaluit (Source: Google Map, 2012)

Iqaluit is Canada's most northern capital of the territory of Nunavut, which is located on the head of Frobisher Bay overlooking Koojesse Inlet on the southeastern coast of Baffin Island. Iqaluit, once known as the community of Frobisher Bay, is the largest community in Nunavut with a population of more than 7,250 (2010 estimate). The temperature in Iqaluit in January averages -30°C, and in July it is about 15°C. There are nearly 24 hours of daylight per day in June whereas in December there are only 6 hours of daylight per day. The long cold winter begins in September and the ground is usually snow-covered until June. The summer months are July and August (United Nations Development Programme 2012).

Iqaluit's key environmental factors include permafrost and ground ice, but also surface hydrology, sea ice, drifting snow, storms and flooding hazards. The macro tidal setting creates spectacular tidal flats and challenges for shipping. Climate change in this area is

imposing changes on a number of species, including seals, which are among the most important country food besides fish (United Nations Development Programme 2012).

Global warming is the biggest climate issue in recent years (Nielsen 2007) mostly affecting extreme changes in weather. Iqaluit has recently experienced different climate change impacts including: extreme weather changes (increase in temperature and wind speed and quantity of rain) , changes in precipitation (quantity of rain and snow in the different months) , and coastal environmental change like sea level rise and ice melting. Since infrastructure in the Arctic area is built based on past climate conditions, extreme changes in climate such as heavier snow or rain fall may cause serious damage to all infrastructures in the community. Furthermore, global warming contributes to sea level rise, coastal flooding, storm surge as well as land falling, i.e., subsidence. Buildings, roads, and other infrastructure in this area are becoming more vulnerable and there is a need to develop a new plan to help the community adapt to the changing climate conditions (Nielsen 2007).

4.4.4 Charlottetown, Prince Edward Island

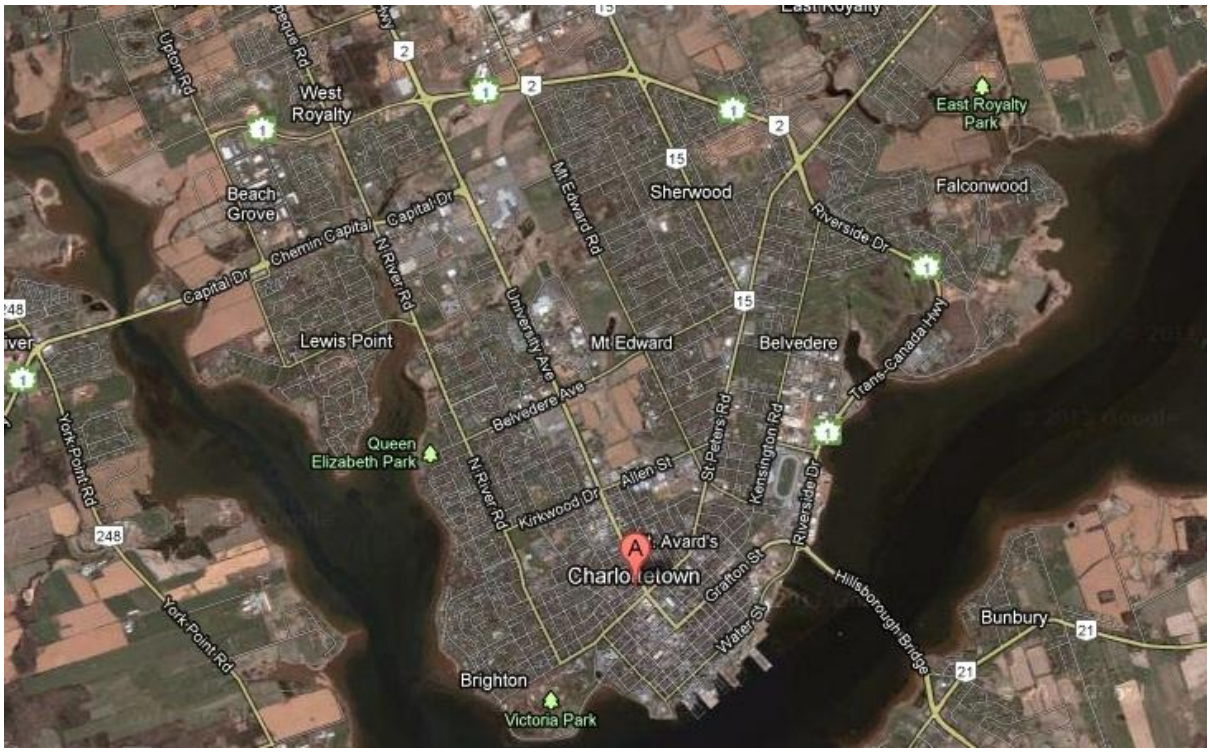


Figure 4-10: Aerial Photo of the Town of Charlottetown (Source: Google Map, 2012)

Charlottetown is the capital of the Canadian Province of Prince Edward Island and is located on the south shore of Prince Edward Island, just off the eastern shore of Canada in the Gulf of the St. Lawrence. The city is situated on Charlottetown Harbor, which is formed by the confluence of three rivers and which opens into the Northumberland Strait. The City of Charlottetown has an impressive inventory of parks and green spaces (approximately 400 acres), which provides a range of passive and active experiences, including the award winning Confederation Landing Park, and a beautifully landscaped waterfront park. Charlottetown has an extensive and distinct architectural heritage including individual heritage buildings as well as a heritage area located in its downtown (International Community-University Research Alliance (ICURA) 2007).

As mentioned in Natural Resource Canada's report in 2009, Charlottetown has had problems with storm surge and land falling (subsidence). Hartt (2010), storm surge affects

shoreline infrastructures including: the harbor, buildings and roads in Charlottetown. The local storm of January 2000 cost almost $20 million to local government to repair the damages.

4.4.5 Community result analysis

After the brief background explanation above about C-Change communities their climate change related vulnerabilities and needs, the same procedure as applied in Phase 1(Evaluation of international protocols), is applied here to rank the communities. Each C-Change community is assessed and scored for the AHP problem formulation, and the resultant score sets analyzed together to rank the adaptation frameworks of the four communities.

The criteria developed in AHP hierarchy of Phase 1 for the scientific method of problem solving is applied among the communities, and the communities' scores compared.

Similar to the procedure of Phase 1, the AHP hierarchy criteria and subcriteria were prioritized using the same weights as in Phase 1 (Figure 4.1).

Ideal mode	INCR	INCR	INCR
Alternative	**Problem Identification Constraining factors (Budget-resource) (L: .283)**	**Criterion Data Availability (L: .046)**	**Criterion Data Measurability (L: .042)**
☑ Isle Madame	3	6	6
☑ Gibsons	6	7	7
☑ Iqaluit	4	5	5
☑ Charlottetown	5	8	8

Table 4.9: Communities Data Grid score. Source: (Expert Choice 2004)

The scores for the four communities are provided for the hierarchy subcriteria measures as in Phase 1. For instance, the score given for the Problem Identification criterion, sub criteria: Constraining factors (Budget-resource) are shown in Table 4.9. Gibsons and Charlottetown have higher scores (6 and 5 respectively) than Iqaluit and Isle Madame (4 and 3 respectively). These scores are assigned because Gibsons is a relatively rich community and has resources and infrastructures to develop the framework in the community. On the other hand, Charlottetown is one of the more developed communities in an urban setting, with local action plans in place and so a considerable community database and forecast analyses about future climate impacts. Therefore, these two communities are justified in receiving higher scores than the other two communities regarding Constraining factors, Budget-resource. The Criterion data availability subcriterion comparison between communities shows a different result. Even though again Gibsons and Charlottetown have a higher score compare than the other two communities, the score given to all communities are almost same (Gibsons = 7, Charlottetown = 7, Isle Madame = 6, and Iqaluit= 5). The reason for these scores is because communities' climate historical information and the necessary infrastructure for developing the framework are available .The difference in scores indicates how each community has more potential in the new framework implementation regarding data availability.

Another example is Criterion data measurability, the second subcriterion under Criterion Data. Analyzing the score received by communities under this subcriterion in Table 4.9 shows all protocols received similar scores in this case, and the lowest score is 5 for Iqaluit. The logic behind these results is because these entire communities keep updated climate related data and information, and the data available in these communities could be used as a initial step of data gathering in problem identification. The difference between scores comes from the quality of the data available, and the infrastructure each community currently has. Therefore, as in the previous example, Gibsons and Charlottetown receive slightly higher scores in comparison to the other two communities.

The score given to all criteria (Data Grid Scores) for the Canadian C-Change communities' analysis are presented in Appendix E - "Communities Data Grids".

After scoring each criterion for each community, the application of the AHP to these data, including the weighted hierarchy enabled a ranking of the communities in terms of their

adaptive framework status to date. The results of the cooperative ranking of the four communities are provided in Figure 4.11 below.

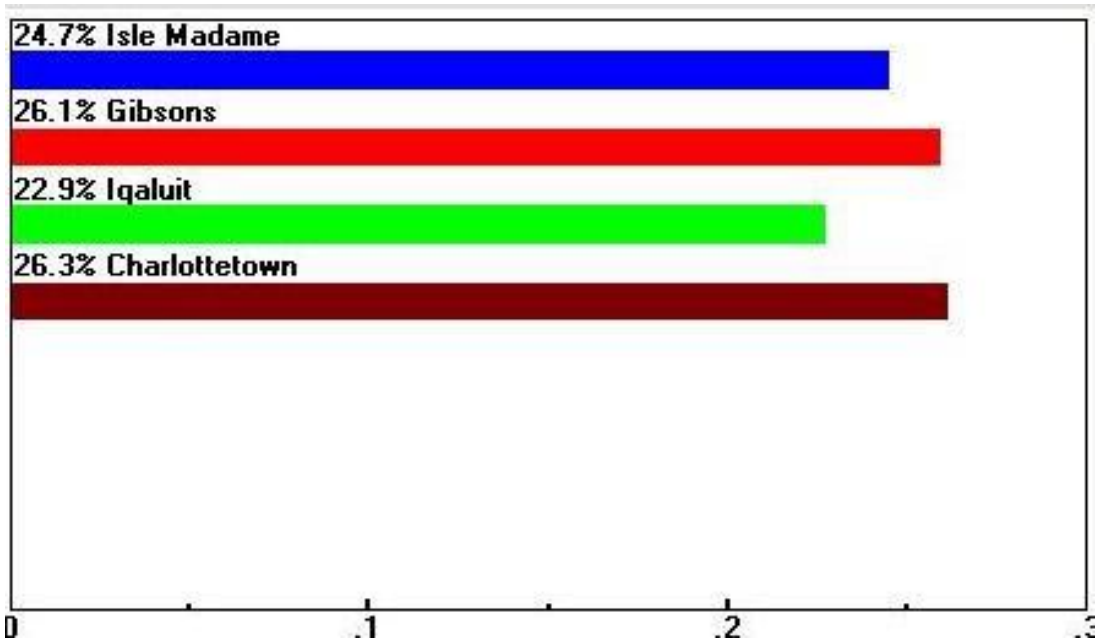


Figure 4-11: Alternative Community comparison. Source: (Expert Choice 2004)

The overall scores for each community (in Figure 4.11) are calculated through summation of scores given to scientific method elements (Figure 4.1) (Problem identification, Criterion data, Modeling, Testing, Monitoring, and Implementation) for that particular community. Regarding the result shown in Figure 4.11, all communities scored similarly. The scores for Gibsons (26.1%) and Charlottetown (26.3%) are higher than the other two communities due to their extent of activity. These two communities are active in developing local action plans, have established historic databases about past climate impacts and employ expert dedicated staff on the issue of local coastal adaptation.

The next step presents the Sensitivity analysis to show the robustness of the Figure 4.12 results. As shown in Figure 4.12, in most of the first criteria comparison between Isle Madame and Charlottetown, Charlottetown scored higher than Isle Madame. In some criterion like Criterion data and Modeling this dominance is much more obvious than in other

criteria. Even though in some cases like Testing and Implementation, Isle Madame was assigned a higher score but the overall comparison in the bottom of the figure we can conclude Charlottetown is dominant in comparison to Isle Madame. Therefore we expect it to be a more appropriate overall community for the application of the adaptation framework to the C-Change coastal communities. See also Appendix F - Communities AHP output-Sensitivity Analysis.

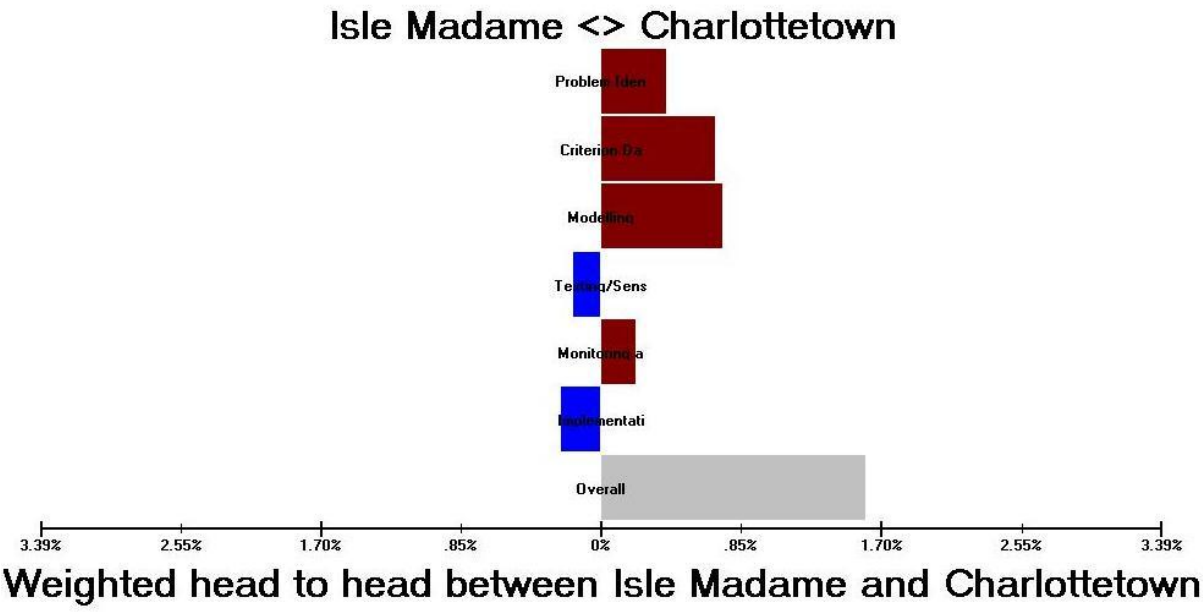


Figure 4-12: Weighted head to head Communities comparison. Source: (Expert Choice 2004)

In the final step of discussion about C-Change communities, the analysis of all protocols and the first level criteria is presented in Figure 4.13. In this figure, all fluctuations are shown regarding to the scores given to each criterion with the related communities.

As shown in the figures below Charlottetown and Gibsons are dominant communities in most criteria except in the Testing and Implementation criterion. In the Testing criterion Isle Madame is assigned a higher rank in comparison to Charlottetown, and in the Implementation criterion Isle Madame and Iqaluit are assigned higher rank than the other two communities. Since Charlottetown and Gibsons are still in their initial step of applying process

implementation. Overall for all criteria, Charlottetown and Gibsons kept their dominance and are assigned higher scores compared to other two communities.

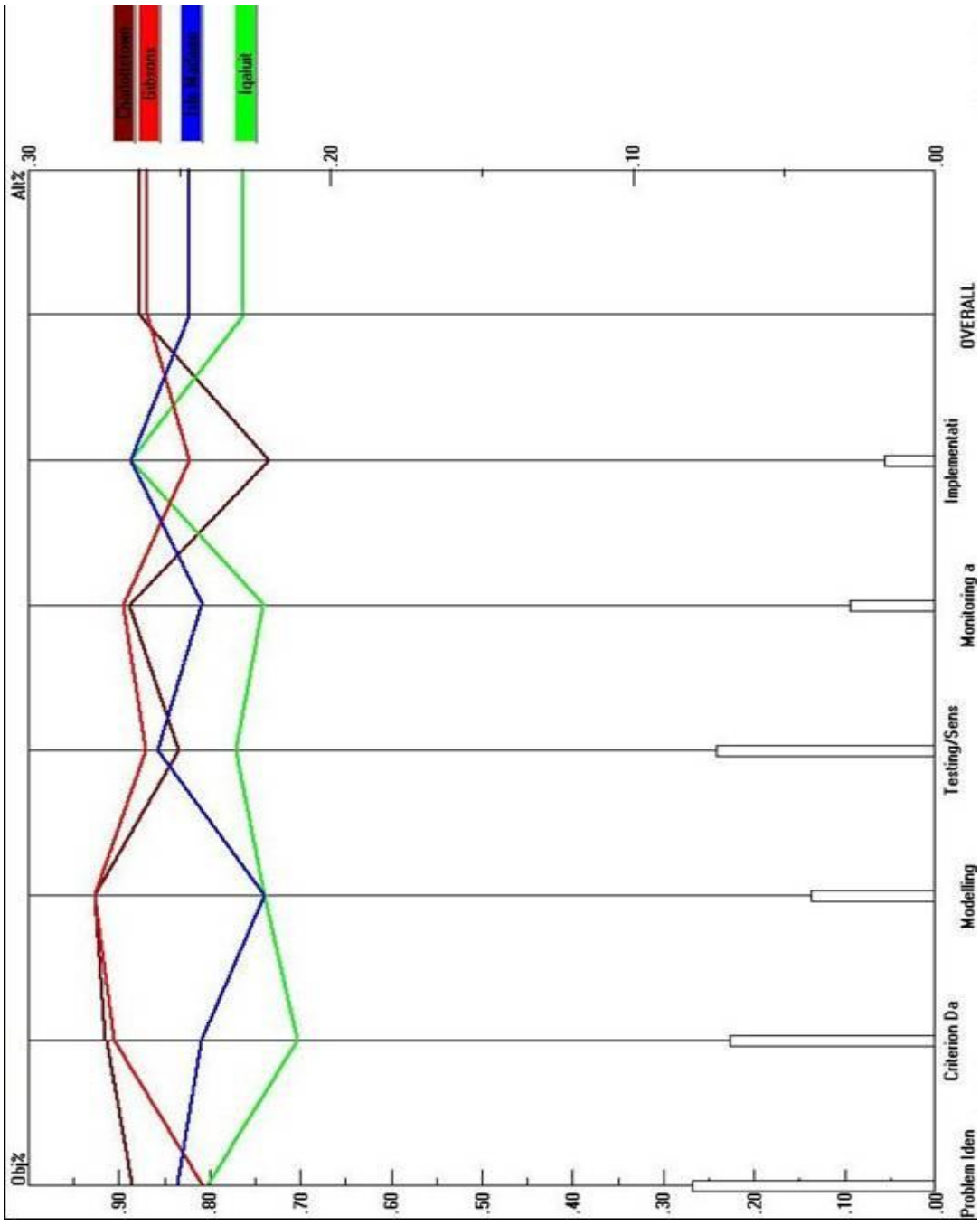


Figure 4-13: Communities detailed comparison. Source: (Expert Choice 2004)

Moreover as shown in Figure 4.13, all communities are very close but Charlottetown and Gibsons are more stable in comparison to the other two communities, therefore these two communities have higher overall scores.

4.5 Gap analysis of the ranked C-Change Canada communities

This section includes:

- Lessons applied from the best practices of the International protocols for managing adaptation resulting from the sensitivity analysis of the AHP model (Phase 2 results)
- Comparison of communities with respect to their overall ranking and statement of why some are better than others and the gaps that communities need to address to "improve", e.g., more data, etc.

In this part (Phase 2) all the C-Change Canadian communities are assessed and the Scientific methods of problem solving steps are applied in the AHP Expert Choice software (Expert Choice 2004). Regarding the results obtained from AHP and analysis done among these data, Charlottetown and Gibsons are chosen as the communities that are currently best prepared for the application of their adaptation frameworks. These two communities attain the highest rank in most criteria (as discussed in section 4.4.5), as a result of years of experience in the developing local action plans, and their source and preparedness.

Regarding Community data (Figure 4.13), Isle Madame should be expected to improve its Criterion Data, Modeling, and Monitoring criteria. Consequently, this community needs to prepare background information about the community's historical climate and threats and vulnerabilities, and develop a concise monitoring plan to track the current climate changes in the community. For this purpose, the community needs to develop an organizational chart of responsibilities to determine all involved organizations in the adaptation process. Isle Madame also has to develop its Model and framework specifically.

Iqaluit as other community analyzed in this study faces serious issues in comparison with Isle Madame. As shown in Figure 4.14, the community of Iqaluit needs to improve in all aspects relative to the scores for Isle Madame. For example, more resources (technical and financial) need to be provided for the community, which should have the authority to train and develop the community's background climate database.

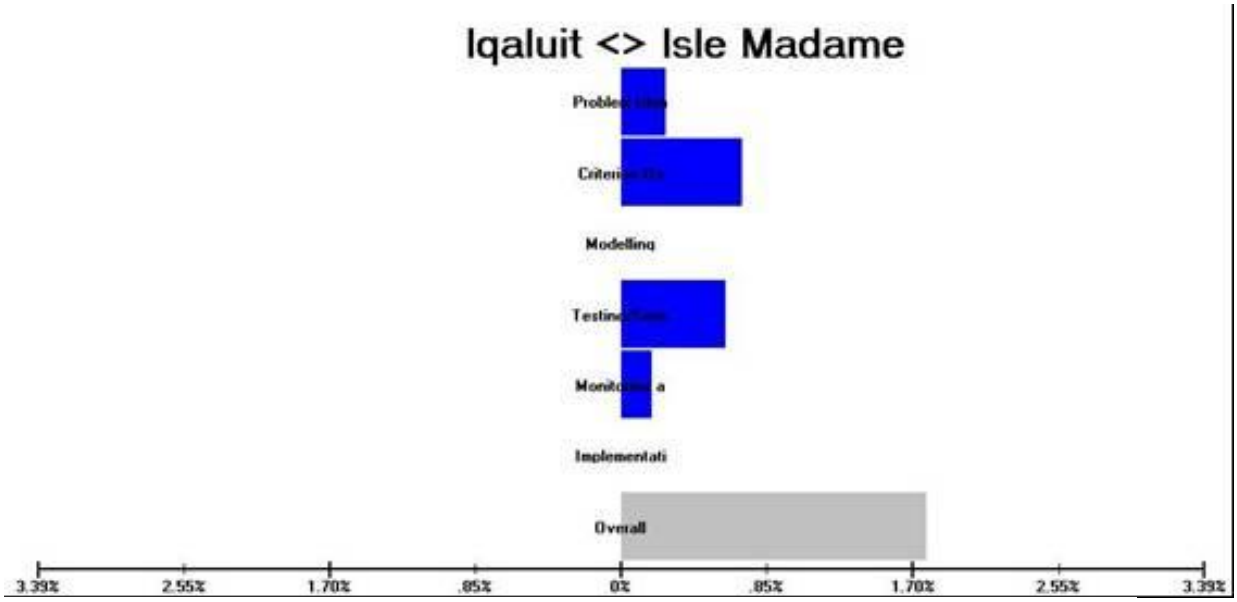


Figure 4-14: Weighted head to head comparison between Isle Madame and Iqaluit

In the next Chapter (Phase 3), the Community Action Plan and guideline is developed through the analyses and results of Phase 1 and Phase 2.

5 Community Action plan and Adaptation Guideline

This chapter presents the Community Action Plan and Adaptation Guidelines for applying the adaptation framework. The Action Plan is developed from lessons learned to date from applied community adaptation planning, e.g., in the international protocols and community cases, and from the recorded experience (e.g., Chapter 2, Section 2.4), and the best practices and gap analysis discussed in Chapter 4 above. The Community Action Plan and Adaptation Guidelines presented here are intended to inform the C-Change project communities in Canada and the Caribbean.

Developing adaptation guidelines at the community level requires consideration of particular characteristics. These characteristics are:

- **Background information and Community Profile** – the collection of community context information regarding the community's climate history, impacts, and vulnerabilities and threats including demographic factors as well as other important social, cultural characteristics.

- **Community Priorities** - evaluation regarding the community's specific social, geographical, economical, and cultural preferences.

- **Simplicity and Engagement** – Community Action Plans and Adaptation Guidelines are to be simple and understandable and apply to community leadership and governance, as well as to community family and individual units equally, and in so doing, are required to engage all members of the community from seniors to youth, to professionals and volunteers.

- **Delivery Format** – Community Action Plans and Adaptation Guidelines are expected to be delivered to community members in multiple formats that include preparing a checklist, so that the community is prepared for an emergency event. The initial step in checklist preparation will apply the general community profile background information and incorporate the community's priority information. Community Adaptation Guideline preparation starts by planning within families, and educates and

informs family members. This will be delivered as an “emergency kit” for use by each family in the community. As well, the Community Action Plan and Adaptation Guidelines develop procedures in the event of emergencies that trigger action by community leaders in response. The roles and responsibilities of the Action Plan are laid out.

- **Integrating the Action Plan in Community Activities** - Community Action Plans and Adaptation Guidelines requires rising awareness in the community and establishing and enhancing the partnership among the in-charge organizations and community leaders.
- **Event Simulation and Monitoring** - Community Action Plan and Adaptation Guidelines include a regular period of repeat simulation, training, and monitoring of emergency events representing a “mock-up” of potential events that require implementation of the Action Plan and involve all representative community groups. The result of event simulation is a revision in the roles and responsibilities of community members and lessons learned from the exercise.

The following sections incorporate the above criteria in the development of a Community Action Plan and Adaptation Guidelines and include:

5.1. General Guideline and action plan

5.2. Assignment of Responsibilities

5.3. Family Emergency Plan, and

5.4. Conceptual Action Plan website output

5.1 General Guideline and Action Plan Frameworks

According to ICLEI's definition, Action Plans are defined by a series of activities in the community to reduce the climate change's future effect and increase the sustainability and preparedness in the community with the targeted goals such as: improving public health and community liveability (Peterson 2011). This guideline is action items discussed since protocols presented in chapter 2. Presenting the Guideline in this stage shows the application of the action and applying the problem solving method in the community.

Following on the ICLEI definition and the characteristics noted above, Community Action Plan and Adaptation Guidelines can be broken down into five steps as follows: (New Brunswick Emergency Measures Organization 2001)

Step 1. Categorizing vulnerable populations and places

One of the major tasks in developing a guideline for the communities is categorizing the vulnerable populations and places in each community and designing the future action plan to assist them in the shortest time possible.

Step 2. Set community priorities

This is Core guideline applicable for all communities. The development of a guideline requires setting the priorities in the communities through identifying the main vulnerabilities and risks.(New Brunswick Emergency Measures Organization 2001)

Step 3. Assign responsibilities

In third step we can develop responsibility plans to manage and highlight the persons responsible and the description of the roles for each person and organization in the community.

Step 4. Communicate the plan

The community could be educated about the specified vulnerabilities and the plan's detail by local media: TV, Newspapers, as well as getting information to families through schools and developing workshops for students and educating them about local environment issues.

Step 5. Monitor the plan

Responsible organizations have to monitor the action plans in order to make needed updates to the community's climate and society changes.

In the development of the Community Action Plans and Adaptation Guidelines for Canadian communities, three levels of government are considered: (i) local (regional and municipal), (ii) provincial, and (iii) federal levels, but since in the following step the plan discussed in community level in following chart shows in Figure 5.1 the plan start from the local government level (New Brunswick Emergency Measures Organization 2001). Figure 5.1 shows the responsible organizations hierarchical chart as well as household emergency activities (72 Hours).

With respect to the local government, the list of organizations responsible for first action and response are as follows (New Brunswick Emergency Measures Organization 2001):

- Fire department
- Police department
- Ambulance and hospitals
- Red Cross Canada
- Municipality coordinators

Initial actions that take place in any community during a hazard, e.g., severe storm, are as follows (New Brunswick Emergency Measures Organization 2001):

i) Analyse the community's situation in the face of the hazard, e.g., storm surge, sea level rise, hurricane, flood, and coastal storm;

ii) Respond via the local action plans;

iii) Implement responsibility chart at high, medium, and low levels to involve all community members in implementing the adaptation and hazard response strategies; and

iv) Recognize the more vulnerable parts of society and prioritize first response action accordingly.

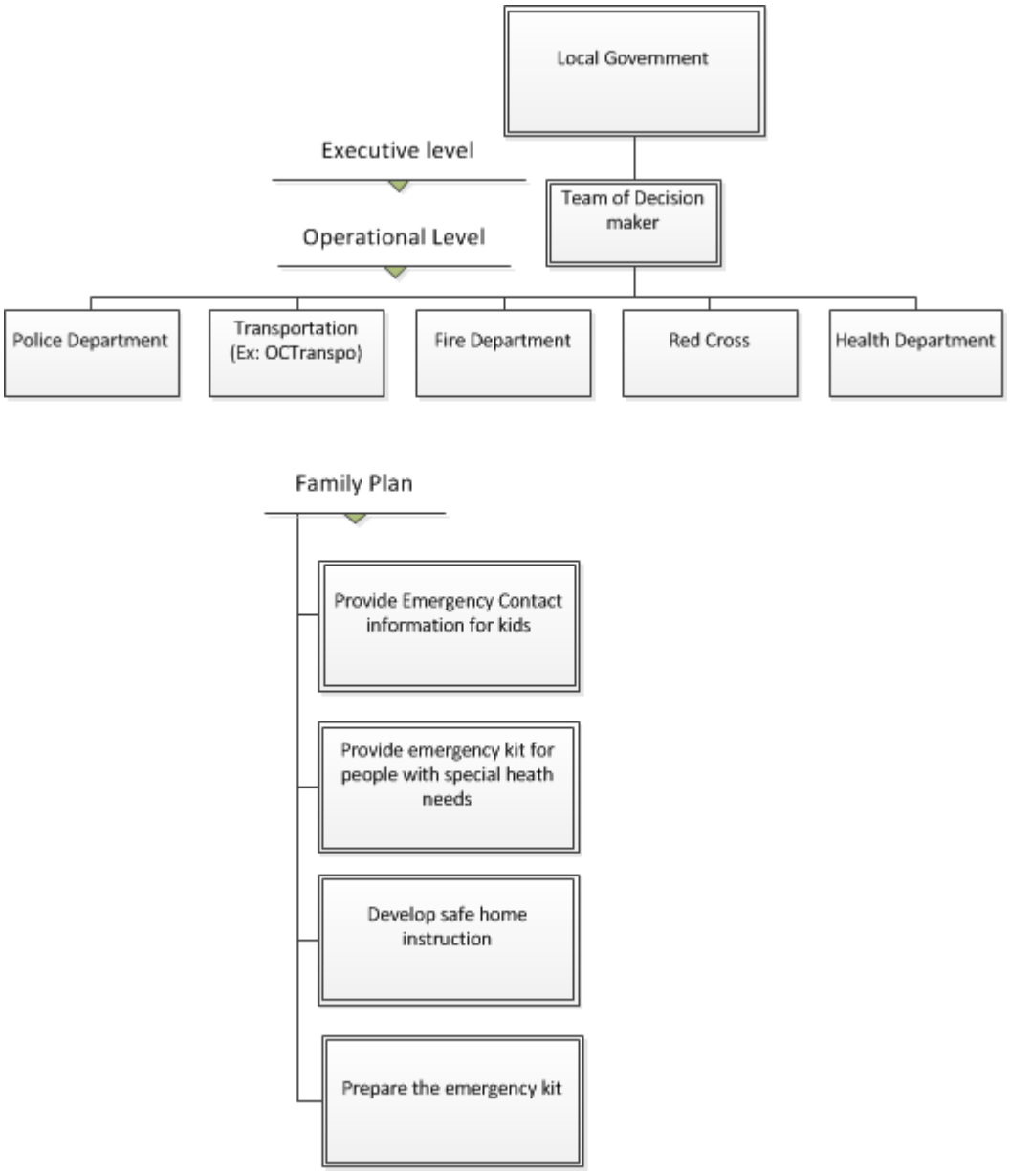


Figure 5-1: Action plan Organization chart Source: (New Brunswick Emergency Measures Organization 2001) (Public Safety and Emergency Prepardness Canada 2011)

The following section discusses each organization's duties in the plan and defines the roles and responsibilities for all authorities mentioned in Figure 5.1.

5.2 Assignment of Responsibilities

In this step the responsibility checklist is developed to show every organization's duties when the climate hazard occurs in a community. The Town of Mattawa's Emergency Plan is used as a reference source of the assignment of that organization's responsibility description, as noted in Table 5.1 (Corporation of the Town of Mattawa 2008). These responsibilities help to implement the developed model in Section 5.1, through defining each particular leader's role in the implementation stage. Through these specified assigned responsibilities, community decision makers are provided instruction to manage the organization during an emergency, and this leads to a more effective and more efficient operation flow and a more successful operation overall. These assigned responsibilities help to avoid confusion among the operational teams and they help to maximize the productivity of all operational components.

The guidelines developed in this section show the application of action items for a community and their leaders in the event of an emergency event in the community. Evidence from community emergency planning exercises are applied to the specific cases of the coastal communities.

Table 5.1 states the community's Mayor's responsibilities as Lead of the local, municipal government.

No.	Action	Group	Lead
1	Declare an emergency to exist.	Municipal Control Group	Mayor
2	Declare the emergency terminated	Municipal Control Group	Mayor
3	Request senior Government assistance	Municipal Control Group	Mayor
4	Inform other members of Council of incident status from time to time	Municipal Control Group	Mayor
5	Consult with the Administrator/ Clerk/ Treasurer on press releases	Municipal Control Group	Mayor
6	Head of Council, and Chair the meetings of the Municipal Control Group	Municipal Control Group	Mayor

Table 5.1: Mayor's responsibilities (Source: Corporation of the Town of Mattawa 2008)

The Table 5.2 outlines the Municipal Control Groups responsibilities during the climate hazards:

No.	Action	Group	Lead
1	Declaring an emergency to exist	Municipal Decision group	Mayor
2	Designating emergency areas	Municipal Decision group	Mayor
3	Authorizing expenditures of funds for implementing the emergency plan	Municipal Decision group	Mayor
4	Evacuating buildings or selections within an emergency area	Municipal Decision group	Mayor
5	Discontinuing utilities or services provided by public or private concerns without advising any consumers in the municipality if necessary	Municipal Decision group	Mayor
6	Arranging for accommodation and welfare on a temporary basis of any residents who are in need of assistance due to displacement as a result of the emergency	Municipal Decision group	Mayor
7	Calling in and employment of any municipal personnel and equipment which is required in the emergency	Municipal Decision group	Mayor
8	Arranging assistance from other agencies (Volunteers) as may be required by the emergency	Municipal Decision group	Mayor

9	Establishing a reporting and inquiry centre to handle individual requests for information concerning any aspect of the emergency	Municipal Decision group	Mayor

Table 5.2: Responsibilities of the Municipal Control Group (Source: Corporation of the Town of Mattawa 2008)

The Police force counts as one of the important organizations in the community for controlling public safety, and helping as part of rescue team. Therefore, the following responsibilities are defined for the police force in general.

No.	**Action**	**Group**	**Lead**
1	Provide information and advice on law enforcement matters	Police Force	Head of Police department
2	Control operations at the scene of an emergency (If necessary)	Police Force	Head of Police department
3	Seal off the area of concern	Police Force	Head of Police department
4	Control, and disperse crowds within the emergency area	Police Force	Head of Police department
5	Control the movement of emergency vehicles to and from the site of the emergency	Police Force	Head of Police department
6	Coordinate police operations with other municipal departments and arrange for additional supplies and equipment when needed	Police Force	Head of Police department
7	Conduct evacuation of buildings or areas	Police Force	Head of Police department

	when ordered by Head of Council		
8	Arrange for maintenance or law and order in temporary facilities	Police Force	Head of Police department
9	Protect property in the emergency area	Police Force	Head of Police department
10	Arrange for additional police assistance, if required	Police Force	Head of Police department

Table 5.3: Police force's responsibilities (Corporation of the Town of Mattawa 2008)

Since the fire department works as a rescue team in the community, they are prepared for emergencies as part of their general duties. The Fire Department is one of the important assets to control the situation during an emergency in the community. Therefore the general duties named for the Fire Department are as follows (Table 5.4).

No.	Action	Group	Lead
1	Provide Head of Council with information and advice on firefighting matters	Fire department	Head of Fire department
2	Develop and maintain a system for alternating MCG members in an emergency	Fire department	Head of Fire department
3	Control operations at the scene of an emergency (If necessary)	Fire department	Head of Fire department
4	Inform the Mutual Aid fire coordinator and trigger mutual aid arrangements for the provision of additional firefighting manpower and equipment (If needed)	Fire department	Head of Fire department

5	Determine if additional or special equipment is needed and recommend possible sources of supply	Fire department	Head of Fire department
6	Provide assistance to other municipal departments and agencies and be prepared to take charge or contribute to non- firefighting operations (If necessary)	Fire department	Head of Fire department
7	Assist the Police Department in conducting any required evacuations	Fire department	Head of Fire department

Table 5.4: Fire department's responsibilities (Corporation of the Town of Mattawa 2008)

Another important first response team during emergencies is Ambulance and health services. Since the possibility of negative human impacts during natural hazards increases, having a prepared health unit will help to handle such problems. The responsibilities mentioned below are classified for the community health team.

No.	Action	Group	Lead
1	Establish facilities at the incident site for on-scene triage and communications with local hospitals	Health department	Head of Health Department
2	Coordinate the response of all Emergencies Medical and Hospital services and facilities	Health department	Head of Health Department
3	Arrange for mass ambulance	Health department	Head of Health

	transportation where required		Department
4	Arrange for a balance distribution of casualties to hospitals.	Health department	Head of Health Department
5	Arrange for relocation of patients to other hospitals outside of the municipality (If necessary)	Health department	Head of Health Department
6	Coordinate and develop individual Hospital Contingency Plans	Health department	Head of Health Department

Table 5.5: Ambulance and health services responsibilities (Corporation of the Town of Mattawa 2008)

Last but not least here in Table 5.6 community service team's duties are as follow:

No.	Action	Group	Lead
1	Provide social services assistance to any person in need of food, accommodation, clothing, financial and personal counselling due to the emergency situation	Health department	Head of Health Department
2	Arrange for the opening, operation, direction and supervision of sufficient Emergency Welfare Centres required providing the immediate emergency social services needed	Health department	Head of Health Department
3	Arrange for and coordinate assistance from the volunteer agencies within the community to carry out the social services functions (e.g. Red Cross, Salvation Army, Church Groups, and	Health department	Head of Health Department

	Local Business & Industry)		
4	Arrange for the establishment of registration and inquiry centre or centres as required with the assistance of the local Red Cross	Health department	Head of Health Department
5	Advise the Emergency Operations Control Group if Senior Government assistance is required for emergency social services	Health department	Head of Health Department
6	Establish and maintain an internal Contingency plan for the provision of emergency social services	Health department	Head of Health Department

Table 5.6: Community services responsibilities (Corporation of the Town of Mattawa 2008)

5.3 Family Emergency Plan

After the local organization's responsibilities are defined, the next step applies to household responsibilities in the community. This step provides clear milestones for families to help them to recover faster during natural hazards. In this part, family plans take the form of 72 hours family preparation plans. Such plans have developed in the "Public Safety and Emergency Preparedness Canada" program which is used as a reference. The main objective of this plan is to require family units to be prepared to live autonomously without power, heat, and water for 72 hours after a hazard has happened in the community. This time is estimated to allow rescue teams time to come to the family with help (Public Safety and Emergency Prepardness Canada 2011).

Canada's Public safety and emergency preparedness plan for families has the following steps in time of emergency as shown in the Table 5.8 below (Public Safety and Emergency Prepardness Canada 2011).

Step	Action Description
1	Identify the escape routes
2	Establish meeting places
3	Plan for children
4	Address special health needs
5	Make plans for pets
6	Make a plan for specific risks
7	Record emergency contact information

Table 5.7: 72 hour plan for families, Source: (Public Safety and Emergency Prepardness Canada 2011)

The first step in the plan as shown in the Table 5.7 is “Identifying the escape routes”. In this part emergency exits from each room of the home, and escape routes from the neighbourhood in case of evacuation order are determined and communicated to all family members.

In the next step, meeting places (or “muster points”) are established for the family to meet up at a designated safe place. Note that meeting places should be designated on the same side of the street as the home, so as to avoid crossing the street into traffic or in front of emergency vehicles (Public Safety and Emergency Prepardness Canada 2011).

In the third step, specific plans for children are determined in case of an emergency during school hours when designated persons are responsible for picking up children from daycare or school. Parents need to make sure that the school or daycare has updated contact information for parents and caregivers (Public Safety and Emergency Prepardness Canada 2011).

The fourth step addresses special health needs and means that a support network of friends, relatives, health-care providers, co-workers and neighbours needs to be established who understand the special needs. At the same time, details about medical conditions, allergies, surgeries, family medical history, medications, health screenings, recent vaccinations, emergency contacts and insurance information must be specified with respect to all household members' special needs (Public Safety and Emergency Prepardness Canada 2011).

After family planning, the fifth step is to have a plan for family pets. The most important thing to protect pets is to take them with the family if there is need to evacuate. This requires advance planning as pets are not allowed in some public shelters or hotels.

In the sixth step, a plan is made for the specific risks of the local region. These should be written down instructions for the risks that are most likely to occur in your region.

In the seventh and final step, families need to record all emergency contact information. Remember that families maybe separated in the event of a hazard. The family Plan therefore includes how to meet or contact one another. This includes a discussion among family members about what to do in different situations (like: fire, storm, and earthquake)and the recording of the local and out-of-town emergency contact numbers (Public Safety and Emergency Prepardness Canada 2011).

Finally, family members should all be aware of the locations of fire extinguishers, water valves, electrical panels, gas valves and floor drains (Public Safety and Emergency Prepardness Canada 2011).

During and after their implementation, plans must be continually monitored and data and equipment regularly updated for improvement purposes in the future. The monitoring phase plays an important role in future implementation because changes in communities', families' and individuals' needs always occur and can be updated and ready to use for each new situation.

One of the main community education and communication awareness sources will be the schools. Schools play a very important role in educating future generations through providing new information, developing workshops and courses related to the community's environmental and climate issues as well as its dynamic vulnerabilities. Therefore, students will one day be more responsible citizens and, in turn, they can teach and communicate their new knowledge to their families.

Through these steps, families are encouraged to prepare their own emergency kits. This kit may be different for each specific family, according to their needs. But, in general, all emergency kits consist of some basic and essential items (Public Safety and Emergency Prepardness Canada 2011). These items include:

- Water – two litres of water per person per day (include small bottles that can be carried easily in case of an evacuation order)
- Food – that won't spoil, such as canned food, energy bars and dried foods (remember to replace the food and water once a year)
- Manual can opener
- Flashlight and batteries
- Battery–powered or wind–up radio (and extra batteries)
- First aid kit
- Special needs items – prescription medications, infant formula or equipment for people with disabilities.
- Extra keys – for your car and house

- Cash – include smaller bills, such as $10 bills (traveller's cheques are also useful) and change for payphones
- Emergency plan – include a copy of it and ensure it contains in–town and out–of–town contact information (Public Safety and Emergency Prepardness Canada 2011).

5.4 Conceptual Action plan website output

In this section, as part of the output of this study, a conceptual model of the Action Plan is presented in the form of an online database and source of reference. This online database is designed to assist federal decision makers to develop this database resource as a product for local governments to apply toward the formation of Community Action Plans and Adaptation Guidelines.

Through this database, local governments develop local action plans specific to their needs and vulnerabilities. Database inputs are the issues of communities (Steps 1 and 2), the list of responsible organizations along with their roles (Step 3), and International protocols' selected criteria and milestones. Therefore, as shown in Figure 5.2, all the information determined through the steps discussed earlier is provided as input for this database. The interface is illustrated in Figure 5.2 below.

Initially, as a local community member, the user chooses the relevant region in the Canada map. Thus, regarding the chosen region related data will be called in the database.

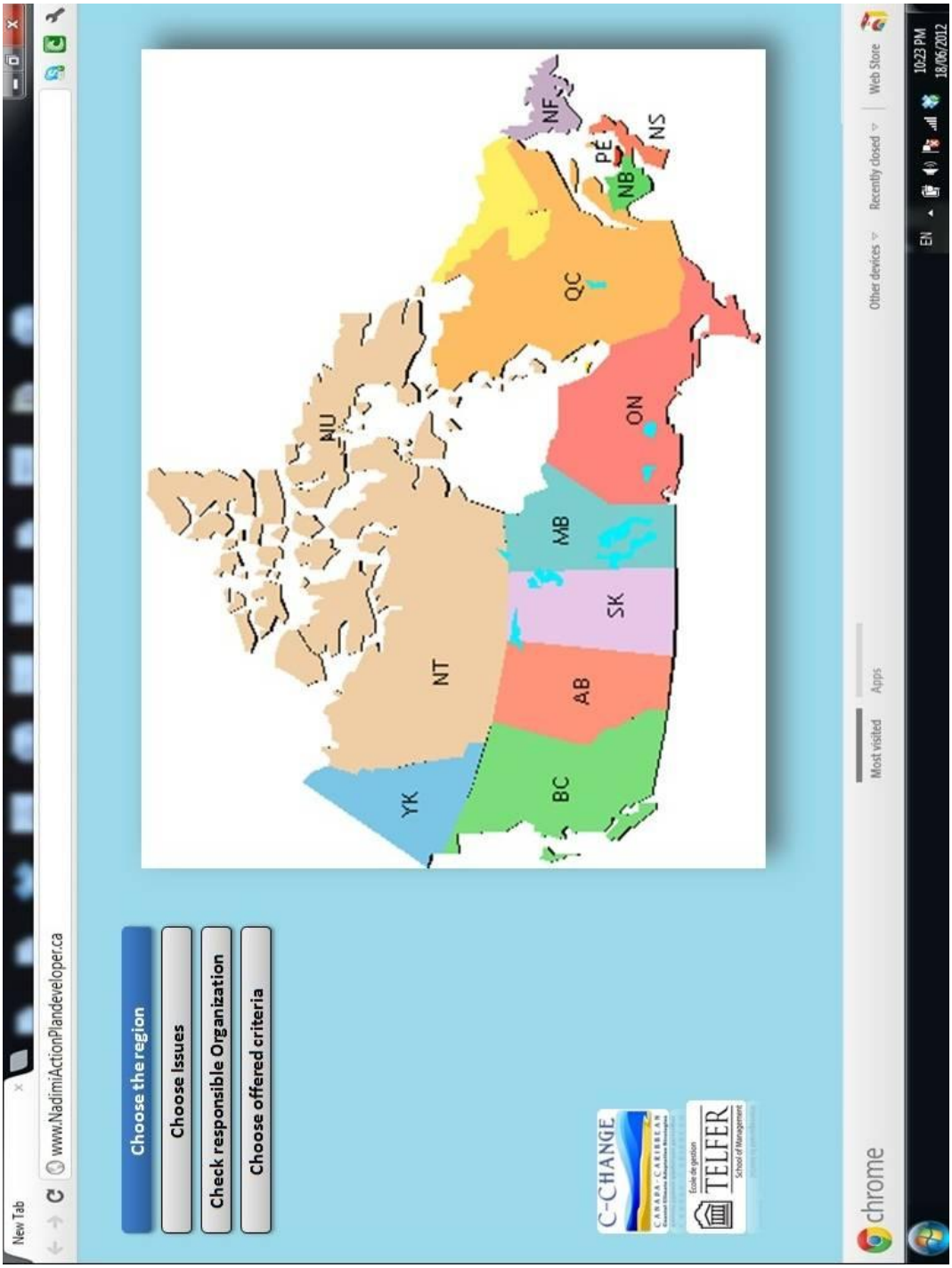


Figure 5-2: Database homepage

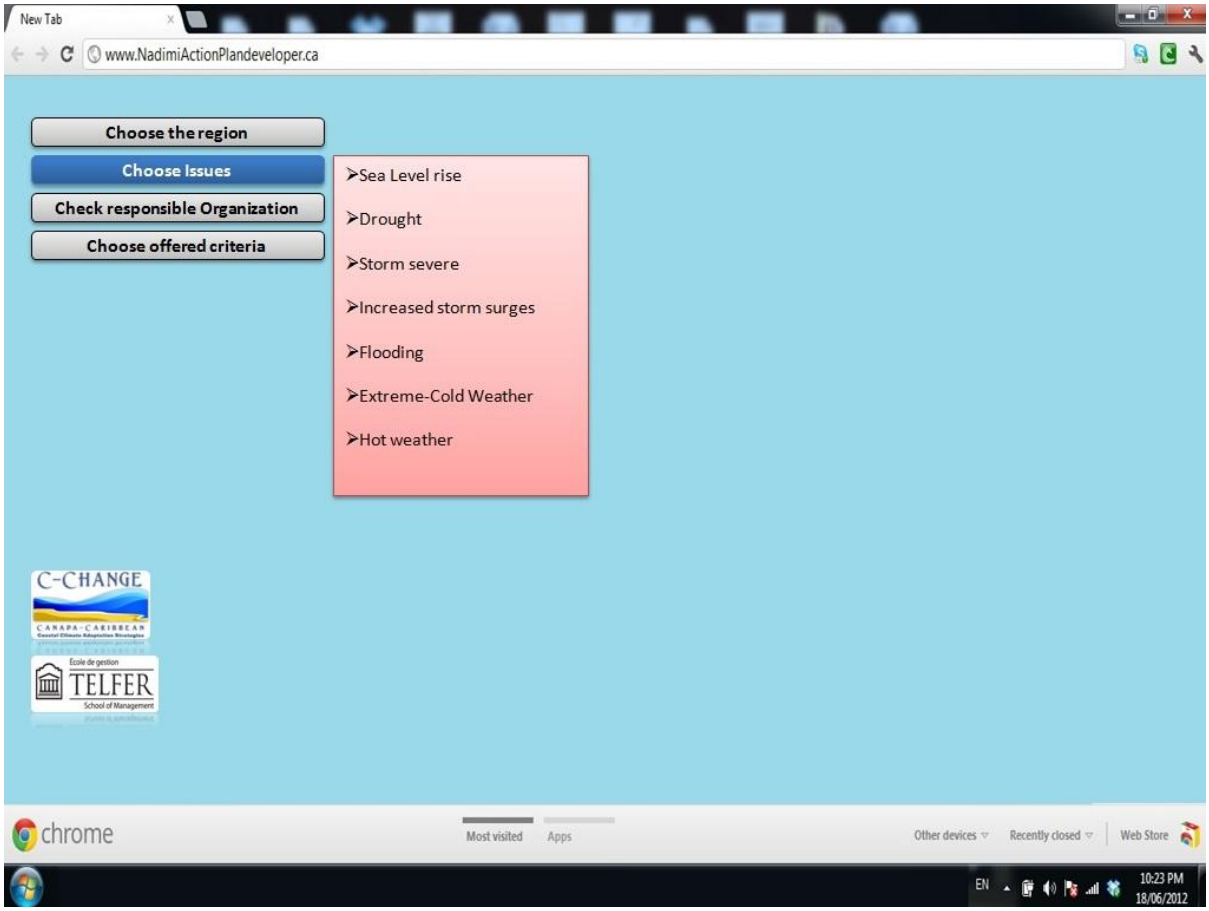


Figure 5-3: Database homepage- Issues

In the next step (and screen), as shown in Figure 5.3, issues are chosen that reflect the communities concerns and vulnerabilities. (Alternative lists of issues appear depending the region selected at the previous step). Users may choose as many issues as they face in their community.

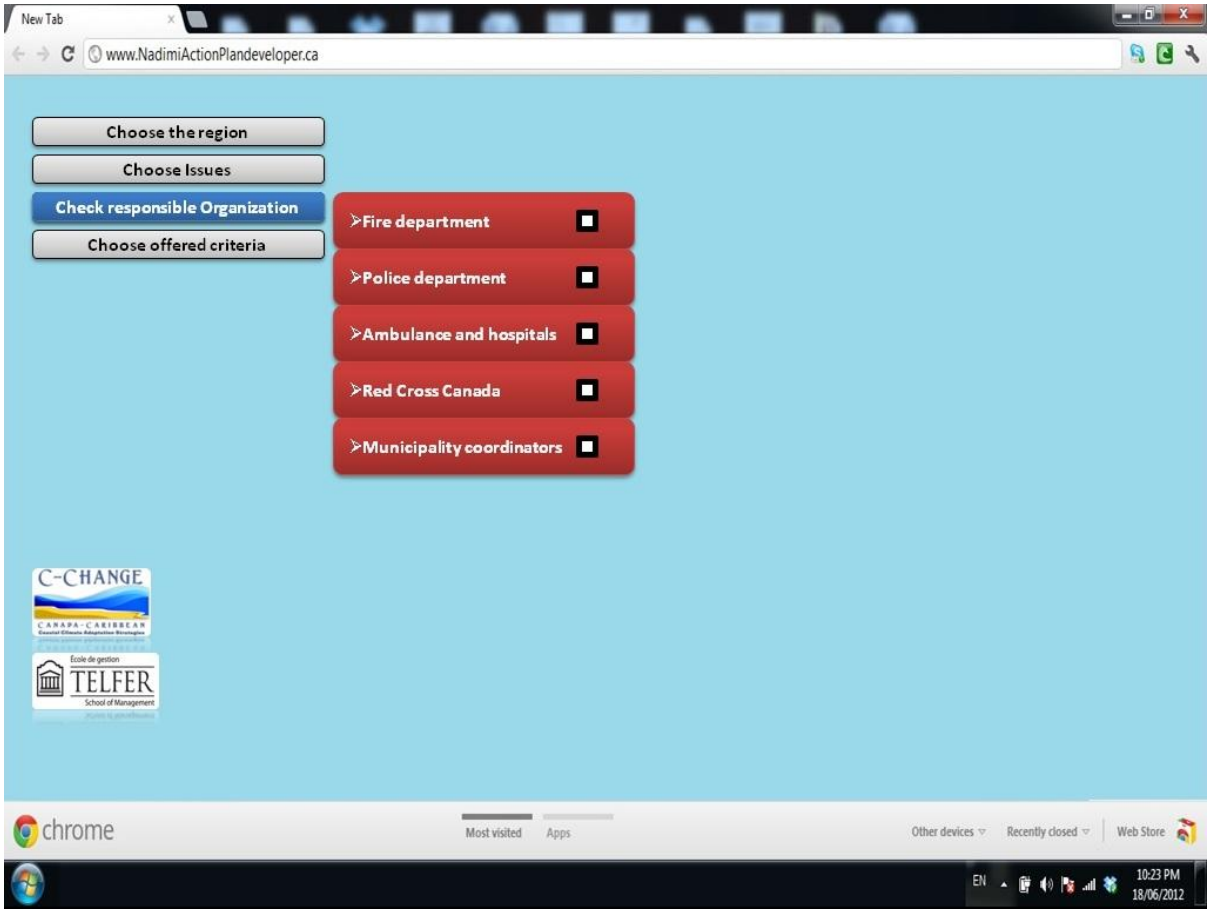


Figure 5-4: Database homepage-Organizations

In following step (Figure 5.4), the user chooses the organizations involved in the community's action plan. Selecting these organizations yields the related responsibilities recalled from the database.

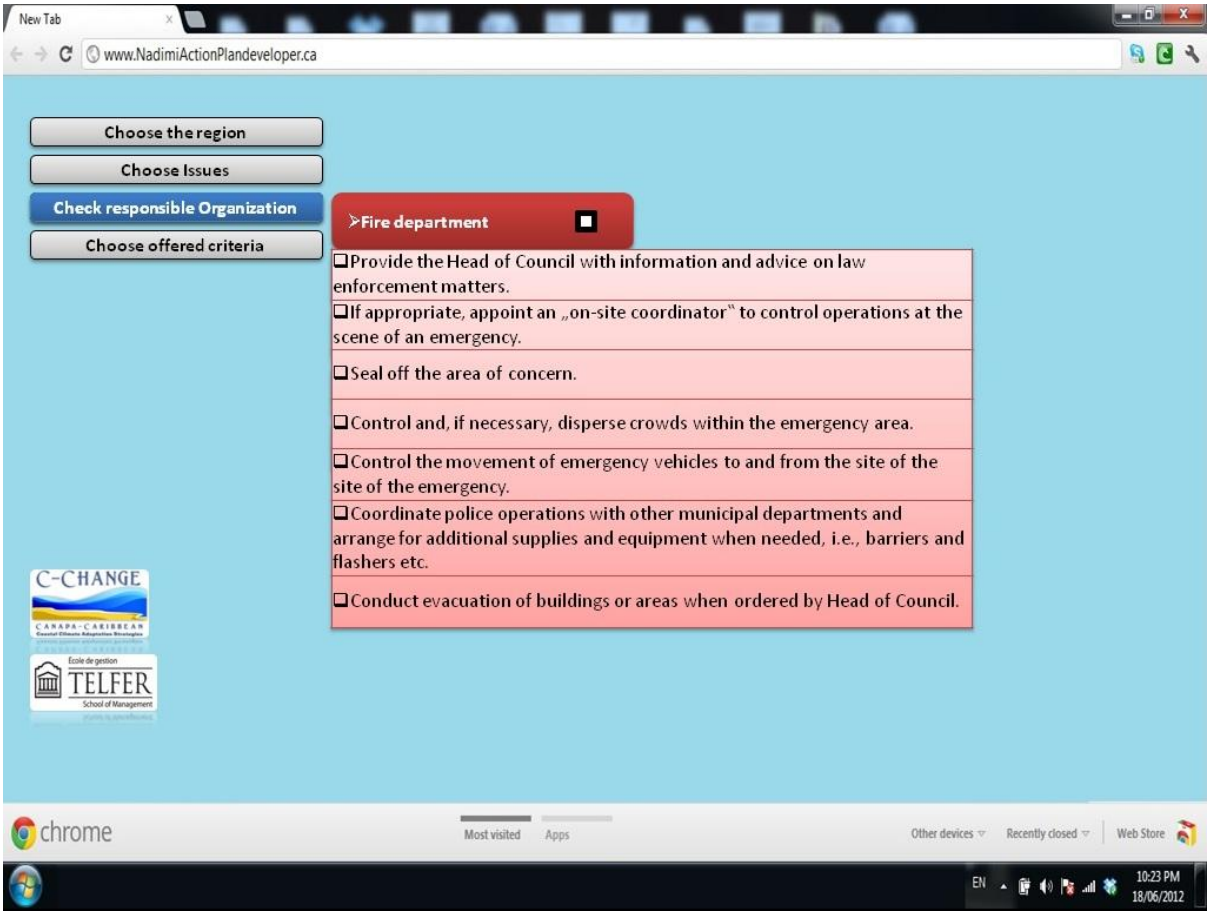


Figure 5-5: Database homepage-responsibilities

Figure 5.5 details the related responsibilities in the local action plan from the Action Plan database.

In the following step, the criteria of the scientific method of problem solving are provided including the AHP top-level criteria, and subsequent subcriteria (as developed in AHP model). The user may choose subcriteri that are related to their local climate issues.

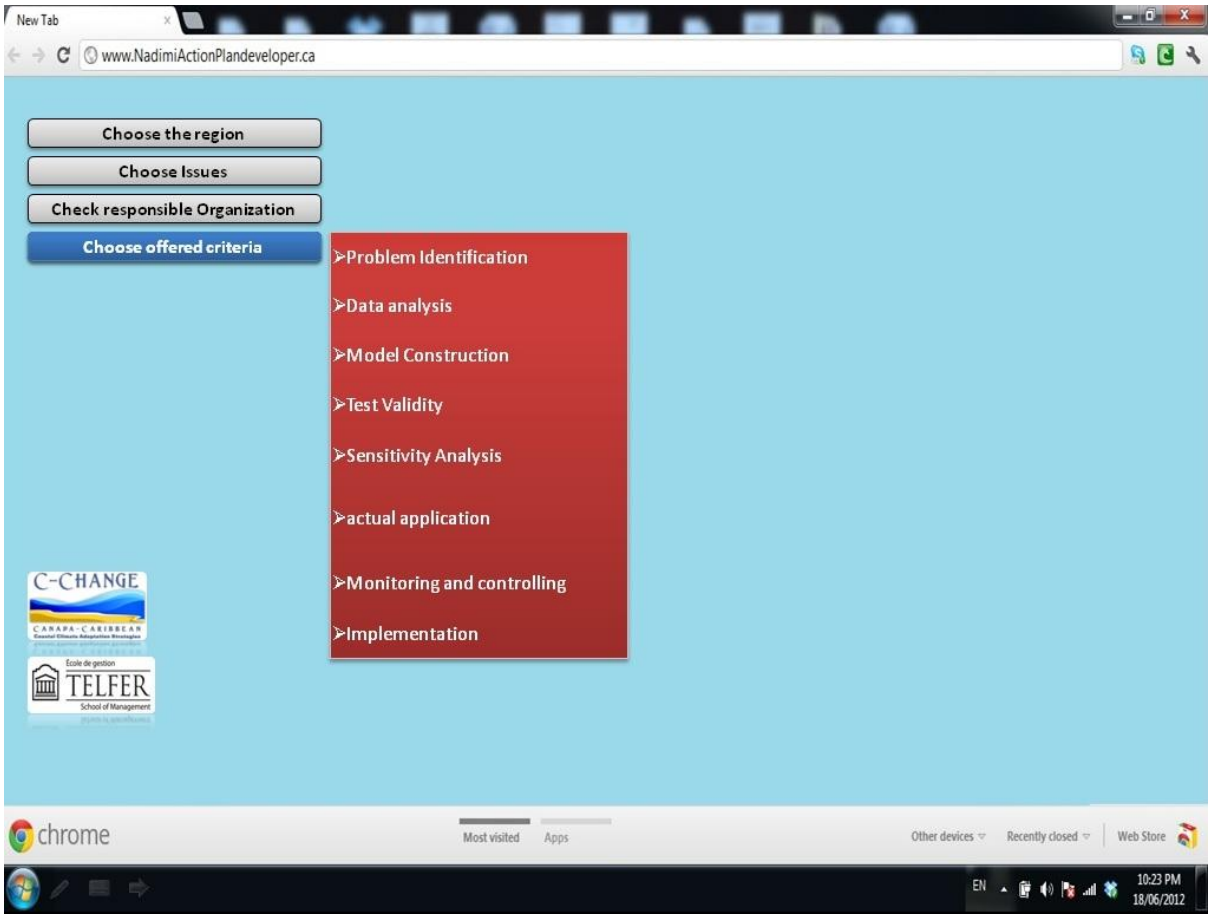


Figure 5-6: Database homepage-criteria

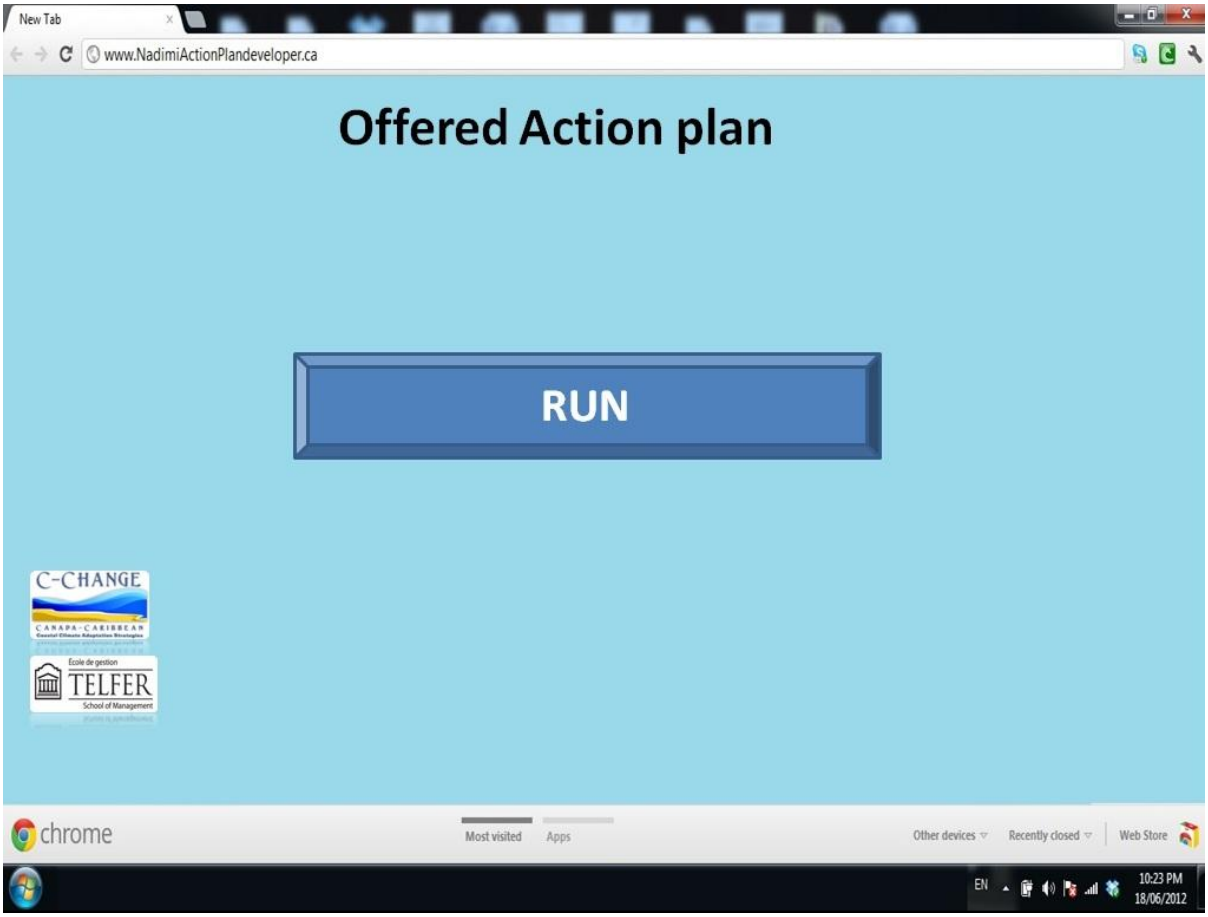


Figure 5-7: Database homepage-Action plan

Finally, after all these steps have been selected, the user can execute the database which then produces a draft final Community Action Plan that involves: Milestones, description of each milestone with detailed responsibilities and related action and involved organizations.

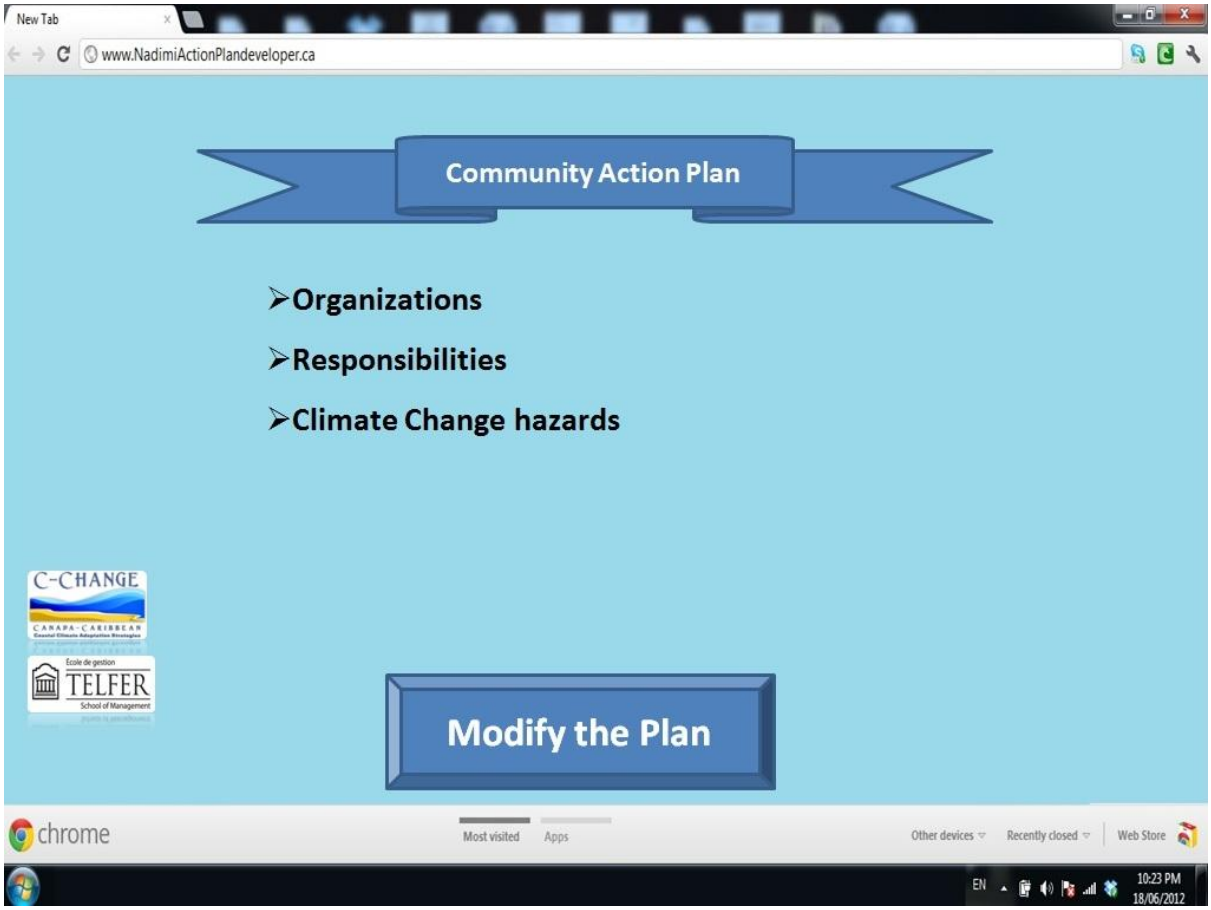


Figure 5-8: Database homepage-modifications

After generating a draft community action plan framework as mentioned in Figure 5.8, the system allows the user to modify the draft framework to their specific needs and local issues. After modification, the offered framework can be used in the community as a starting point, and updating of the plan can take place before final implementation.

In conclusion, this Community Action Plan and Adaptation Guideline framework development can be used to assist all communities. Further, their feedback systems will improve and could offer a more developed framework related to the community's exact issues and problems.

The following final chapter discusses the findings of this research project, provides a consolidation of the research results and demonstrates how this work satisfies the objectives of this project presented in the introduction of the thesis. As well, it recommends how the proposed framework will facilitate further studies in coastal community adaptation practices.

6 Conclusions and Recommendations

This chapter summarizes the findings of this research project. The first section of this chapter provides a consolidation of the research results and demonstrates how this work satisfies the objectives originally stated in the introduction of the thesis. The second section of the chapter recommends how the proposed framework will facilitate further studies in coastal community adaptation practices.

6.1 Conclusions

The conclusions of this study relate to the research objectives presented in Chapter 1. These objectives are summarized as follows:

1. **Identifying the suite of specific protocol and adaptation processes currently in place through known international initiatives and local case studies.**

This objective is fulfilled in the literature review of Chapter 2, Section 2.1 (Global Adaptation Protocols). The identified International adaptation protocols include ICLEI, FCM, Care, UNDP, and the EU Commission. The international protocols processes, methods, milestones, action plans, and applications are presented and analyzed. These initiatives provide a framework for the development and application of local community-based adaptation protocols.

2. **Defining and applying the scientific method of problem solving as the multi-criteria framework to compare and evaluate adaptation processes for international initiatives.**

The scientific method of problem solving is researched and presented in the literature review of Chapter 2. Further, the steps of the method are detailed in the methodology of Chapter 3 in order to prepare a formulation of the method in terms of a multi-criteria decision problem. The formulation corresponds to the hierarchy for an AHP model developed using the Expert Choice software by applying the prioritized steps of the scientific method of problem solving to the AHP model hierarchy and evaluated pairwise comparison of the criteria and sub-criteria attributed to the scientific method. Relative to the AHP problem formulation, the International protocols are scored to identify the ranking of the protocols for identification of best practices (Phase 1). In this part, all the international protocols introduced in Chapter 2 are assessed and the scientific method of problem solving steps are applied in the AHP Expert Choice software. Regarding the results obtained from AHP and analysis done among these data, ICLEI and UNDP chosen as the best practices. These two protocols obtain the highest rank in all criteria as a result of years of experience in the field, and developing and implementing their framework in partnership with different groups of communities in developed and developing countries.

3. Applying the adaptation framework to determine best practices for coastal communities through current protocols, and communities' vulnerabilities.

As for the analysis of the International protocols through AHP, the same hierarchy formulation of the scientific method is applied to the set of Canadian C-Change communities to evaluate and rank the relative performance of the community adaptation procedures. This work is presented in Chapter 4 and the AHP complete results provided in Appendices E and F.

Through the assigned measurements among the first level criteria of the defined AHP hierarchy in Chapter 4 (Figure 4.10), the weighting of the importance of 3 criteria: Problem identification, Criterion data, and Testing/Sensitivity/Validity are much more than other criteria in the formulation. Hence, it can be concluded that these factors are more important than other factors in relation to all components of the problem solving framework.

4. **Detailing the key components and guidelines of coastal communities' climate change action plans including identifying roles and responsibilities, and operational activities of community members from best practices of evidenced-based examples.**

Through the international protocols and previous studies done in this area, an appropriate framework for applying community adaptation guidelines is developed for the C-Change communities Action Planning requirement of that project. The work of Chapter 5 presents the community guideline framework, including the community organization (in general) along with the roles and responsibilities of local government and first responders during emergency situations. The guidelines also include a household plan for family units to follow as part of their individual contribution to the overall community action plan.

As final goal of this study, the Action Plan for coastal communities' adaptation strategies introduced an online website and database for adaptation action plan content and checklist. The checklist develops how communities provide the required information of the local community adaptation action plan.

This guideline framework can be applied to all coastal communities. Expansion of the community database, input data, and some modification can be used to assist other coastal communities in Canada and Caribbean toward managing their adaptation strategies.

6.2 Recommendations for Future Research

This thesis analyzed the International protocols and applied best practices in four Canada C-Change communities. Further research is suggested in the following areas:

6.2.1 Developing Applications for Community Use

The proposed online database is in its conceptual stage. In the future, researchers can develop this database through some coding language like: C++ or Java and test among the C-Change communities in actual area. With ongoing monitoring and reporting of adaptation strategies (as a required element of the scientific method of problem solving), scholars can update the database after each implementation so it will be more reliable and useful in the future. The online database is also a good gateway for communities to share their experiences.

Mobile (cell phone and computer pads) App (i.e., applications) could also be added to the online database to remind leaders of their responsibilities during the hazard to the person or organization in charge, and provide emergency contact numbers to members of the community so that everyone could directly contact people in charge during emergency situations.

6.2.2 Further Analysis of Cases (and identification of best practices)

In this study, four Canadian C-Change communities introduced and analyzed, for further research, accurate data should be gathered from these communities to improve the reliability and validity of the study as well as develop more appropriate framework for the communities, finalizing the protocols evaluation, using the best practices in protocols to apply to C-Change communities, continuing ongoing evaluation of C-Change communities, and preparing of guidelines for each community.

6.2.3 Further analysis of the AHP hierarchy and a more objective means of assigning pairwise comparisons and data grid scores

Since International protocols are still in the developing and implementing phase, the data provided for AHP model in this study may be considered preliminary with respect to how well these protocols deal with the elements of the problem solving method. Therefore, in future research, researchers could use actual developed data taken from International protocols and their implementation results, and apply it in the AHP model.

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Appendices

Appendix A. Scientific Method of Problem Solving AHP Hierarchy Pairwise Comparison Inputs and Criteria and Subcriteria Weights

In this Appendix following Scientific methods of problem solving input will present:

- Scientific method step, and defined sub criteria
- The pairwise comparison between criteria and the criteria ranking
- Hierarchical model of Scientific method

First Table shows all the pairwise comparison between each two first level criteria. As shown in the table most difference is between modeling and testing criteria, and Testing is Very stronger than Modeling regarding to Saaty's scale shown in Table 2.6. The next Tables will examine the pairwise comparison in more details (sub-sections).

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Problem Identificatio	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Criterion Data
2	Problem Identificatio	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Modelling
3	Problem Identificatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Testing/Sensitivity/V
4	Problem Identificatio	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Monitoring and contr
5	Problem Identificatio	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Implementation
6	Criterion Data	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Modelling
7	Criterion Data	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Testing/Sensitivity/V
8	Criterion Data	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Monitoring and contr
9	Criterion Data	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Implementation
10	Modelling	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Testing/Sensitivity/V
11	Modelling	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Monitoring and contr
12	Modelling	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Implementation
13	Testing/Sensitivity/V	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Monitoring and contr
14	Testing/Sensitivity/V	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Implementation
15	Monitoring and contr	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Implementation

Table A.1: Pairwise Comparison the relative importance with respect to: Goal

This Table shows the comparison between Problem Identification sub-criteria analyzed. As shown in the Table, all the elements have equal importance in this project. Therefore, for example Problem definition and constraining factors comparison got score 1, it means both of these sub-criterions have a same value of importance regarding to fulfilling the project main objectives.

1	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Affected Clients (How
2	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Declaring objectives? (
3	Problem definition (For	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu
4	Affected Clients (How	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Declaring objectives? (
5	Affected Clients (How	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu
6	Declaring objectives? (	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Constraining factors (Bu

Table A.2: Comparison the relative importance with respect to Problem Identification

After assessing the sub-criteria of the problem identification in previous Table, below Table shows the comparison and relationship between each two sub-criterion under the Criterion Data.

1	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Measurability
2	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost and Issue
3	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
4	Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
5	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost and Issue
6	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
7	Measurability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
8	Cost and Issue	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Data Management
9	Cost and Issue	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie
10	Data Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Profiling risk / Prioritie

Table A.3: Comparison the relative importance with respect to Criterion Data

This Table shows the comparison between the criteria under the Modeling exposed this factor has almost two different group of criterion and some of them are much more important than others.

1	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Relevance to objective
2	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication (interpı
3	Static / Dynamic (short	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil
4	Relevance to objective	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication (interpı
5	Relevance to objective	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil
6	Communication (interpı	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Deterministic / Probabil

Table A.4: Comparison the relative importance with respect to Modeling

Testing has just three sub-criteria, and pairwise comparison with them shows Robustness is almost equal with both other sub-criteria (Analysis in place, and Feedback for adjustment), but the Analysis in place is slightly more important than Feedback for adjustment.

1	Analysis in place	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Robustness(is there fle:
2	Analysis in place	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Feedback for adjustmer
3	Robustness(is there fle:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Feedback for adjustmer

Table A.5: Comparison the relative importance with respect to Testing

Same as Testing, Monitoring has three sub-criteria, and as shown in the Table below. Monitoring experiencing same phenomena as experienced in Testing in comparison between the sub-criteria. In this Table pairwise comparison shows Switching capabilities almost have equal value as other two sub-criteria (Control process, and Advantage and ongoing objectives), but the Advantage and ongoing objectives is slightly more important than Control process.

1	Advantage and ongoinc	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Switching capabilities f
2	Advantage and ongoinc	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control Process
3	Switching capabilities f	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control Process

Table A.6: Comparison the relative importance with respect to Monitoring

The last pairwise comparison done between the Implementation factor's two criteria (Evidence of result, Guideline of design model), through the information provided in previous chapter (Chapter 2, Chapter 3), and regarding to study's main objectives decided Guideline of design model is moderately important than Evidence of result because without the Guideline of design model the Evidence of result does not make sense and we have to develop guideline first.

1	Evidence of results	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Guideline of decision m

Table A.7: Comparison the relative importance with respect to Implementation

The Analytical Hierarchy Process (AHP) result shows the hierarchy developed through scientific method of problem solving steps among the coastal communities.

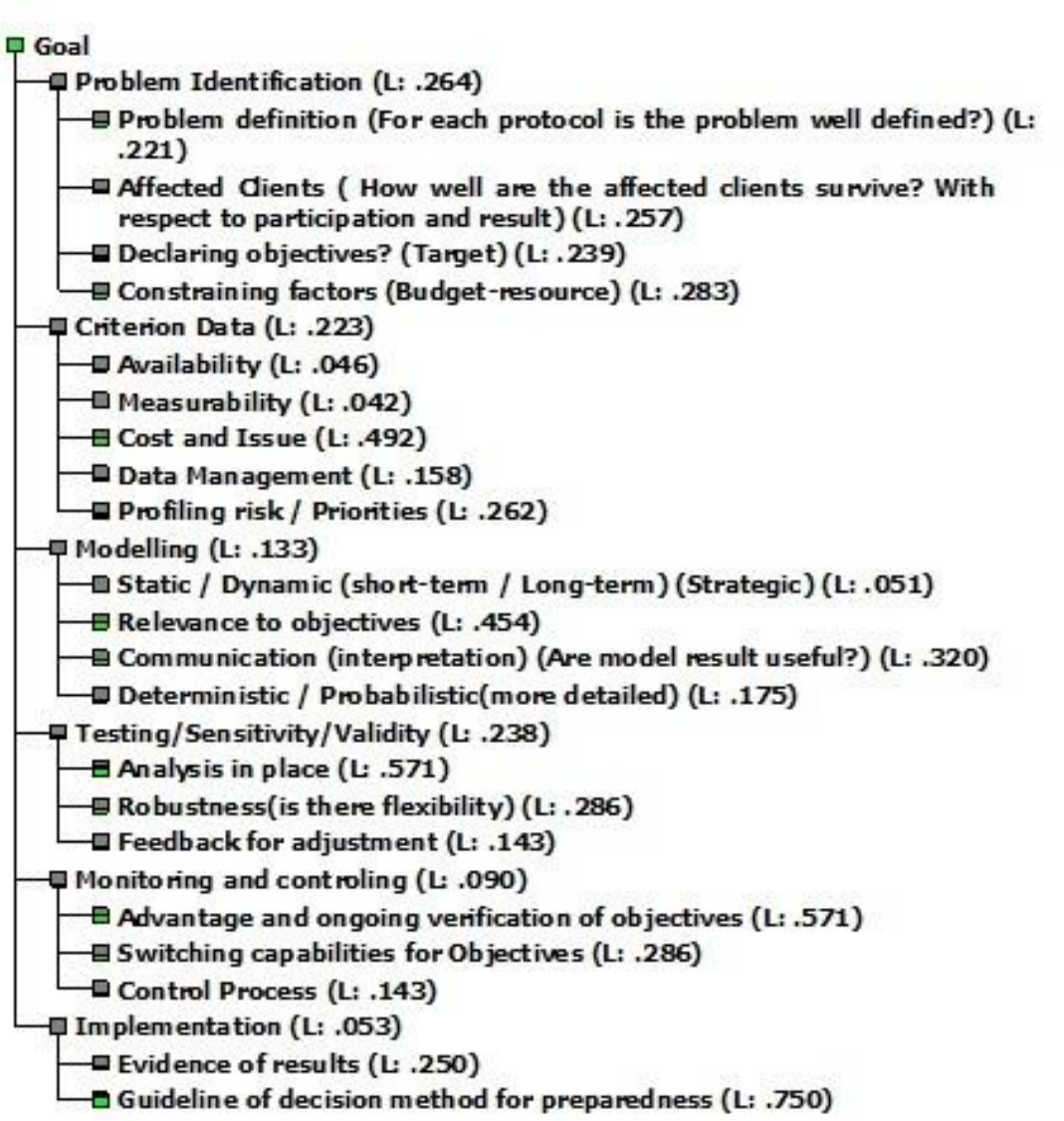

Figure A.1: Detail AHP hierarchy model for the Scientific Method of Problem Solving formulation

The output results analyzed are shown in the Figure below, the measurement shown regarding the first level elements of the defined hierarchy. In this Figure the importance of 3 elements: Problem identification, Criterion data, and Testing/Sensitivity/Validity are more heavily weighted than other elements and account for a combined 72.5% of the hierarchy total weight (of 100%). Hence we can conclude these factors are more important than other factors in relevance to the decision of managing community adaptation.

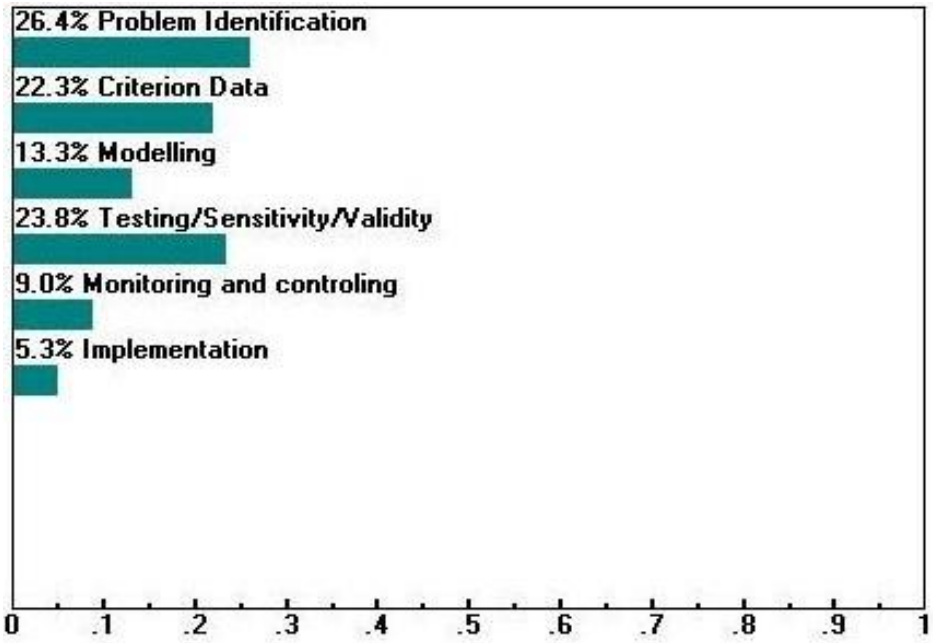

Figure A.2: Main Criteria's final scores

Appendix B. Data Grid Utility Function

The Analytical Hierarchy Process (AHP) results shows data Grid utility curves, these curves as shown below are divided in different parts, in this case two sample curve chosen here to compare as shown in the Figures below, first curve belong to Advantage and ongoing verification of objectives, and the other one belong to robustness criterion; in first curve due to errors (qualitative errors) it cannot be distinguished, therefore all scores higher than 6 can be considered acceptable.

On the other hand because middle part of the scale, statistically is the most selected area in the researches so in this study scores in this area kept close.

As in qualitative studies the worst or the lowest score should be very different than the scores are one level higher because statistically worst score in research is marked (closed) when the parameter is really low on that particular analysis.

As shown here for robustness curve, we divided the curve in two parts, one is less than 4 and other part is more than 4. It means that for this curve the values less than 4 are not acceptable and all the given values to protocols, if more than 4, are almost the same and they are acceptable.

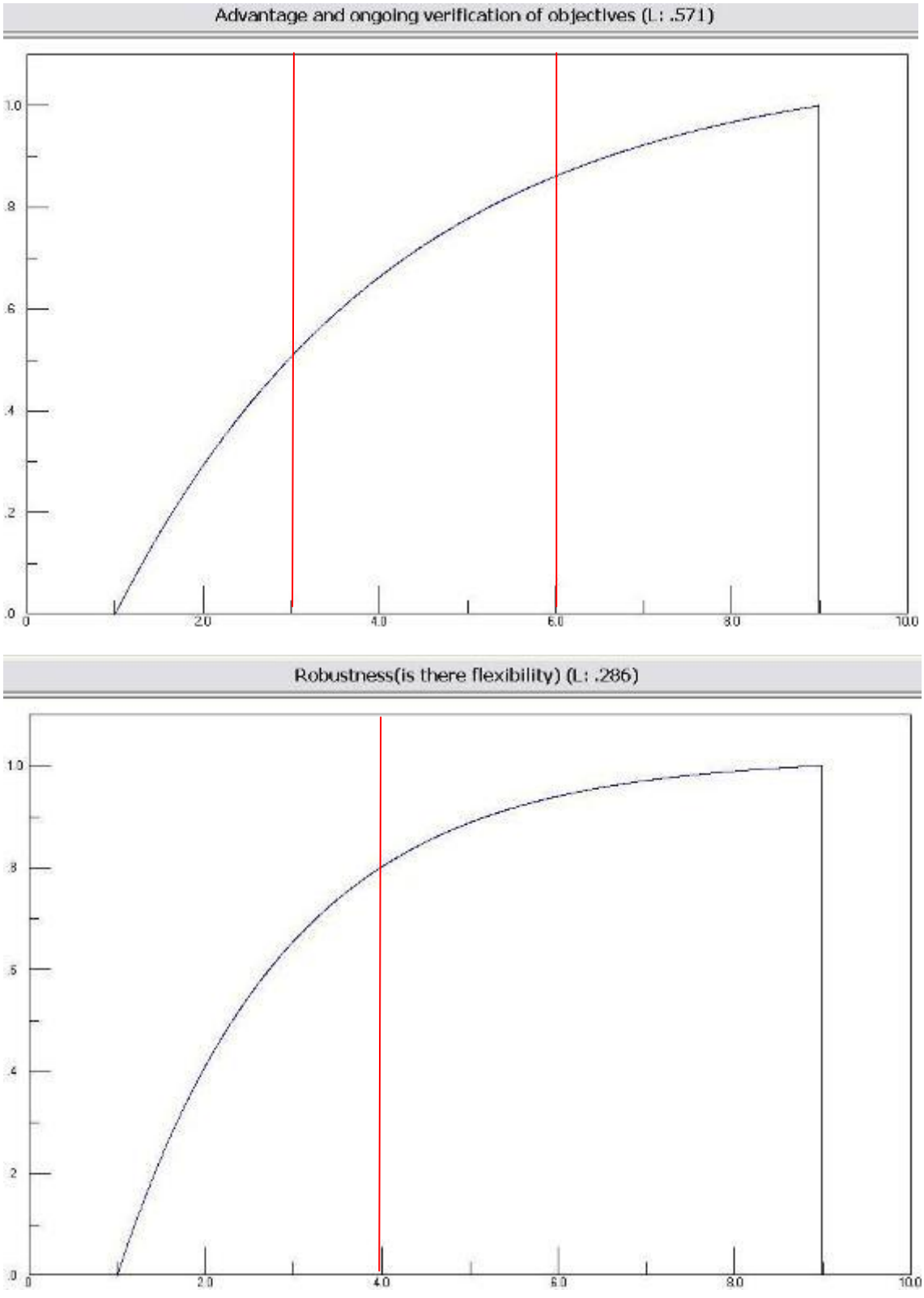

Figure B.1: Data Grid output curves

Appendix C. Protocol's Data Grids

Data input in Protocol's evaluation's data grids part. These data shows the scores given to each protocol regarding to their relation with each sub steps of scientific methods of problem solving. The scores in pairwise comparison between the elements are provided through the specific relationship between that element and the higher level criterion. For instance, the score given for Problem Identification element (sub criterion: Problem definition, for each protocol is the problem is well defined?), as shown in Figure 4.8, is very different between ICLEI and EU Commission (ICLEI score is 9 and for EU Commission is 3). The logic behind these differences is that regarding to this study's objective; these protocols are compared and scored through their level of relation with the objective of this thesis. For this particular example, these scores are given because ICLEI received highest score due to experience in defining milestone for different type of communities. On the other hand, EU Commission's framework developed to help the EU countries reduce the GHG emission and adapt with climate changes in that particular area. This protocol is new and EU still proceeding initial phases of defining project problem, and solution process still is not practically implemented therefore this protocol receive lower weight (3).

	INCR	INCR	INCR
Alternative	**Problem Identification Constraining factors (Budget-resource) (L: .283)**	**Criterion Data Availability (L: .046)**	**Criterion Data Measurability (L: .042)**
ICLEI	9	8	8
FCM	7	6	6
Care	6	3	5
UNDP	9	9	9
EU Commission	8	6	7

Table C.1: Data Grid scores (Protocols)

	INCR	INCR	INCR
Alternative	**Criterion Data Cost and Issue (L: .492)**	**Criterion Data Data Management (L: .158)**	**Criterion Data Profiling risk / Priorities (L: .262)**
ICLEI	9	7	7
FCM	7	5	5
Care	2	6	8
UNDP	9	9	9
EU Commission	6	4	4

Table C.2: Data Grid scores (Protocols)

	INCR	INCR	INCR
Alternative	**Modelling Static / Dynamic (short-term / Long-term) (Strategic) (L: .051)**	**Modelling Relevance to objectives (L: .454)**	**Modelling Communication (interpretation) (Are model result useful?) (L: .320)**
ICLEI	8	8	9
FCM	7	6	2
Care	4	2	2
UNDP	9	9	8
EU Commission	5	4	4

Table C.3: Data Grid scores (Protocols)

	INCR	INCR	INCR
Alternative	**Modelling Deterministic / Probabilistic(more detailed) (L: .175)**	**Testing/Sensitivity /Validity (Analysis in place (L: .571)**	**Testing/Sensitivity/Validity (Robustness(is there flexibility) (L: .286)**
☑ ICLEI	8	8	8
☑ FCM	5	5	7
☑ Care	2	3	5
☑ UNDP	9	9	9
☑ EU Commission	4	7	7

Table C.4: Data Grid scores (Protocols)

	INCR	INCR	INCR
Alternative	**Testing/Sensitivity /Validity (Feedback for adjustment (L: .143)**	**Monitoring and controling Advantage and ongoing verification of objectives (L: .571)**	**Monitoring and controling Switching capabilities for Objectives (L: .286)**
☑ ICLEI	8	9	9
☑ FCM	7	8	7
☑ Care	2	2	5
☑ UNDP	9	8	9
☑ EU Commission	5	4	6

Table C.5: Data Grid scores (Protocols)

	INCR	INCR	INCR
Alternative	**Monitoring and controling Control Process (L: .143)**	**Implementation Evidence of results (L: .250)**	**Implementation Guideline of decision method for preparedness (L: .750)**
☑ ICLEI	9	8	9
☑ FCM	8	6	7
☑ Care	5	3	5
☑ UNDP	7	8	9
☑ EU Commission	6	6	8

Table C.6: Data Grid scores (Protocols)

Appendix D. Protocol's AHP output

All the scores for each protocol calculated through summation of scores given to scientific method elements (Figure 4.1) (Problem identification, Criterion data, Modeling, Testing, Monitoring, and Implementation) under that particular protocol.

Consequently, this Figure provided the final score for each protocol after abovementioned calculation done for each protocol. Regarding the result shown in Figure below, the scores for ICLEI (22.3%) and UNDP (22.6%) have slightly higher than other protocols due to their extent of activity (These two protocols are expanded their scope in all different kind of communities; rural, urban, in developing and developed countries).

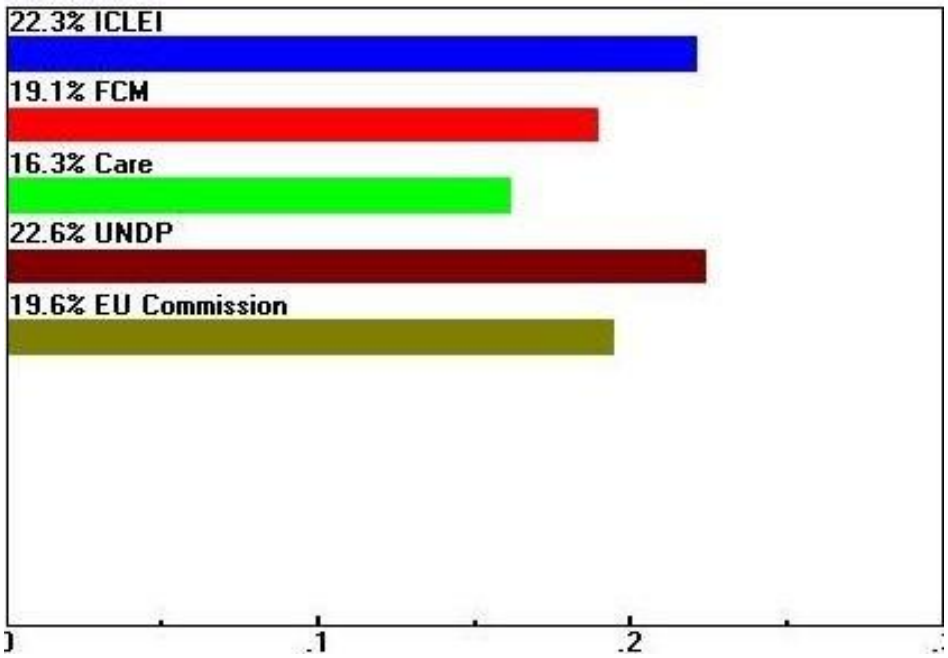

Figure D.1: International Protocols final AHP overall scores

Figure D.2: Synthesis with respect to: Goal

Sensitivity Analysis

After doing the analysis for International protocols in previous parts, next step will be the Sensitivity analysis to show the robustness of results.

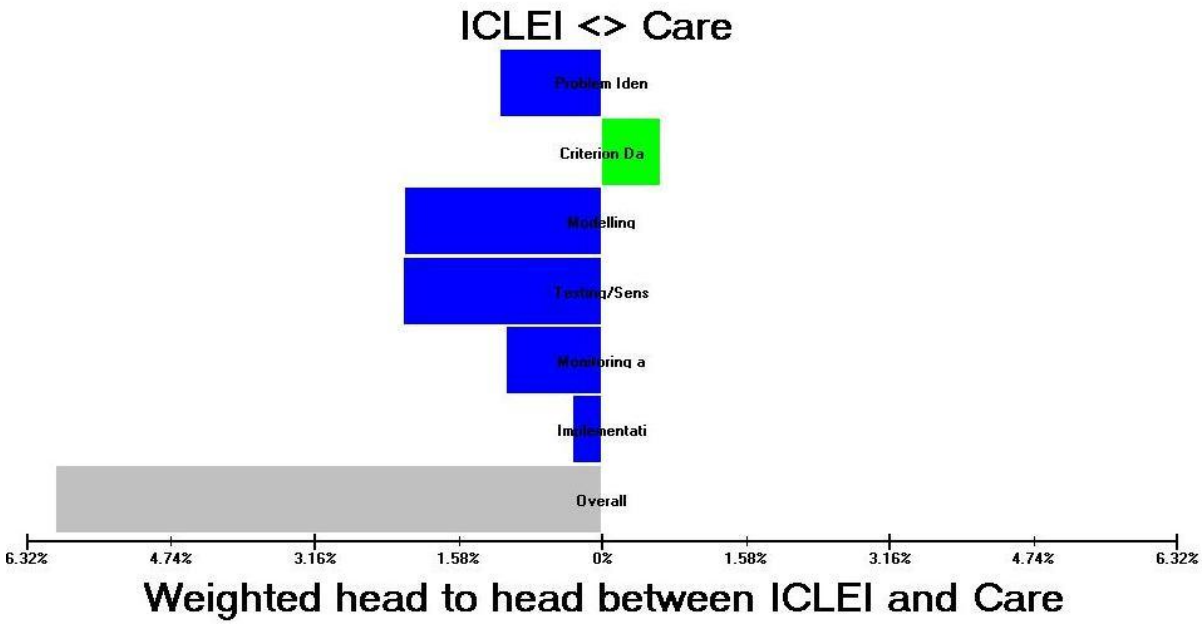

Figure D.3: Weighted head to head Protocols Comparison (ICLEI and Care)

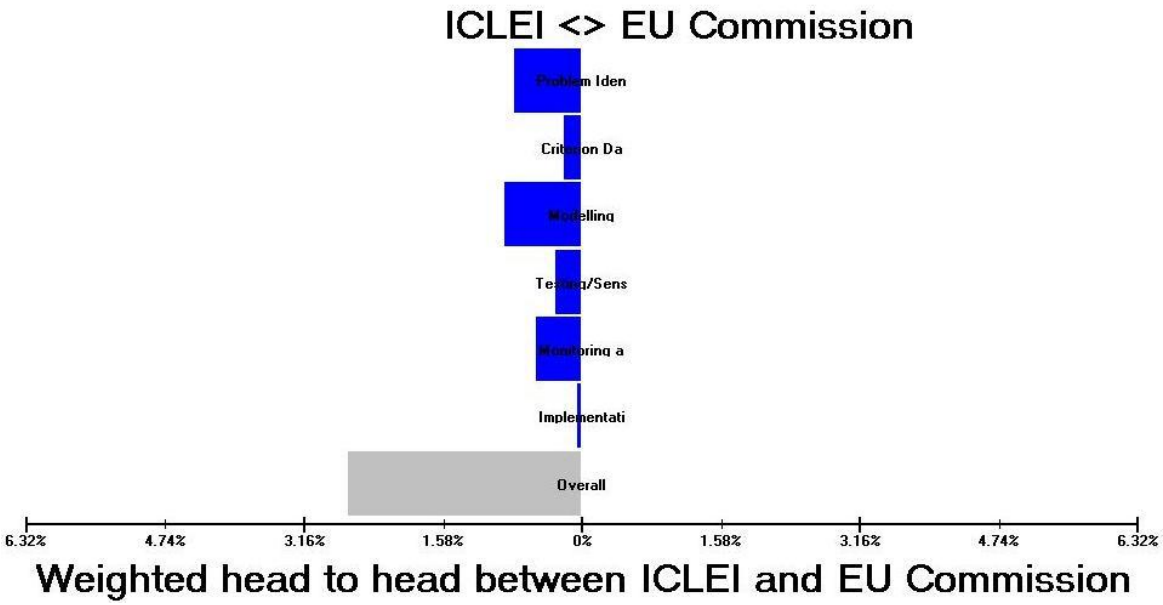

Figure D.4: Weighted head to head Protocols Comparison (ICLEI and EU)

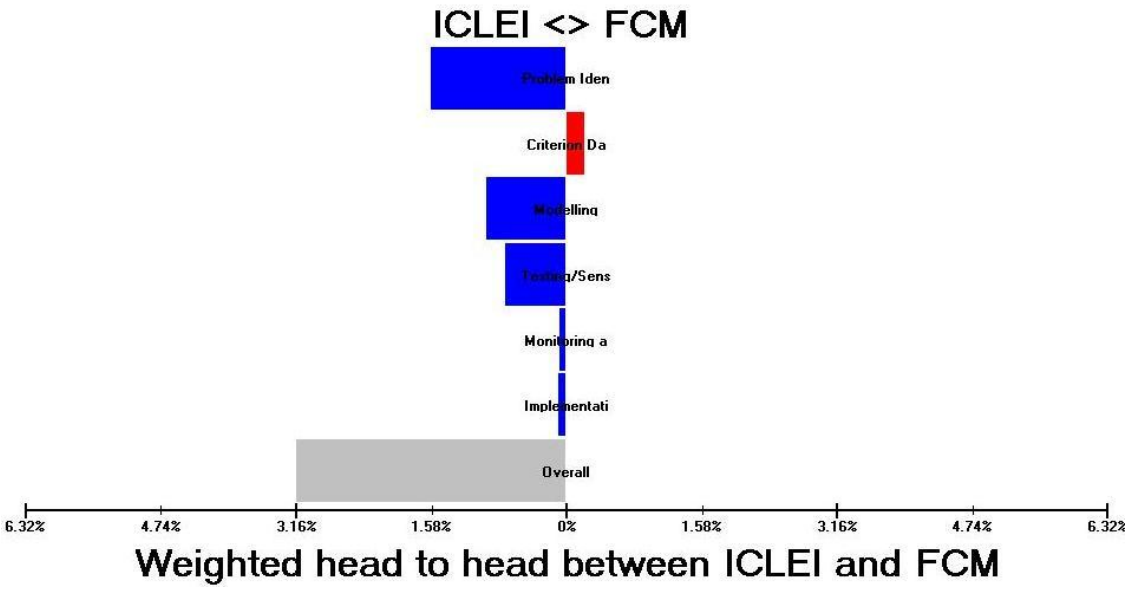

Figure D.5: Weighted head to head Protocols Comparison (ICLEI and FCM)

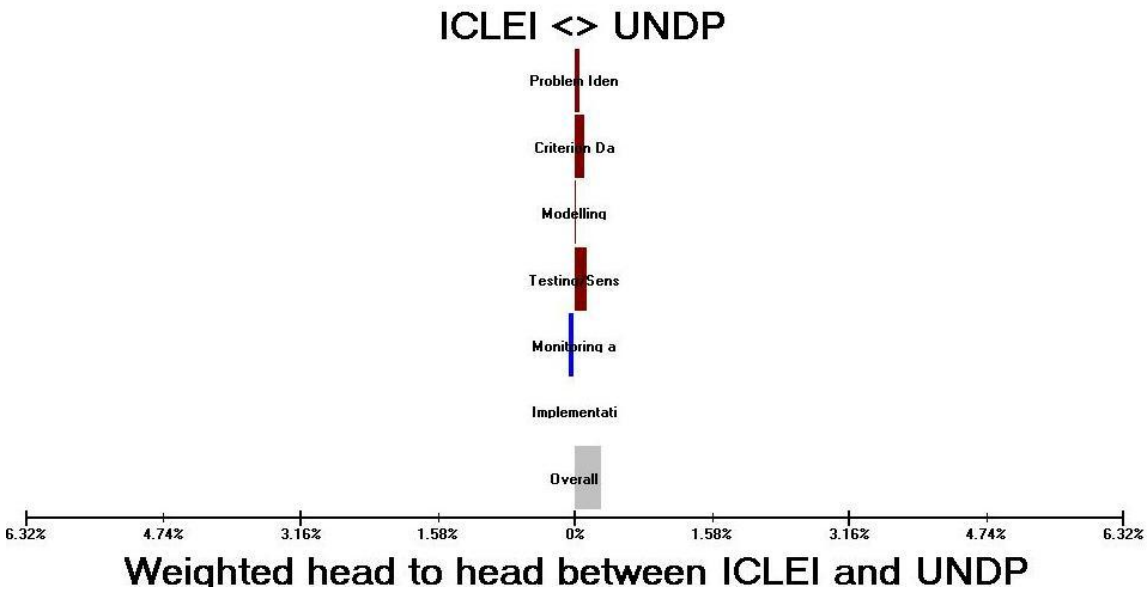

Figure D.6: Weighted head to head Protocols Comparison (ICLEI and UNDP)

Protocol's comparison

As shown in figures below UNDP and ICLEI are very close to each other and both of them have much higher score than other protocols in all criteria. The highest score belongs to modeling criterion and again ICLEI and UNDP with almost 9 have highest score in this criterion, and CARE with 3 get lowest score. Furthermore, the lowest score for all protocols is in implementation part due to progress of implementation of all these protocols.

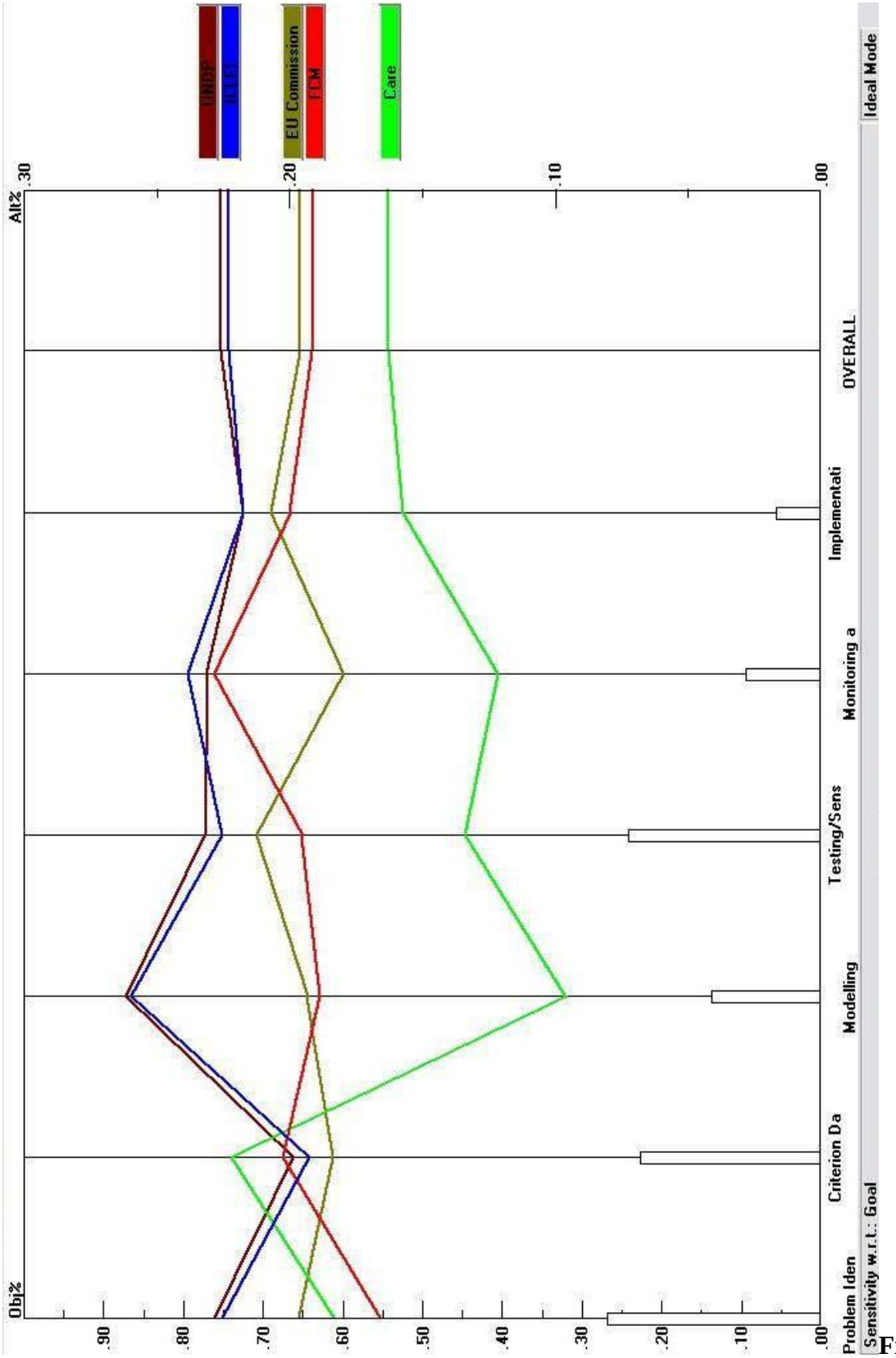

Figure D.7: Protocol's comparison

Appendix E. Communities Data Grid's

Data input in Communities evaluation's data grids part. These data shows the scores given to each Community regarding to their relation with each sub steps of scientific methods of problem solving. The scores in pairwise comparison between the elements are provided through the specific relationship between that element and the higher level criterion. For instance the score given for problem identification element (sub criterion: Constraining factors, Budget-resource) as shown in Figure 4.9 is almost same for all communities but in closer look Gibsons and Charlottetown have higher score than Iqaluit and Isle Madame, these scores given because Gibsons is a rich community and have resources infrastructures to develop the framework in the community on the other hand Charlottetown is one of the communities developed so many local action plans so have a huge database about community situation and forecasted analysis about future climate impact, therefore this two communities get slightly more scores than other two communities regarding to this criterion (Constraining factors, Budget-resource).

Ideal mode		INCR	INCR	INCR
Alternative	**Total**	**Problem Identification Problem definition (For each protocol is the problem well defined?) (L: .221)**	**Problem Identification Affected Clients (How well are the affected clients represented with respect to participation and results? (L: .257)**	**Problem Identification Declaring objectives? (Target) (L: .239)**
☑ Isle Madame	.815	8	7	4
☑ Gibsons	.863	5	5	3
☑ Iqaluit	.760	5	8	3
☑ Charlottetown	.868	7	6	4

Table E.1: Data Grid scores (Communities)

Ideal mode	INCR	INCR	INCR
Alternative	**Modelling Static / Dynamic (short-term / Long-term) (Strategic) (L: .051)**	**Modelling Relevance to objectives (L: .454)**	**Modelling Communication (interpretation) (Are model result useful?) (L: .320)**
☑ Isle Madame	5	4	6
☑ Gibsons	7	7	8
☑ Iqaluit	5	4	6
☑ Charlottetown	7	7	8

Table E.2: Data Grid scores (Communities)

Ideal mode	INCR	INCR	INCR
Alternative	**Criterion Data Cost and Issue (L: .492)**	**Criterion Data Data Management (L: .158)**	**Criterion Data Profiling risk / Priorities (L: .262)**
☑ Isle Madame	4	6	5
☑ Gibsons	5	7	6
☑ Iqaluit	3	5	5
☑ Charlottetown	5	8	6

Table E.3: Data Grid scores (Communities)

Ideal mode	INCR	INCR	INCR
Alternative	**Modelling Deterministic / Probabilistic(more detailed) (L: .175)**	**Testing/Sensitivity /Validity (Analysis in place (L: .571)**	**Testing/Sensitivity/Validity (Robustness(is there flexibility) (L: .286)**
☑ Isle Madame	3	7	5
☑ Gibsons	7	7	6
☑ Iqaluit	3	5	5
☑ Charlottetown	7	6	6

Table E.4: Data Grid scores (Communities)

Ideal mode	INCR	INCR	INCR
Alternative	**Monitoring and controling Control Process (L: .143)**	**Implementation Evidence of results (L: .250)**	**Implementation Guideline of decision method for preparedness (L: .750)**
☑ Isle Madame	7	6	6
☑ Gibsons	9	6	5
☑ Iqaluit	7	6	6
☑ Charlottetown	8	6	4

Table E.5: Data Grid scores (Communities)

Ideal mode	INCR	INCR	INCR
Alternative	**Testing/Sensitivity /Validity (Feedback for adjustment (L: .143)**	**Monitoring and controling Advantage and ongoing verification of objectives (L: .571)**	**Monitoring and controling Switching capabilities for Objectives (L: .286)**
☑ Isle Madame	6	5	5
☑ Gibsons	6	6	6
☑ Iqaluit	6	4	5
☑ Charlottetown	6	6	6

Table E.6: Data Grid scores (Communities)

Appendix F. C-Change Communities AHP output.

Analytical Hierarchy Process (AHP) results from communities' evaluation. In figures below all the scores came from pairwise comparison of the protocol shown.
All the scores for each community calculated through summation of scores given to scientific method elements (Figure 4.1) (Problem identification, Criterion data, Modeling, Testing, Monitoring, and Implementation) under that particular protocol.

Consequently, this Figure provided the final score for each community after abovementioned calculation done for each community. Regarding the result shown in Figure above, even all communities almost receive similar result, still Gibsons and Charlottetown have higher rank than other two communities, due to their extent of activity (These two communities are active in developing local action plans, have established historic database about past climate impacts and expert staffs).

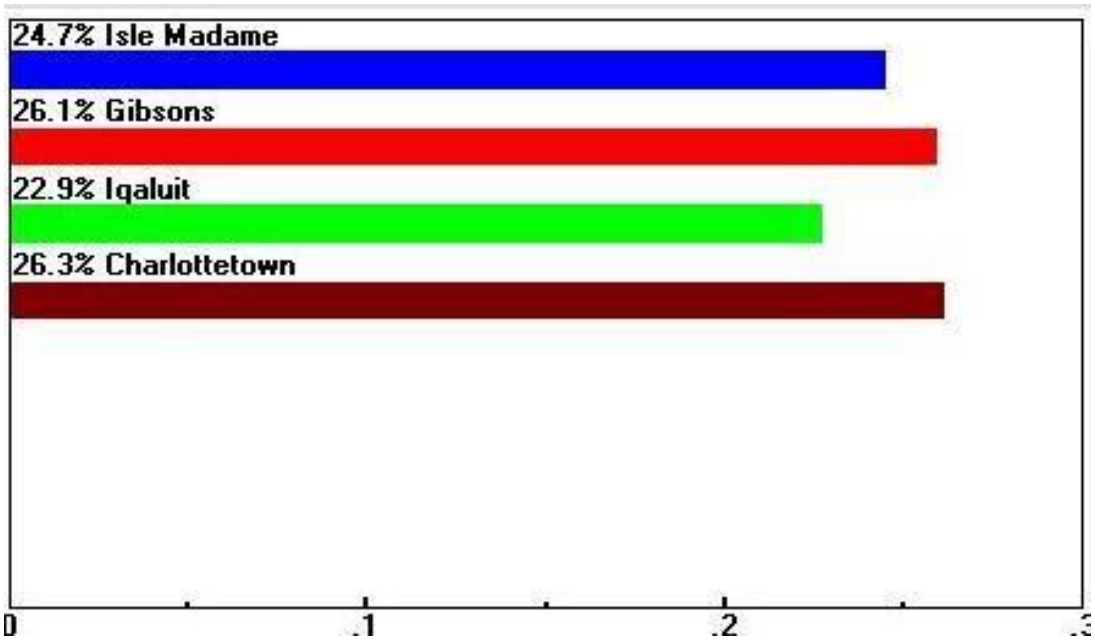

Figure F.1: Communities final AHP overall scores

Alternatives

Isle Madame	.247
Gibsons	.261
Iqaluit	.229
Charlottetown	.263

Table F.1: Communities final AHP overall scores

Sensitivity Analysis

After doing the analysis for C-Change communities in previous parts, next step will be the Sensitivity analysis to show the robustness of results.

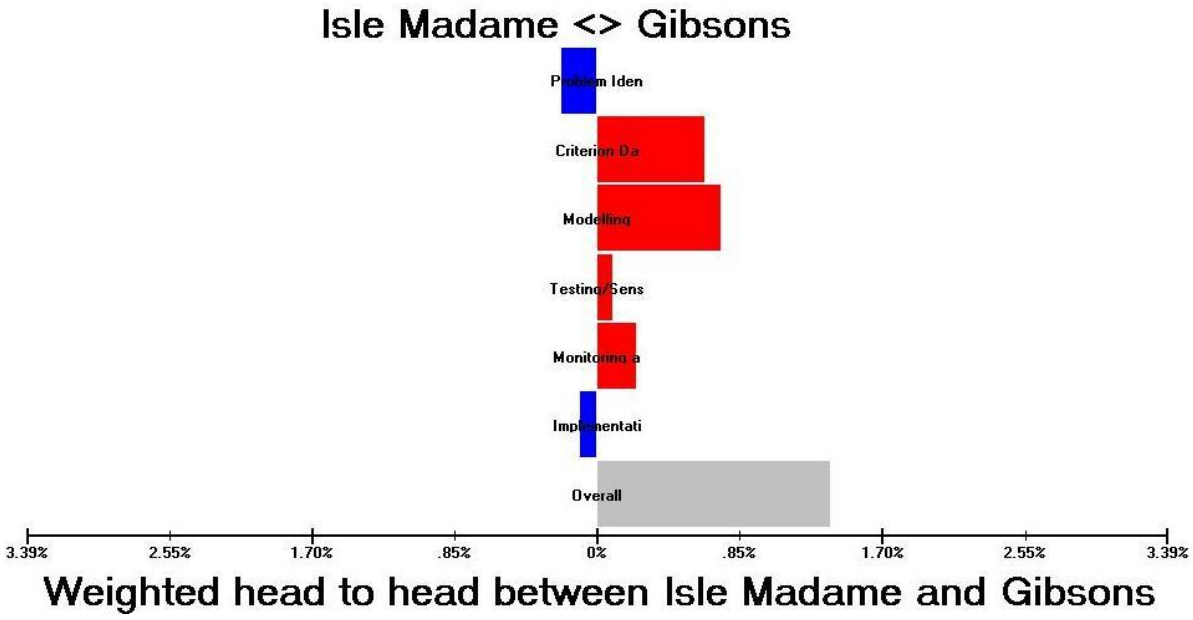

Figure F.2: Weighted head to head Communities Comparison (Isle Madame and Gibsons)

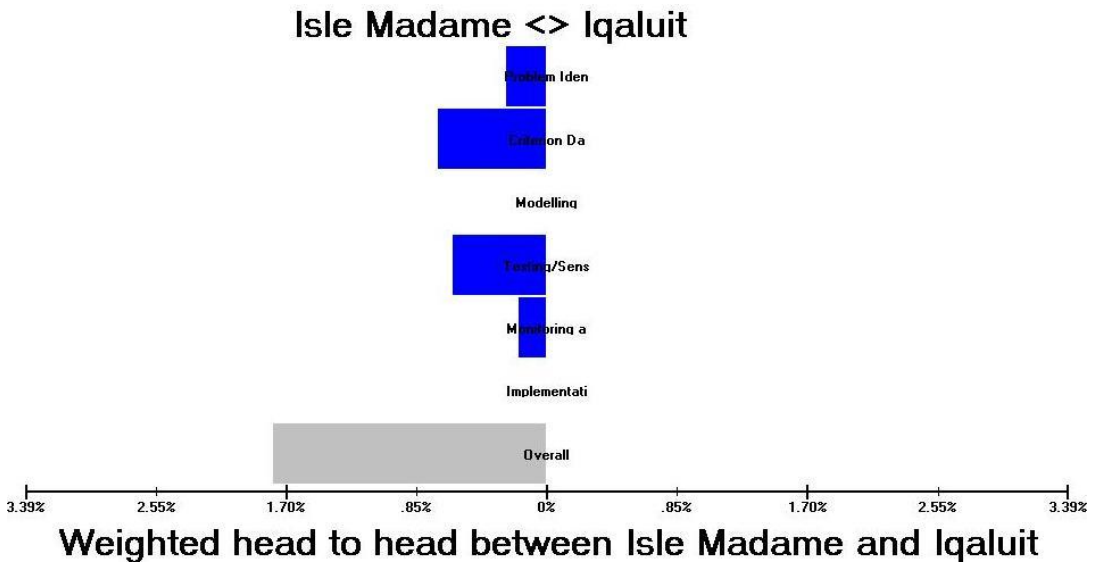

Figure F.3: Weighted head to head Communities Comparison (Isle Madame and Iqaluit)

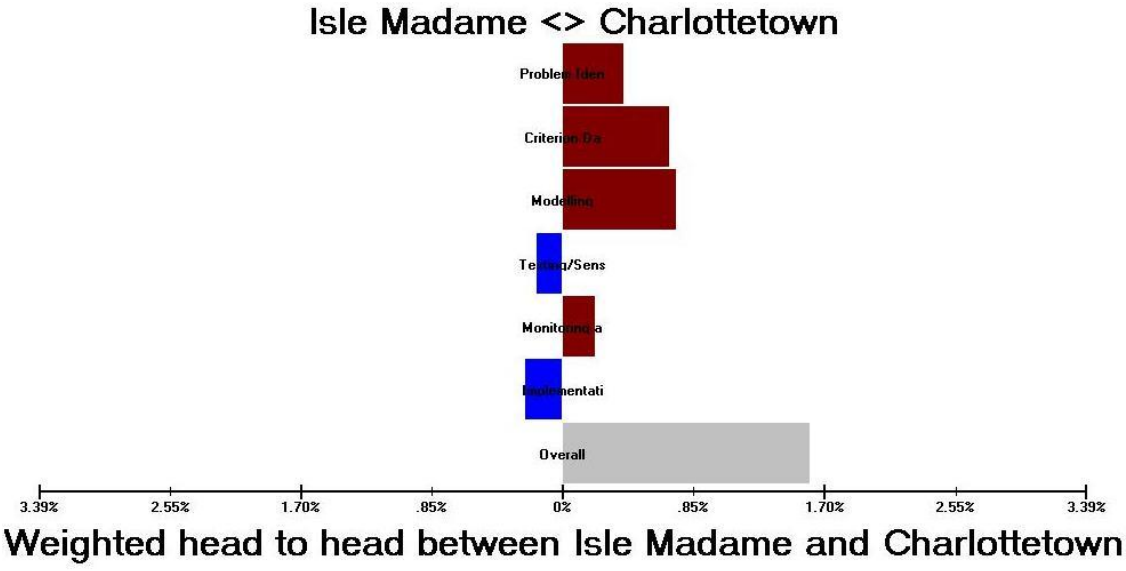

Figure F.4: Weighted head to head Communities Comparison (Isle Madame and Charlottetown)

As shown in Figure below, all communities are very close but Charlottetown and Gibsons are more stable in compare to other two communities, therefore these two communities have higher score through their score regarding to all criteria.

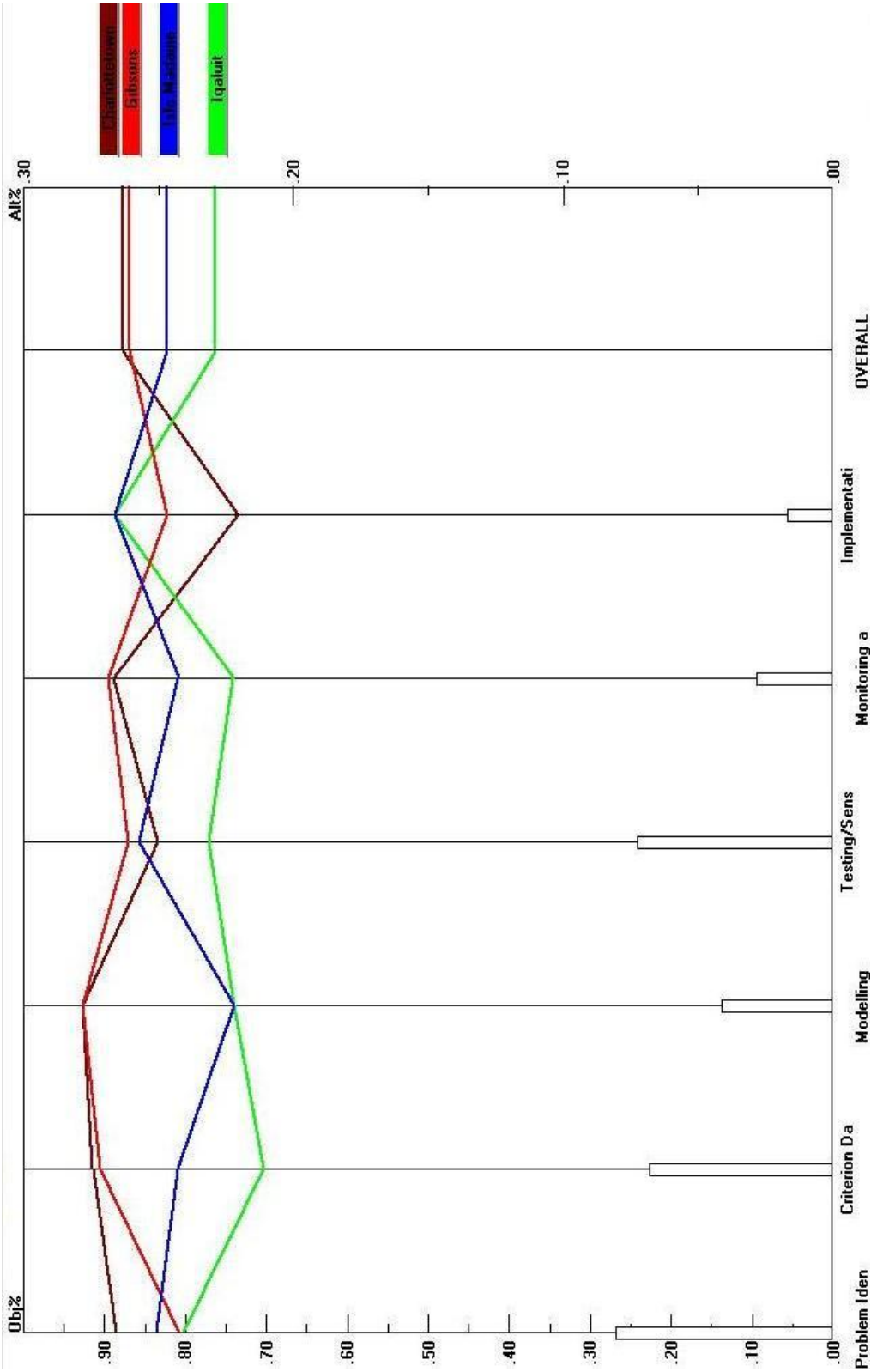

Figure F.4: Communities Comparison