

Supplementary Information

Prioritizing Climate Change Adaptations in Canadian Arctic Communities. *Sustainability* 2015, 7, 9268-9292

Clara Champalle *, James D. Ford and Mya Sherman

McGill University, Geography Department, Montreal, QC H3A 0B9, Canada;
E-Mails: james.ford@mcgill.ca (J.D.F.); Mya.Sherman@mail.mcgill.ca (M.S.)

* Author to whom correspondence should be addressed; E-Mail: clara.champalle@mail.mcgill.ca;
Tel.: +1-514-550-0882.

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Table S1. Literature review of existing prioritization tools.

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Prioritization Tools</i>			
Approach to address climate change-related health risks [1] Focused on health-related risks/sector	MCA	5 criteria for screening of theoretical range: Feasibility, effectiveness, acceptability (environmental, social and legal), efficiency 7 criteria for practical evaluation: technical viability, financial capacity, Human skills and institutional capacity, Compatibility with current policy, is there a target of opportunity for implementing the policy?; What are the potential negative consequences of implementing the option?	Local & regional scale: health sector Overall adaptation assessment within which the 5 th step concerns prioritization of options. 1. Screening of the theoretical range of options assessed with 5 criteria to determine which choices are practical. 2. Analysis of practical range of options with 7 additional criteria to select & prioritize options. E.g.,: tested on theoretical country facing a projected increase in malaria due to climate change and in Cambodia [2]
Climate Adaptation Options eXplorer—ADx [3]	Multiple approach (Voting, AHP, MCA)	Their philosophy: “there is no cure-all method to analyze everything: do not rely on only one approach”	Local & regional scale To screen adaptation options and provide guidance on appropriate options by using several methods. Each adaptation option is ran through different methods, called ‘engines’ (CBA, PAR, MCA) and if the option works with all engines then it is the one to prioritize among others. E.g.,: NAPA for agriculture in Tanzania.
MCDM based policy analysis [4] <i>et al.</i>	MCDM (SAW, ELECTRE, TOPSIS)	Efficiency, responsivity, cost, implementability, flexibility	Local to national scale To assess the effectiveness of adaptation options. Uses different MCDM methods to enhance the robustness of decision-making as each may result in different rankings. The tool embeds three different MCDM techniques (SAW, ELECTRE, TOPSIS) E.g.,: Case study in Georgia Basin, Canada

Table S1. *Cont.*

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Prioritization Tools</i>			
Index of Usefulness of Practices for Adaptation (IUPA) [5] <i>et al.</i>	Multi-purpose index (MCA)	Implementation time, total cost, robustness, autonomy in deciding, n# beneficiaries, continuity in time, resilience, integration w/ other policy domains, participation of target pop, incorporation of local/traditional knowledge...	<p>Local to national scale</p> <p>To evaluate practice, compare alternatives, support project formulation, assist in fund-raising process.</p> <p>Use of indexes that integrate multiple criteria (Multi-purpose index)→qualitative expressions (high, moderate and low)</p> <p>E.g.,: case study in Chile to improve disaster management related to natural hazards</p>
Qualitative assessment of the characteristics of the options [6] <i>et al.</i>	MCA	Importance of option in terms of expected gross benefits; urgency of option; no-regret characteristics of the option; co-benefits to other sectors and domains; effect on climate change mitigation	<p>National scale</p> <p>To systematically assess adaptation options to find if they are technically, economically, and politically feasible to enable policy makers to make well-informed choices about different adaptation options. To harmonize a national adaptation policy with the spatial planning policy.</p> <p>The criteria are used in a MCA and in parallel, they assess feasibility in the implementation phase→technical, social and institutional complexity.</p> <p>E.g.,: Netherlands case study</p>

Table S1. *Cont.*

Tool Name, Author and Year	Method Used	Criteria Used	Objectives Means Example
<i>Adaptation Prioritization Tools</i>			
Adaptation Decision Matrix (ADM) first described by Benioff and Warren 1996 and Smith <i>et al.</i> 1996 [7] <i>et al.</i>	2 steps: screening + CEA	Screening of options: local expert go through each option and answer Yes or No to 5 questions: early implementation, target of opportunity, other benefits, low costs, low barriers. Analysis of cost-effectiveness of option with the same cost and different benefits, to select the option with higher benefits. Score of 1 to 5 for benefits and weights were assigned to 8 identified policy objectives. Use of the Adaptation Decision Matrix. 8 policy objectives: food security, max agri prod, max exports, sustainable agri, protect the env, prevent desertification, maintain genetic div, max employment.	National scale To estimate benefits using expert judgment (using an arbitrary numerical scale, not monetary values) and benefits estimates were compared to costs to determine cost-effectiveness. 1. Screening of options: local expert go through each option and answer Yes or No to 5 questions: early implementation, target of opportunity, other benefits, low costs, low barriers. 2. CEA of options with the same costs and different benefits E.g.,: case study on agriculture in Kazakhstan
Four normative principles to guide responses to CC [8] <i>et al.</i>	N/A	Recognize the context for vulnerability, including multiple stressors; Acknowledge that differing values & interests affect adaptation outcomes; Integrate local knowledge into adaptation responses; Consider potential feedbacks between local and global processes	Local scale Four normative principles to guide responses to CC to be sustainable adaptation and contribute to sustainable. Advocate sustainable adaptations that take into account effects on social justice and environmental integrity. E.g.,: Case studies in Nigeria, Chile, Norway and South Africa

Table S1. *Cont.*

Tool Name, Author and Year	Method Used	Criteria Used	Objectives Means Example
<i>Adaptation Prioritization Tools</i>			
Bellagio Framework for Adaptation Assessment and Prioritization [9]	MCA	Broad applicability, flexibility to accommodate national circumstances, user-friendliness & common sense, top-down approach that empowers bottom-up action, comprehensiveness with regard to key national adaptation functions, compatibility with other tools, frameworks, and decision criteria	Local to national scale To identify strengths and gaps in adaptation capacities E.g., Bellagio in Italy on tuna fisheries
CLIMACT Prio Tool—CLIMATE ACTION Prioritization [10]	MCA with criteria weighting	Vulnerability reduction (%), Enhancement of ecological conditions (scale 1–5), Employment generation (scale 1–5), Achievement of MDGs (scale 1–5), Public and political acceptance (scale 1–5), Institutional and technical capacity (scale 1–5), Costs (\$)	City scale (so far) Climate awareness, decision support and capacity building tool for the prioritization and assessment of climate mitigation and adaptation actions at a local level. Participatory MCA approach with several stakeholders deciding on the weights for each criterion and experts scoring each option with the set of criteria in a MCA; includes a sensitivity analysis to make sure the weights assigned do not skew the results.

Table S1. *Cont.*

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Prioritization Tools</i>			
MCDA and network-centric approach [11] <i>et al.</i>	MCDA + network centric approach (NCA)	<p>5 performance attributes: cost, effectiveness, timescale of option implementation, delay in feeling the effect, timescale of effects</p> <p>3 implementation attributes: technical complexity, public unacceptability, institutional complexity</p> <p>5 types of relations btw each pair of measures: Precondition (the successful implementation of A can only happen if B has been implemented first), Facilitation (A works better after B has been implemented), Synergy (2-way facilitation), Potential contradiction, Contradiction</p>	<p>Local to national scale</p> <p>They use these attributes to rank each measure and score them from 1 (low) to 5 (high). The possibility of applying weights on each of the attributes is subject to experts and will depend on the policy's main objectives.</p> <p>5 types of relations between each pair of measures to be able to map them using a network-centric approach.</p> <p>e.g.,: the objective of the policy is walking and cycling in the city in this case</p>
DEFINITE (Decision on a finite set of alternatives) [12]	MCA, CBA, CEA	<p>5 different multi-criteria methods</p> <p>Cost-benefit Analysis</p> <p>Cost-effectiveness Analysis</p>	<p>To improve the quality of environmental decision-making, by weighing alternatives to assess the most reasonable one.</p> <p>Tool kit of methods used on wide variety of issues, includes a number of graphical methods for representation.</p> <p>Developed by the Institute for Environmental Studies at VU University in Amsterdam. The tool is not free (750 euros) so information on criteria are unavailable on the website.</p>

Table S1. Cont.

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Decision Support Methods Embedded within Adaptation Assessment Frameworks: ADAPTATION AND DEVELOPMENT</i>			
Criteria for selecting priority activities in LDCs for NAPA preparation [13]	MCA, CBA or CEA suggested	<p>2 orders of criteria:</p> <p>level of CC adverse effects, poverty reduction enhancing AC, synergy w/ other multilateral environmental agreements, cost-effectiveness loss of life and livelihood, human health, food security & agriculture, water security, infrastructure, cultural heritage, biodiversity, land-use mgt & forestry, coastal zones & associated loss of land</p>	<p>National scale (LAPAs are also being developed for local scale)</p> <p>Steps 4 and 5 of the NAPA preparation process→outcome of NAPA is a list of adaptation priority activities, in line with the country’s development goals and poverty reduction programs</p> <p>e.g.: NAPA for LDCs are available online</p>
Climate change and environmental degradation risk and adaptation assessment (CEDRA) [14]	MCA participatory	<p>Environmental sustainability: short and long term, Impact: effective in addressing climate impacts, Building the capacity of vulnerable people, Building on community’s existing coping mechanisms, Cost-effectiveness, Time-frame, Maladaptation risks, No-regrets, Compatibility with cultural and social norms, Policy environment, Complementarity</p>	<p>National scale</p> <p>Overall 7-step approach to climate change and environmental degradation risk and adaptation assessment (CEDRA), within which Step 5 concerns “Identify and prioritize adaptation options”</p> <p>e.g.: case study in Zimbabwe on farming practices adaptation in communities</p>
How to integrate climate change adaptation into national-level policy and planning in the water sector [15]	CBA and MCA	<p>Political feasibility; Cost-effectiveness based on Cost-Benefit Analysis; Timeframe; Practicality of the option; Effectiveness in building capacity of vulnerable people; Chance of unintended negative consequences; Number of people helped; Environmental sustainability short & long term; Compatibility with national adaptation objectives; Likelihood of success regardless of climate change (e.g., no regrets/low regrets characteristics)</p>	<p>National scale: water sector</p> <p>Overall 4-tasks practical guide. One step of Task 3 ‘Develop and implement a climate-resilient action plan for water sector’ to select the appropriate adaptation options.</p>

Table S1. *Cont.*

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Decision Support Methods Embedded within Adaptation Assessment Frameworks: ADAPTATION AND DEVELOPMENT</i>			
Community Risk Screening Tool – Adaptation and Livelihoods CRiSTAL [16]	MCA participatory	Helps vulnerable groups Number of beneficiaries Sustainable with long-term climate change Political feasibility Cultural appropriateness Long-term cost-effectiveness Greenhouse gas emissions (mitigation)	Local scale/community scale Decision making framework centered on livelihoods. Tool to help users integrate climate adaptation into community-level projects Participatory process focused on livelihood and climate-risks e.g., Launched in 2007 and since then applied in over 20 countries in Asia, Africa and Latin America by various institutions and development professionals
Opportunities and Risks of Climate Change and Disasters—ORCHID [17] <i>et al.</i>	CBA participatory	Cost-benefit analysis: 3 criteria: Net Present Value (NPV) Benefit-Cost Ratio (BC) Internal Rate of Return (IRR) Economic analysis: comparison of costs and benefits	Local to national scale Systematic consideration of climate risks in the context of development aid programs. Climate risks screening of development interventions in Bangladesh.
A UNDP Toolkit for Practitioners: Designing climate change adaptation initiatives [18]	MCA (with CBA & CEA)	Considerations when formulating a plan for expected initiative results MCA: Cost-benefit ratio Flexibility/Robustness Cost-effectiveness Sustainability Replicability Cross-cutting: stakeholder involvement	National scale/sub-national scale/local scale Aimed at practitioners called up to support adaptation initiatives It's a step-by-step process, but looks more like guidelines than an actual tool used to prioritize. Hypothetical examples

Table S1. Cont.

Tool Name, Author and Year	Method Used	Criteria Used	Objectives
			Means
			Example
<i>Adaptation Decision Support Methods Embedded within Adaptation Assessment Frameworks: ADAPTATION AND DEVELOPMENT</i>			
Climate change adaptation planning: a Nunavut toolkit [19]	Risk assessment (very simple) participatory	<p>Risks are considered in terms of:</p> <ul style="list-style-type: none"> expected frequency (rare, sometimes, often) extent of damage (low, moderate, high) cost of adaptation (low, moderate, high) <p>Opportunities are ranked by:</p> <ul style="list-style-type: none"> economic impacts (low, moderate, high) ease of implementation (easy, moderate, difficult) 	<p>Local scale/community scale</p> <p>5 steps, among which the 3rd one concerns preparing the plan to prioritize risks and opportunities.</p> <p>Participatory process, straightforward assessment as it is subjective.</p> <p>e.g.: Nunavut (NCCP)</p>
		<i>Adaptation Decision Support Methods Embedded within Adaptation Assessment Frameworks: ADAPTATION IN ORGANIZATIONS</i>	
United Kingdom Climate Impacts Programme [20]	CBA or MCA	<ul style="list-style-type: none"> - effectiveness, efficiency, equity, flexibility, sustainability, practical, legitimacy, urgency, costs (not only economic, but social and environmental), robust, synergies/coherence with other strategic objectives, other factors 	<p>Local to regional scale: being used in organizations</p> <p>5 steps, among which the 4th concerns: <i>Identify, assess and implement adaptation options</i></p> <p>Available online: wizard, tables on excel to fill and checklist of each step on Word.</p> <p>This tool has been used in several organizations with the help of UKCIP</p>
		Climate Adaptation Toolkit CAT [21]	

Evaluation Rubric for the Multi-Criteria Decision Analysis (MCDA) of the Adaptation Prioritization Framework

A. *Timescale of An Adaptation Option*

These temporal elements should be found in adaptation planning documents and discussed during stakeholder and expert workshop to ensure that the timescale of adaptation is taken into account and includes all stakeholders' viewpoints.

Three elements are used to assess the timescale of adaptation options:

A1. Timescale of implementation: time required to implement the adaptation option

- Short length of time to implement (1–2 months): score of 5
- Short to mid length of time to implement (3–4 months): score of 4
- Mid length of time to implement (5–6 months): score of 3
- Mid to long length of time to implement (7–8 months): score of 2
- Long length of time to implement (9–10 months): score of 1

A2. Delay: the length of time from implementation of the option to the time its effect is felt

- Effects are expected to be felt immediately after implementation: score of 5
- Effects are expected to be felt shortly (1–2 months) after implementation: score of 4
- Effects are expected to be felt 3–4 months after implementation: score of 3
- Effects are expected to be felt 4–5 months after implementation: score of 2
- Effects are expected to be felt long (5–6 months) after implementation: score of 1

A3. Timescale of effect: the length of time during which the option's effect will be felt after implementation (relates to sustainability)

- Effects of the adaptation option are expected to be long-lasting: score of 5
- Effects of the adaptation option are expected to last in the long-term (5 years & more): score of 4
- Effects of the adaptation option are expected to last in the mid-term (2–5 years): score of 3
- Effects of the adaptation option are expected to last in the mid to short term (2–3 years): score of 2
- Effects of the adaptation option are expected to last in the short-term (0–2 years) or effects will last as long as the intervention is still going on: score of 1

B. *Equity of An Adaptation Option*

Equity can be assessed by examining adaptation plans and the expected outcomes of options on the targeted population in the short-, mid- and long-term.

- High equity (score of 5): the option outcomes are expected to include all vulnerable populations, including marginalized groups, indigenous people and ensure gender/ethnic equality.
- Medium-high equity (score of 4): the option outcomes are expected to include some vulnerable populations, including marginalized groups, such as indigenous people.
- Medium equity (score of 3): the option outcomes target a widespread audience for maximum efficiency, and are expected to include a few of the most vulnerable populations.

- Medium-low equity (score of 2): the option outcomes target a widespread audience but do not consider the most vulnerable populations or marginalized people.
- Low equity (score of 1): the option outcomes do not target vulnerable populations, nor consider gender/ethnic inequalities.

C. Sustainability of An Adaptation Option

Examining past documents on climate change impacts, results from workshops conducted in the community, and adaptation plans as well as investigating expected outcomes, externalities, and co-benefits to other sectors can help analyze the sustainability and the compatibility of the option with other strategies at various spatial scales.

- High sustainability (score of 5): an option is sustainable when it is not only compatible with other sectoral policies (e.g., health care) and mitigation strategies, but also when it is consistent with cultural and social values of the given population, and when it is sufficiently flexible and robust to incorporate climate uncertainty. The option is sustainable if it is able to learn from and adapt to emerging conditions *without* resulting in unintended externalities.
- Medium-high sustainability (score of 4): the option is expected to provide some co-benefits to other sectors; the option ensures that most social and environmental welfare are not adversely affected by any unintended consequences. In this case, the option is flexible and robust; it remains useful and adaptable under uncertain and unexpected climate change manifestations in the long-term and may bring benefits regardless climate change.
- Medium sustainability (score of 3): the option is expected to provide few co-benefits to other sectors; the option does not necessarily ensure that most social and environmental welfare are not adversely affected by any unintended consequences. The option takes into account climate change uncertainty, and may be flexible or robust enough to sustain unexpected changes.
- Medium-low sustainability (score of 2): the option is not expected to provide co-benefits, and does not necessarily incorporate other policies. The option does not ensure that most social and environmental welfare are not adversely affected by any unintended consequences. The option does not sufficiently include climate change uncertainties.
- Low sustainability (score of 1): the option does not account for its externalities nor does it consider the current and future policies and strategies that might be affected by the option's outcomes. The option does not include climate change uncertainties.

D. Cost of An Adaptation Option

To assess this attribute, documents related to other strategic priorities at national and regional level should be examined and workshop with stakeholders conducted to ensure success and efficiency of the option regardless of climate change. For instance, a high cost means that the option requires financial support that has not been already invested in other policies. A medium cost means that the option can be mainstreamed into other development policies, while a low cost means that the option will be absorbed and mainstreamed into other development policies. Corresponding scores in MCDA: high cost = 1; medium cost = 2.5; low cost = 5).

Table S2. Evaluation Rubric Table for the Adaptation Prioritization Framework: MCDA.

Adaptation Performance Attributes & Refs	Definition	Questions	Qualitative Expressions	Information Needed	Source of Information
Timescale [5,11,14,15] <i>et al. et al.</i>	The timescale of an option refers to 3 elements: the time needed for implementation, the related delay in feeling the effects, and its continuity in time	Is the timescale of the option process well defined? How long does the implementation require to be complete? When are the effects expected to be felt? Does the option plan short, medium and/or long-term impacts/effects?	Time required to implement the adaptation option: short = 5, long = 1; Delay: long = 1, Immediate = 5; Timescale of effect: short = 1, long=5	Timescale of the implementation. Timescale of lasting implementation effect. Time from end of implementation to effect being felt (delay): immediate, medium, long	Detailed adaptation options planning documents from implementation to effect being felt. Workshop with stakeholders and experts.
Equity [20,22–24] <i>et al.</i>	Equity of an option refers to the fact that adaptation options should not adversely affect other areas or vulnerable groups.	Does it target countries & populations most worthy of assistance? Does it consider gender and/or ethnic inequalities? Do the expected results of the option consider marginalized groups? Does it negatively affect other areas or vulnerable groups?	Low = 1 Medium-low = 2 Medium = 3 Medium-high=4 High = 5	Population, period and area covered by the adaptation option (transparency in the approach used: utilitarian vs. egalitarian, or a combination). Inclusion of indigenous communities?	Adaptation plans and detailed adaptation impacts in the short- to long-term in the area.

Table S2. Cont.

Adaptation Performance Attributes & Refs	Definition	Questions	Qualitative Expressions	Information Needed	Source of Information
<p>Sustainability [1,5,9,11,14,16,18,20,22,23, 25]</p>	<p>Sustainability of an option refers to the viability and the flexibility of an option in the long term with minimum externalities generated. Compatibility with current and future policies at the local, regional, and national levels.</p>	<p>Is the option consistent/compatible with: National/sub-national sustainable strategies, National adaptation objectives, Millennium Development Goals, National development objectives, Disaster Risk Reduction programs Other sectoral policies Mitigation strategies Indigenous peoples' livelihoods</p> <p>Does the option provide co-benefits to other sectors / domains? Are externalities considered? Does the option ensure that most social and environmental welfare are not adversely affected by any unintended consequences? Does the option consider and build upon the community/region's existing coping and adapting mechanisms, as well as past, present and future impacts in its planning process? Does the option remain useful under uncertain and unexpected climate change manifestations?</p>	<p>Low = 1 Medium-low = 2 Medium = 3 Medium-high=4 High = 5</p>	<p>Evidence of compatibility with other strategies at different spatial scales and with local livelihoods. Externalities of options at the social, political, environmental level in the long-term. Benefits of adaptation to continue after termination of projects. Evidence of evaluation of past adaptation's effectiveness Climate change uncertainty. Knowledge of strategic priorities in development and adaptation.</p>	<p>Adaptation option planning documents, tool kits describing different phases. Past documents and reports on adaptation/coping. Adaptation option plans. Analysis of potential negative externalities and co-benefits. Results of workshops with stakeholders and experts. Consideration of multiple climate change models Documents related to other strategic priorities at national & regional level.</p>
<p>Cost [5,11]</p>	<p>Total cost of adaptation option</p>	<p>How much does the adaptation option cost? How much of the cost can be absorbed in other adaptation options within the intervention?</p>	<p>Low cost = 5 Medium cost = 2.5 High cost = 1</p>	<p>Details on cost of design and implementation of adaptation option.</p>	<p>Documents on adaptation option planning and design: cost-benefit analysis, cost-effectiveness analysis, adaptation readiness, and financial feasibility.</p>

Table S3. List of adaptation options to adapt to food insecurity in an Inuit community setting in the Arctic.

TYPE	CODE	MEASURE (GOAL)	HOW?	WHY IS IT IMPORTANT?
Technical	FT1	Collaboration on weather and hazard forecasting between meteorologists and Inuit communities[26] <i>et al.</i> Level of action: local and territorial government	Improve weather and hazard forecasting to help hunters in their decision making on where to hunt and fish, through more regular radio broadcasting, and possibly thanks to more localized forecasting by local meteorologists.	Being able to make an informed decision on where to hunt and fish thanks to reliable information will prevent dangerous situations for hunters, and may help them in their anticipatory adaptation strategies.
Technical	FT2	Investment in community freezers [26] Level of action: local and territorial governments	A better conservation of food bought or locally harvested by providing freezers to community members or by investing in community freezers.	Refrigerating food can reduce food-borne diseases considerably and enhance food security.
Educational and advisory TK based intervention	FE1	Strengthening of institutional services for indigenous communities [27–29] Level of action: community; local and territorial governments	This measure aims at: Raising awareness of community conditions and needs, Facilitating cross-cultural communication, Improving communication between institutions, Building capacity among community representatives to solicit the services they are entitled to.	Improving institutional services in indigenous communities is necessary in order for the communities to obtain support from the local government to reach adaptation. In the Arctic context, community members say that more extensive programming and government support is needed [26].
Educational and advisory TK based intervention	FE2	Food safety education campaign [30] Level of action: community; local government	Promote safe practices such as avoiding high risky food, separating cooked and raw food, or washing hands, cutting boards and contaminated surfaces [30]. The food safety education is combined with traditional knowledge on food preparation and storage (in FC1).	Food-borne diseases are usually transmitted through ingestion of contaminated food or water or because of a contact with contaminated surfaces.

Table S3. Cont.

TYPE	CODE	MEASURE (GOAL)	HOW?	WHY IS IT IMPORTANT?
Educational and advisory TK based intervention	FE3	Promotion of livelihood diversification through capacity building programs [27] Level of action: community; local government	Organize programs such as: Capacity-building of business management, technical skill Foster formal livelihoods organizations (e.g. artisans committee) in order to improve market access and gain access to local and regional fairs. Improve local education quality and access to higher education Promote initiatives to develop commercial ventures based around traditional foods [26]	The main outcome of this measure is to increase ability to engage effectively in income-generating livelihoods other than traditional harvesting livelihoods in order to face food insecurity in case of traditional food shortages.
Educational and advisory NOT Technical	FE4 (FT2)	Foster community hunters through harvester support programs <i>et al.</i> [26: 184,28,29] Level of action: community; local and territorial governments	Strengthen support to Hunter Trapper Organization and existing Harvester Support Program to sustain hunting livelihoods and provide services that decreases costs of food to families by: Enhancing financial support (to cover the purchase of safety equipment and training costs), Promote co-management of wildlife Increasing their effectiveness, Better communicating programs to hunters, Better allocating funds in terms of transparency, Reviewing programs to account for new climate change data. These programs provide small equipment funds to help Inuit afford new tools for anticipating and managing risks.	Because it is increasingly more expensive to go hunting nowadays (cost of material, transport...), investing in capitalizing community hunters can contribute to reduce food insecurity and provide traditional foods, essential to indigenous peoples.

Table S3. Cont.

TYPE	CODE	MEASURE (GOAL)	HOW?	WHY IS IT IMPORTANT?
Cultural and behavior TK based intervention	FC1	Enhancement of traditional knowledge and land-skills training programs [28] <i>et al.</i> Level of action: community; local government	Training given by elders to younger generations to teach them land-skills while hunting. Elders also teach how to prepare and store traditional food (feeds into the food safety education). Training should also cover non- traditional harvesting skills, such as GPS use, snowmobile maintenance [28] <i>et al.</i> .	Important for cultural preservation. This option enhances hunting skills; strengthen relationships within the communities, with their cultural heritage and their elders. Through this training, community members can improve their food security.
Cultural and behavior TK based intervention	FC2	Promotion of community food programs [26,29] Level of action: individual and community; local government	Aimed at: Organizing community meetings and committees to discuss how to better access adequate food for families and promote healthy food [29], Improving collaboration on food production/distribution between and among communities Improving the distribution of traditional foods between communities (e.g., via Food banks), Subsidizing healthy store foods Extending the food mail program to include traditional foods (Arctic specific) Strengthening food sharing relationships within communities	Giving access to affordable food in stores to enhance food security. Regular knowledge exchange among communities is important to better access both traditional and store foods and to prevent the spread of food-borne diseases.

Legend for the codes: F for Food; T for Technical options; E for Education and advisory options; C for Cultural and behavior options. (Adapted from [30,31])

Table S4. Detailed results of the MCDA for the pilot case study on adaptation to food insecurity in an Inuit community setting in the Arctic.

Criteria	Score	Option FT1: Collaboration on Weather and Hazard Forecasting between Meteorologists and Inuit Communities (Level of Action: Local and Territorial Government)	Score	Option FT2: Investment in Community Freezers (Level of Action: Local and Territorial Governments)	Score	Option FE1: Improve Institutional Services for Indigenous Communities (Level of Action: Community; Local and Territorial Governments)	Score	Option FE2: Food Safety Education Campaign (Level of Action: Community; Local Government)
A1. Timescale of implementation	4	We estimate that this option will take 3 to 4 months to be implemented and to set up an exchange platform for hunters and meteorologists.	4	Assuming the funds are available. 3 months to set up the community freezers and raise awareness about their usefulness for community members (safety, food security). <i>(goes with food safety education program)</i>	3	We estimate that it may take between 5–6 months to: assess community conditions and needs, act upon the needs identified, set up a platform to facilitate cross-cultural communication, improve communication between institutions, and build capacity among community representatives.	4	Education campaigns work in the long term. It may take up to 2–3 months to set up the campaign.
A2. Delay: time till effect is felt	4	The effects are expected to be felt shortly after implementation (1–2 months)	4	The benefits and effects of investing in community freezers may be felt shortly after their implementations, <i>i.e.</i> between 1 to 2 months after the freezers are effectively being used.	3	The benefits and effects of improving institutional services to indigenous communities may be felt 3–4 months after its implementation.	4	The benefits and effects of the food safety education campaign may be felt shortly after its implementation, <i>i.e.</i> , between 1 to 2 months after the campaign is effectively running.

Table S4. *Cont.*

Criteria	Score	Option FT1: Collaboration on Weather and Hazard Forecasting between Meteorologists and Inuit Communities (Level of Action: Local and Territorial Government)	Score	Option FT2: Investment in Community Freezers (Level of Action: Local and Territorial Governments)	Score	Option FE1: Improve Institutional Services for Indigenous Communities (Level of Action: Community; Local and Territorial Governments)	Score	Option FE2: Food Safety Education Campaign (Level of Action: Community; Local Government)
A3. Timescale of effect	3	Hunters will definitely learn valuable insights from meteorologists' analysis. Effects are expected to last within 2 to 5 years or longer if the platform exchange becomes a permanent part of hunting practices and weather forecast in the North. In other words, it will last as long as the program is on.	4	We estimate that effects will last for 5 years and more, or as long as the freezers run and can be maintained.	3	We estimate that the continuity in the effects of this option will last within 2 to 5 years and will largely depend on the knowledge transfer from one government to the next.	3	The timescale of the effects will depend on the quality of the campaign and the level of awareness raised on food safety. We estimate this campaign's effects to last within 2 to 5 years after the first effects are felt.
B. Equity	4	This measure is designed to improve access to indigenous and traditional livelihoods, however the some communities may not be able to have access to this information due to their remote locations.	3	Although this measure targets all community stakeholders, community freezers will not be useful to people living far away from the community center.	4	Improving services for indigenous communities allows giving voice to the most vulnerable population.	3	The food safety education campaign targets as many communities as possible, but might exclude marginalized population located in remote areas.
C. Sustainability	3	This option is expected to provide some co-benefits to other sectors, such as the economy (in terms of more hunting), health, and education. These effects are expected to be sustainable if the program keeps receiving funding and if the collaboration is between hunters and meteorologists is maintained on a regular basis.	5	The option's outcomes are not only expected to last in the long term, but also to provide co-benefits to other sectors such as health, wellbeing, economy, and education.	4	The option's outcomes are not only expected to last within 2 to 5 years after implementation is complete, but also to provide co-benefits to other sectors such as health, education, and culture.	4	The option's outcomes are expected to provide co-benefits to other sectors such as health, education, and culture, without adversely affecting social and environmental welfare.

Table S4. Cont.

Criteria	Score	Option FT1: Collaboration on Weather and Hazard Forecasting between Meteorologists and Inuit Communities (Level of Action: Local and Territorial Government)	Score	Option FT2: Investment in Community Freezers (Level of Action: Local and Territorial Governments)	Score	Option FE1: Improve Institutional Services for Indigenous Communities (Level of Action: Community; Local and Territorial Governments)	Score	Option FE2: Food Safety Education Campaign (Level of Action: Community; Local Government)
D. Total cost	1	This option’s total cost estimate is relatively high.	2.5	This option’s total cost estimate is medium.	2.5	This option’s total cost estimate is medium.	5	This option’s total cost estimate is relatively low.
Total score	19	This measure scores the lowest among the three technical adaptation options (19). We argue that this score reflects the challenging nature of implementing and sustaining in the long term an exchange platform with meteorologists, be they based in the North or in the South. This option has the potential to help hunters better understand climate change and hazard in order to pursue their traditional livelihoods and provide traditional foods for their family/community and revenue to buy store foods.	22.5	This measure scores high in all attributes, except for equity because remote indigenous communities may be involuntary excluded. Nonetheless, we argue that this is an option that proves to be efficient to increase food security by securing and stabilizing access to food.	19.5	This measure scores only 19.5 in the adaptation performance, largely because of the time needed to implement and sustain institutional change in the long term. Once implemented, it will support programs dedicated to help indigenous improve their food security in the face of climate change.	23	This measure scores only 23, largely because it may exclude marginalized population and therefore scores low on equity, but also because the timescale of the effects will depend on the quality of the campaign and the level of awareness raised on food safety.

Table S4. Cont.

Criteria	Score	Option FE3: Promotion of Livelihood Diversification through Capacity Building Programs (Level of Action: Community; Local Government)	Score	Option FE4: Foster Community Hunters through Harvester Support Programs (Level of Action: Community; Local and Territorial Governments)	Score	Option FC1: Enhancement of Traditional Knowledge and Land-Skills Training Programs (Level of Action: Community; Local Government)	Score	Option FC2: Promotion of Community Food Programs (Level of Action: Individual and Community; Local Government)
A1. Timescale of implementation	3	1–2 months to set up the capacity building programs and to raise awareness about the programs (users needs assessments) + 2 months to get the capacity building programs running.	3	We estimate that this measure may take 4 to 5 months to be set up in communities.	4	2-3 months to set up every aspect of training that needs to be covered by elders and to organize timing for younger generations to meet with elders in one place. 3rd month: start looking for feedback (M&E)	4	Assuming the funds are available. 3 months to: raise awareness about the programs (through meetings twice a month), start subsidizing healthy foods in stores and extend the food mail program to traditional foods + 3rd month: start looking for feedback (M&E)
A2. Delay: time till effect is felt	3	The benefits and effects of the capacity building programs may be felt 3–4 months after their implementation, allowing for time to look for and find income-generating opportunities in the nearest village or city.	4	Harvesters will feel the effects of this measure immediately after they benefit from its implementation (training and safe equipment costs covered). Other components of the support programs will be felt later on (wildlife co-management, better communication of the programs to hunters).	4	The benefits and effects of the traditional knowledge and land-skills programs may be felt shortly after its implementation, <i>i.e.</i> between 1 to 2 months after the programs are effectively running.	4	The benefits and effects of investing in community food programs may be felt shortly after their implementations, <i>i.e.</i> , between 1 to 2 months after the programs are effectively running.

Table S4. *Cont.*

Criteria	Score	Option FE3: Promotion of Livelihood Diversification through Capacity Building Programs (Level of Action: Community; Local Government)	Score	Option FE4: Foster Community Hunters through Harvester Support Programs (Level of Action: Community; Local and Territorial Governments)	Score	Option FC1: Enhancement of Traditional Knowledge and Land-Skills Training Programs (Level of Action: Community; Local Government)	Score	Option FC2: Promotion of Community Food Programs (Level of Action: Individual and Community; Local Government)
A3. Timescale of effect	4	The timescale of the effects will depend on the income-generating opportunity that was found by stakeholders. We estimate that on average the benefits of the capacity building program to find income generating opportunities will last in the long-term (5 years and more). If one opportunity does not work out, then another one can be sought out.	4	We estimate that this option's outcomes will be felt for 5 years or more once implemented.	4	The timescale of the effects will depend on the quality of the campaign and the level of awareness raised on food safety. We estimate the effects of traditional knowledge and land-skills programs to last in the long-term (5 years and more) as long as the elders and young generations keep exchanging.	3	Once implementation is complete, the lasting effects of the programs will depend on the uptake of programs such as food sharing relationships within communities and collaboration on food production/distribution between communities. We estimate that effects will last within 2 to 5 years, because some of the programs require funding from the local/territorial governments, hence these are conditional on sufficient funding.
B. Equity	3	This measure targets as many communities as possible, but might exclude marginalized population located in remote areas too far away from income generating livelihoods.	5	This measure is targeted at improving community hunters' equipment and aims at covering as many communities as possible by starting with the most vulnerable ones.	4	Because communities guide this option, its outcomes are expected to include vulnerable populations, including marginalized groups, such as indigenous people.	4	Thanks to a strong partnership between communities and government, this option's outcomes will include vulnerable populations, including marginalized groups, such as indigenous people.

Table S4. *Cont.*

Criteria	Score	Option FE3: Promotion of Livelihood Diversification through Capacity Building Programs (Level of Action: Community; Local Government)	Score	Option FE4: Foster Community Hunters through Harvester Support Programs (Level of Action: Community; Local and Territorial Governments)	Score	Option FC1: Enhancement of Traditional Knowledge and Land-Skills Training Programs (Level of Action: Community; Local Government)	Score	Option FC2: Promotion of Community Food Programs (Level of Action: Individual and Community; Local Government)
C. Sustainability	5	The option's outcomes are not only expected to last in the long term, but also to provide co-benefits to other sectors such as health, wellbeing, economy, and education.	5	The option's outcomes are not only expected to last in the long term, but also to provide co-benefits to other sectors such as health, wellbeing, economy, and education.	5	The option's outcomes are not only expected to last in the long term, but also to provide co-benefits to other sectors such as health, wellbeing, economy, and education.	4	The option's outcomes are expected to provide co-benefits to other sectors such as health, education, and culture, without adversely affecting social and environmental welfare.
D. Total cost	5	This option's total cost estimate is relatively low.	2.5	This option's total cost estimate is medium.	5	This option's total cost estimate is relatively low.	2.5	This option's total cost estimate is medium.
Total score	23	We argue that this measure scores lowest among soft measures because it is driven by the local government and promotes non-traditional livelihoods, which may not be seen as successful for indigenous communities. However, once implemented, the potential benefits for the community are not only expected to last in the long term, but also to provide co-benefits to other sectors such as health, wellbeing, economy, and education.	23.5	This measure scores the second highest among the 8 options (23.5). Although it may take 4 to 5 months to implement and it has a rather low stakeholder involvement, fostering community hunters through harvester support programs will show efficient outcomes in terms of acceptability and equity among communities and proves to be sustainable, flexible and well transferrable. Therefore we can argue that this measure increases access to traditional foods and increases food security at large, at a medium cost of implementation.	26	This measure scores the highest among the 8 options presented in this intervention. We argue that its community driven approach ensures a high adaptation performance on all attributes as it aims at preserving traditional and indigenous knowledge and land-skills while also integrating modern techniques in a rather short timeframe with long-term effects and a low cost of implementation.	21.5	We argue that its community driven approach ensures a high adaptation performance on all attributes as it aims at promoting collaboration on food production and distribution between and among communities while also promoting healthy food on a regular basis via community meetings in a rather short timeframe with long-term effects and a medium cost of implementation.

Table S5. Example multi-relational matrix of the MCDA-NCA Adaptation Prioritization Framework.

Type of option	Code	Adaptation options— Description	Multi-Criteria Decision-Making Analysis						Network-Centric Analysis			
			A1. Timescale of implementation: time to implement	A2. Delay: time from implementation of the option to time its effect felt	A3. Timescale of effect: length of time effects of the adaptation option are expected to last	B. Equity	C. Sustainability	D. Total cost	TOTAL (without weights: max = 30; min = 6)	Interactions between adaptation options		
	Weights		1	1	1	1	1	1		AO1	AO2	AO3
Technical; education; cultural	AO1	Adaptation Option 1	4	4	3	4	3	5	23		P	-
Technical; education; cultural	AO2	Adaptation Option 2	4	4	4	3	5	2.5	22.5	-		S
Technical; education; cultural	AO3	Adaptation Option 3	3	3	3	4	4	2.5	19.5	F	S	

References

1. Ebi, K.L.; Burton, I. Identifying practical adaptation options: An approach to address climate change-related health risks. *Environ. Sci. Policy* **2008**, *11*, 359–369.
2. Ebi, K.L. Protection Health from Climate Change—Vulnerability and adaptation assessment (WHO Adaptation Resources for Health Partners). Available online: <http://www.who.int/globalchange/resources/adaptationresources/en/> (accessed on 7 July 2015).
3. Taylor, R. Climate adaptation options explorer (adx) (version 2.1). Available online: <http://weadapt.org/knowledge-base/adaptation-decision-making/adaptation-decision-explorer> (accessed on 21 May 2014).
4. Qin, X.-S.; Huang, G.H.; Chakma, A.; Nie, X.H.; Lin, Q.G. A mcdm-based expert system for climate-change impact assessment and adaptation planning—A case study for the Georgia Basin, Canada. *Expert Syst. Appl.* **2008**, *34*, 2164–2179.
5. Debels, P.; Szlafsztein, C.; Aldunce, P.; Neri, C.; Carvajal, Y.; Quintero-Angel, M.; Celis, A.; Bezanilla, A.; Martínez, D. Iupa: A tool for the evaluation of the general usefulness of practices for adaptation to climate change and variability. *Nat. Hazards* **2009**, *50*, 211–233.
6. Bruin, K.; Dellink, R.B.; Ruijs, A.; Bolwidt, L.; Buuren, A.V.; Graveland, J.; Groot, R.S.D.; Kuikman, P.J.; Reinhard, S.; Roetter, R.P.; *et al.* Adapting to climate change in The Netherlands: An inventory of climate adaptation options and ranking of alternatives. *Clim. Chang.* **2009**, *95*, 23–45.
7. Mizina, S.V.; Smith, J.B.; Gossen, E.; Spiecker, K.F.; Witkowski, S.L. An evaluation of adaptation options for climate change impacts on agriculture in Kazakhstan. *Mitig. Adapt. Strateg. Glob. Chang.* **1999**, *4*, 25–41.
8. Eriksen, S.; Aldunce, P.; Bahinipati, C.S.; Martins, R.D.A.; Molefe, J.I.; Nhemachena, C.; O'Brien, K.; Olorunfemi, F.; Park, J.; Sygna, L.; *et al.* When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Clim. Dev.* **2011**, *3*, 7–20.
9. World Resources Institute (WRI). *Bellagio Framework for Adaptation Assessment and Prioritization (Working Paper)*; WRI: Washington, DC, USA, 2009.
10. Haque, A.N.; Grafakos, S.; Huijsman, M. Participatory integrated assessment of flood protection measures for climate adaptation in Dhaka. *Environ. Urban.* **2012**, *24*, 197–213.
11. Taeihagh, A.; Givoni, M.; Bañares-Alcántara, R. Which policy first? A network-centric approach for the analysis and ranking of policy measures. *Environ. Plan. B: Plan. Des.* **2013**, *40*, 595–616.
12. Spatial Information Laboratory. Definite—A DSS for a Finite Set of Alternatives. Available online: <http://www.ivm.vu.nl/en/projects/Projects/spatial-analysis/DEFINITE/index.asp> (accessed on 8 July 2015).
13. Least Developed Countries Expert Group. Annotated Guidelines for the Preparation of National Adaptation Programmes of Action. Available online: http://unfccc.int/resource/docs/publications/annguid_e.pdf (accessed on 8 July 2015).
14. CEDRA. Step 5: Adaptation: Identify and prioritise adaptation options. In *Climate Change and Environmental Degradation Risk and Adaptation Assessment*; Tearfund: Teddington, UK, 2012; pp. 49–61.

15. Venton, P. How to Integrate Climate Change Adaptation into National-Level Policy and Planning in the Water Sector: A Practical Guide for Developing Country Governments; Tearfund: Teddington, UK, 2010.
16. International Institute for Sustainable Development (IISD). *Community-Based Risk Screening Tool—Adaptation and Livelihoods (Cristal User’s Manual—Version 5)*; IISD: Winnipeg, MB, Canada, 2012.
17. Tanner, T.; Conway, D.; Hassan, A.; Alam, M.; Islam, N.; Ahmed, A.; Mechler, R. *Orchid: Piloting Climate Risk Screening in Dfid Bangladesh. Research Report*; Institute of Development Studies, UKCIP: Sussex, UK, 2007.
18. United Nations Development Programme (UNDP). *Designing Climate Change Adaptation Initiatives: A UNDP Toolkit for Practitioners*; UNDP, Bureau for Development Policy: New York, NY, USA, 2010.
19. Bowron, B.; Davidson, G. *Climate Change Adaptation Planning: A Nunavut Toolkit*; Canadian Institute of Planners: Ottawa, ON, Canada, 2011.
20. UK Climate Impacts Programme (UKCIP). *The UKCIP Adaptation Wizard v 3.0—UKCIP*; UKCIP: Oxford, UK, 2010.
21. Bellamy, R.; Aron, H. *The Climate Adaptation Tool: A Practical Guide in Adapting to Climate Change*; Norfolk Climate Change Partnership: Norwich, UK, 2010.
22. Adger, W.N.; Arnell, N.W.; Tompkins, E.L. Successful adaptation to climate change across scales. *Glob. Environ. Chang.* **2005**, *15*, 77–86.
23. Brooks, N.; Anderson, S.; Ayers, J.; Burton, I.; Tellam, I. *Tracking Adaptation and Measuring Development*; International Institute for Environment and Development (IIED): London, UK, 2011.
24. Keskitalo, E.C.H. Governance in vulnerability assessment: The role of globalising decision-making networks in determining local vulnerability and adaptive capacity. *Mitig. Adapt. Strateg. Glob. Chang.* **2009**, *14*, 185–201.
25. Fankhauser, S.; Smith, J.B.; Tol, R.S.J. Weathering climate change: Some simple rules to guide adaptation decisions. *Ecolog. Econ.* **1999**, *30*, 67–78.
26. Ford, J.D.; Pearce, T.; Furgal, C.; Duerden, F.; Smit, B. Climate change policy responses for Canada’s inuit population: The importance of and opportunities for adaptation. *Glob. Environ. Chang.* **2010**, *20*, 177–191.
27. Vásquez, J.; Mori, R.; Zucchelli, M.; Zito, A.; Lindner, A.; Rebaza, A.M. *Emergency Support to the Communities Most Affected by the Flood in Ucayali—2011*; INDECI, Ucayali Regional Government, ECHO, OCHA, FAO, UNICEF, COOPI, German Red Cross (Peru): Lima, Peru, 2012.
28. Ford, J.; Pearce, T.; Smit, B.; Wandel, J.; Allurut, M.; Shappa, K.; Ittusujurat, H.; Qrunnut, K. Reducing vulnerability to climate change in the arctic: The case of nunavut, canada. *Arct. Inst. North Am.* **2007**, *60*, 150–166.
29. Chan, H.M.; Fediuk, K.; Hamilton, S.; Rostas, L.; Caughey, A.; Kuhnlein, H.; Egeland, G.; Loring, E. Food security in nunavut, Canada: Barriers and recommendations. *Int. J. Circumpolar Health* **2006**, *65*, 416–431.
30. Markandya, A.; Chiabai, A. Valuing climate change impacts on human health: Empirical evidence from the literature. *Int. J. Environ. Res. Public Health* **2009**, *6*, 759–786.

31. WHO. Climate Change and Health: A Tool to Estimate Health and Adaptation Costs. Available online: <http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/Climate-change/publications/2013/climate-change-and-health-a-tool-to-estimate-health-and-adaptation-costs> (accessed on 5 July 2013).

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