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Climate Change Adaptation: Planning for BC

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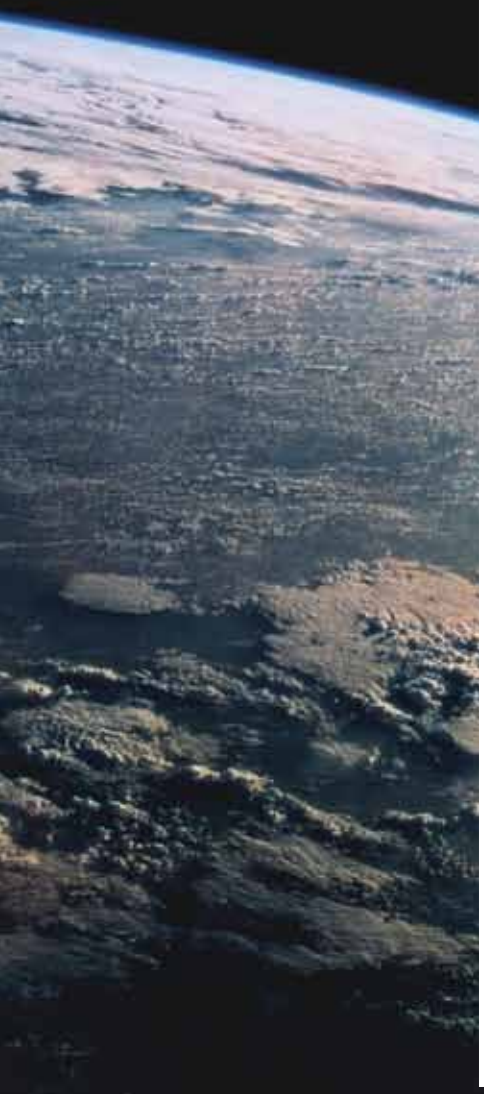

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In this paper, we have done our best to do justice to the vast volume of climate change and adaptation literature and initiatives currently available. However, there will inevitably be important factors and data that are not included. We would therefore like to characterize this paper as a snapshot of current threats, selected relevant activities in BC and elsewhere, notable recommendations that have been made, and additional thoughts based both on these considerations and BC resources.

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INTRODUCTION

Awareness of the need for climate change adaptation is growing as the Intergovernmental Panel on Climate Change (IPCC) projections for weather extremes are validated around the globe. The pressure to develop responses is also increasing, as it becomes clear that global emissions are now higher than the concentrations on which the IPCC's worst-case calculations are based, and therefore climate change impacts may occur faster and be more severe than originally thought.[1] While adaptation has by necessity been built into certain climate-vulnerable sectors, countries around the world are acknowledging this new pressure and associated action is apparent on every continent. The pace of change will have a profound effect on a wide variety of processes, such as public policies, in economic, environmental and social terms; major impacts to resources and infrastructure are already galvanizing planning in cities like Toronto and sectors such as BC's forestry industry.

As we move ahead with planning for responses to the challenges, it is essential to acknowledge the links between adaptation and mitigation, or emissions reduction. Both concepts require major investment in research, education and infrastructure, and coordination of these actions would be beneficial in developing "smart adaptation" that supports comprehensive, effective responses. Smart adaptation policies cut across all major government functions—infrastructure, energy, water, economic development, resource management, agriculture—and therefore require an integrated response as part of a long term strategy. Best practices indicate that one lead agency must be identified to guide this approach, and that funding must derive from the combined public, private and non-profit sectors, as no one sector alone will have sufficient resources. BC's Climate Action Secretariat (CAS) has already assumed a leadership role on mitigation, and the provincial government is currently building momentum on adaptation; it would therefore be ideal for the CAS to integrate smart adaptation into its mandate, and to lead this planning as a complement to the work already being done.

Adaptation to the stresses induced by climate change builds resilience, and there is also now an opportunity to effect the transition from a traditional resource-based economy to an ecosystem-based economy that recognizes and values environmental goods and services, and diversifies the economic base at a time when the traditional base is being challenged. The CAS should include in its mandate the means to study this transition as well as ways to incorporate these values into decision-making across the board.

Extensive resources exist to assist with these initiatives in BC's universities and the private and not-for-profit sectors, which together boast some of the nation's most dynamic innovators.

This paper summarizes some key principles of smart adaptation; explores the climate challenge in the context of nine top-of-mind issues; and proposes a set of over-arching recommendations that would help to facilitate the development of smart adaptation in BC.

KEY ADAPTATION PRINCIPLES

Adaptation practices have largely developed piecemeal in reaction to challenges in a variety of sectors, and it has therefore been difficult to mandate adaptation as a practice; however, certain measures and strategies that consistently cut across individual contexts and challenges are emerging. These key principles range from strategic communications and organizational

development such as inter- and multi-disciplinary team-building,[2,3] institutional capacity development and stakeholder engagement,[4,5,6] and mainstreaming adaptation planning into existing mechanisms;[7] through knowledge exchange and transfer,[8] long-term community pilots and models,[9] and assessment and planning tools;[10,11] to development of tools and practices such as enhancing and maintaining ecological services;[12] strategic incentives, financial and market-type instruments,[13] updated legislation, standards and codes,[14] technological innovations,[15] and new surveillance and monitoring programs.[16] The emergence of these principles offers a strong foundation for smart adaptation planning in BC.

TOP-OF-MIND ISSUES

Much work has already been done to identify key climate change challenges by region (e.g. NRCan 2007) and by industry sector (e.g. BC Hydro). This section highlights critical issues that cut across regions and sectors; each is summarized in terms of threats; current BC responses and precedents being set in Canada and around the world; recommendations under discussion; and next steps specific to each issue.

Biodiversity

BC has become a refuge for many species and now boasts the highest biodiversity of any province. Climate change poses an imminent challenge for this extraordinary legacy.[17] With only a 1°C increase in mean annual temperature, ecosystems are expected to shift as much as 150km northwards and 300m in elevation, increasing fragmentation and loss of vulnerable habitat[18] and diminishing the effectiveness of BC's protected areas to preserve biodiversity.[19,20,21,22] Climate impacts will have especially severe effects on some regions; for instance, coastal forests will suffer from increased storm activity and intensity, while increasing temperatures and loss of soil moisture combined with the proliferation of pest species such as the mountain pine beetle, will result in worsening wildfires.[23, 24,25,26] Impacts to aquatic systems are of high concern: climate-induced changes in water supplies are already disrupting BC's freshwater ecosystems[27,28,29] and impacts on marine protected areas caused by increasing ocean temperatures and chemistry changes[30] require significant additional investment in research. As climate change affects BC's terrestrial and marine ecosystems, resource-based communities are being forced to adapt, in particular those dependent on BC's forestry industry.[31]

Several provincial government initiatives are already addressing these issues, such as the Climate Action Plan,[32] the Conservation Framework,[33] the Living Water Smart Plan,[34] Forests for Tomorrow,[35] and the Future Forest Ecosystem Initiative.[36] BC's involvement in NRCan's Regional Adaptation Collaboratives (RAC) program has the potential to further biodiversity-relevant adaptation planning, as will a federal commitment to establish a network of Marine Protected Areas by 2012.[37] Many BC communities are already adapting.[38] However, experts have noted institutional and policy barriers to adaptation; many strategies and guidelines are designed for the current climate regime.[39] Forest management is one example in which more guidelines and planning for adaptation are needed, along with experienced personnel to aid such activities.[40] While short-term funding is often available, access to long-term funding (>3 years) presents another barrier.[41]

Threats to biodiversity differ across BC. Therefore, planning to increase the resilience of BC's biodiversity requires consultation with communities as well as overarching leadership on ecosystem management and careful assessment of intersecting jurisdictional responsibilities.[42] Forestry adaptation strategies must incorporate new knowledge about climate and forest vulnerabilities as it develops.[43] Short-term actions should include development of new forest policies, training to develop adaptive capacity, and conducting vulnerability assessments.[44] Fisheries-specific recommendations that have been discussed include reducing harvest rates, reinforcing habitat protection and restoration, increasing hatchery production of salmon, licensing and regulating river systems, and increased investment in infrastructure for newly emergent fisheries.[45] It is also vital to consider ways to increase adaptive capacity and resilience in resource-based communities.[46] Examples of action elsewhere include Washington State's Forestry Preparation and Adaptation Working Group (PAWG), which recommends development of policies on knowledge transfer, data gathering, adaptive management, and education and outreach.[47] King County, Washington has plans directed at homeowners that have retained forests on their property.[48]

Key recommendations for BC biodiversity adaptation planning include: a) Resource decision-making that supports maintenance of ecosystem function to protect ecosystem resiliency. There should be a transition to a governance structure where decisions regarding land and water use are made consistent with supporting ecosystem function; over time, it may be more efficient to have all land and water-related decisions made by a single agency;[49] b) Key connectivity corridors and conservation networks between protected areas should be established where these are identified as critical migration corridors for species adjusting to climate change.[50] Restoration of degraded ecosystems would help to increase ecosystem resiliency; c) Increased monitoring of impacts of climate change to representative ecosystems in protected areas should be conducted, and boundaries amended or new protected areas created to maintain ecosystem integrity and diversity;[51] d) Ecosystem services such as flood control, drinking water quality, and low-flow augmentation in droughts should be evaluated as key issues in supporting communities as they adjust to climate change; and e) Secondary and post-secondary education programs should include a core course on biodiversity and the value of ecological goods and services.[52]

Extreme Events

Extreme weather and related events directly affect British Columbians more than any other climate risk. Climate models project a continuing rise in their frequency and severity,[53,54,55] with major impacts for communities, infrastructure, industry[56,57] and parks.[58] Remote communities are particularly vulnerable,[59] and the risks will be magnified in low-lying coastal areas by sea-level rise and increasing storms.[60,61] Emergency personnel describe the 2006 southern BC windstorms as the most destructive storm event for hydro and phone infrastructure in BC's history.[62] The impacts include high financial costs to industry and communities: extreme events recorded by BC's Provincial Emergency Program (PEP) from 2003-2005 cost on average $86 million per year, compared to $10 million per year from 1999-2002.[63] Risks also include water shortages and fire associated with frequent droughts;[64] at $250 million, the Insurance Bureau of Canada identifies the 2003 firestorm as the single largest Canadian insurance loss for a wildfire.[65,66,67,68]

The Pacific Climate Impacts Consortium (PCIC) provides a wide spectrum of key data about past, current and future climate and weather events in BC. Several BC government ministries

are planning for adaptation to extreme weather impacts through initiatives such as Living Water Smart,[69] PEP,[70] and the Emergency Response Management System,[71] and are working with the federal Department of Fisheries and Oceans (DFO) on rainwater management on Vancouver Island with the goal of promoting sustainable drainage practices province-wide.[72] The GVRD is a recognized leader in storm water management with its Greater Vancouver Integrated Storm Water Management Plan.[73] BC's NRCan RAC application proposes integrating flood adaptation into official community plans; improving interfaces for climate and other scenario usage; updating flood risk maps and developing decision-support tools such as the water balance model; implementing new infrastructure flood protection standards; and instituting new professional guidelines for flood hazard/risk assessment.[74]

Other provincial governments are also developing innovative approaches, such as Québec's Civil Protection Act, Ontario's Emergency Readiness Act,[75] and Alberta's Emergency Public Warning System.[76] Sécurité Publique Québec and the Canadian Red Cross Expect the Unexpected program provide disaster education and preparedness,[77] and Ontario's Institute for Catastrophic Loss Reduction (ICLR) has developed a disaster planning toolkit for businesses.[78] The Canadian Natural Hazards Assessment Project is a potential tool for governments seeking to identify and assess local hazards.[79] Municipal governments and scientists are developing a weather-resistant "Sustainable Subdivision" in Iqaluit, Nunavut.[80] Toronto; King County, Washington; Chicago; Queensland, Australia; the European Union (EU); the Dutch ARK program; and the UK Climate Impacts Programme (UKCIP) are all developing innovative planning for adaptation to extreme events.[81]

Overall critical infrastructure protection and planning resides with a host of public agencies from all levels of government, and work is needed to coordinate planning across jurisdictions to ensure consistent standards.[82] The ICLR recommends that communities incorporate natural hazard assessments into municipal planning to minimize risk, and enforce building codes to ensure enhancement of structural resilience.[83]

Energy

Activities of BC's energy sector most vulnerable to climate change include energy production, energy distribution, and energy demand.[84] Hydroelectricity currently accounts for nearly 90% of BC's power supply. Climate change impacts on snow pack and glaciers will limit quantity and alter timing of water availability for hydroelectric generation, as will increasing drought,[85] exacerbating competing water demands and threatening BC obligations in inter-provincial and international agreements.[86,87] Climate impacts in mountainous and permafrost regions threaten increased maintenance costs for pipeline infrastructure expansions.[88] A sustained increase in the number of storms and other major events poses threats to power delivery;[89] remote communities are particularly vulnerable to the impact of extreme weather events on critical electrical infrastructure.[90] Moreover, these challenges will be compounded by the fact that BC's electricity demands are expected to increase by 30-60% over the next 20 years,[91] partly as a result of increasing temperatures.[92]

It is essential that we study the potential for new energy generation and secure delivery of power on a province-wide basis, as well as considering the impact of weather extremes on energy distribution. Future energy demand forecasts and resource supply options must therefore consider climate change, as improved energy efficiency measures and building designs will only alleviate some of the expected increases in demand. Improvements in quantitative

stream-flow prediction modeling that take changing climate into consideration are a starting point in assessing supply vulnerabilities for hydroelectric power generation.[93] Another suggested measure is the expansion of reservoir systems to include supplemental 'pumped-storage' facilities, which store water above the reservoir to supply a generating station.[94] Numerous options already being modeled for developing adaptive responses to BC's energy include: Toronto's programs addressing increased energy demand during heat waves;[95] King County, Washington's land fill gas–to–energy project to meet increasing energy demands and reduce greenhouse gas emissions[96] and BC's Capital Regional District's plans for a similar program at Victoria's Hartland Landfill.[97] Tidal energy is emerging as a new option,[98] and BC's alternative energy technology innovation is developing fast in all areas. The UK has created the Department of Energy and Climate Change to explore the twin challenges of climate change and energy supply.[99]

Water Supply

Changes in hydrology and increasing floods and droughts are set to affect ecosystems and communities and exacerbate water use conflicts in many BC watersheds. Declining snowpack and glaciers and precipitation shifts will limit water supply during peak demand periods,[100,101] affecting key economic sectors including hydro, fisheries and agriculture, and impacting municipal infrastructure.[102] Key impacts include decreased summer and fall supplies; supply-demand mismatches in reservoirs; increased demands on water and sewage treatment facilities; and overloading of storm water management systems.[103] Concerns over surface and ground water-related impacts are growing as precipitation becomes more sporadic and extreme, with particular challenges for First Nations and other communities in remote areas.[104] Sea-level rise may impact groundwater due to saltwater intrusion,[105,106] and reduced summer flows will affect salmon habitat and other aquatic ecosystems, while longer low-flow periods could raise summer stream temperatures by almost 2°C, with serious implications for fisheries.[107]

Governments and stakeholders across the West are involved in planning processes to address water-related issues, such as BC's Climate Action and Living Water Smart plans,[108] the federal-territorial Canada-Yukon Water Supply Expansion Program, the Alberta Water Council, and the federal Pacific North Coast Integrated Management Area.[109] The BC government is committed to modernizing water laws via a legislative review.[110] MoE is partnering with Washington State's Department of Ecology on projections of Columbia River flows[111] and working with NRCan and PCIC to model effects of pine beetle and salvage logging on Fraser River hydrology and flood risks.[112] As noted above, the GVRD is a recognized leader in storm water management.[113] Knowledge transfer tools are being developed;[114] for instance, the Ministry of Community Services (MCS), in partnership with the Ministry of Health (MoH) and MoE, is creating a portal for small communities on fresh water, wastewater, and storm/rainwater management.[115] Decision-support and modeling tools are also available, such as the provincial-federal Water Balance Model.[116] The BC NRCan RAC's goals include irrigation demand models and targets, updated watershed risk assessment procedures, criteria and management policies for watersheds, a new forest management scenarios tool, and formation of a new Water and Aquatic Resources Network.[117] The Columbia Basin Trust's community pilot projects are good examples of multi-stakeholder negotiations in a voluntary governance system responding to climate change.[118] In the Okanagan, a participatory process was used to expand the dialogue on adaptation choices for water management to include domestic and agriculture uses and in-stream conservation flows.[119]

Many regions are in the advanced stages of developing water re-use technologies – King County is investing in a reclaimed water facility that will produce seven million gallons per day by 2010.[120] Australia's NSW Murray-Darling Basin Initiative, the largest integrated catchment management program in the world, emerged because no one government or group of people could cope with the Basin's natural resource management problems;[121] the Murray Wetlands Working Group has developed tools that help decision-makers manage wetland habitats and regulate river flows during prolonged droughts.[122] Also, Australia's $82 million National Groundwater Action Plan, initiated by the National Water Commission in 2007, is investing in projects to improve knowledge and understanding of groundwater.[123] BC can benefit by exchanging information with, and/or emulating, such programs.

Recommendations for further actions include: Revision of BC's Drinking Water Protection Act to reflect climate change concerns.[124] Water's role as a natural good/service must be analyzed, and key regional disturbances further examined in context of both individual area impacts and community adaptive decision-making, as well as provincial processes. Communities should develop a portfolio of demand-side measures to cope with projected changes in supply and demand.[125] A lack of regulations and guidelines regarding water reuse/recycling in Canada has been cited as a hindrance to implementing projects, and continued innovation, such as BC's upcoming legislation mandating reclaimed water regulation and purple pipes, in this area would be useful.[126] The desire to avoid future conflicts over water management objectives underscores the value of searching now for smart adaptive responses via informed dialogue, co-operation and integration among involved groups, and development of further tools to satisfy information needs for complex water management decisions.[127]

Crop Adaptation

British Columbia's agricultural sector faces both positive and negative impacts from climate change: shifting precipitation, worsening droughts, and increased water demand will stress most forms of agriculture, while on the plus side longer growing seasons and milder winters will increase the range of available crops and build development potential in certain regions. However, lack of water supply and transportation may present barriers,[128] and the ability to expand growing regions will be constrained by soil suitability and water availability.[129] Increasing requirements for irrigation are predicted for drier areas, and higher temperatures may result in new pests and diseases as well as forest fires that threaten crops.[130] Saltwater intrusion into aquifers may affect irrigation water supplies.[131,132] Climate change will also affect access to food resources for rural and First Nation communities.[133]

Specific horticultural responses include frost and heat protection, disease management and pest control; non-horticultural responses include introducing new grape varieties, alternative processing methods, and provision of crop insurance and government support programs, though we note that the latter may undermine measures taken by producers to reduce climate risks.[134]

Several countries and cities have already implemented adaptation into food production plans, for example: New Zealand's Sustainable Land Management and Climate Change Plan integrates agriculture into cross-sector strategies that produce both adaptive and mitigative benefits.[135] The Washington State Agricultural PAWG is examining the effect of climate change on water supplies for agriculture.[136] The Saskatchewan Soil Conservation Association supports development of collaborative adaptation research programs, and the federal govern-

ment has partnered with Alberta, Saskatchewan and Manitoba on the **Prairie Adaptation Research Collaborative**, which also fosters the development of new professionals in this emerging area.[137] Chicago's adaptation plan recommends research for farmers into crops that thrive under increased CO_2 scenarios,[138] and King County, Washington is carrying out collaborative research and outreach to farmers.[139]

Ongoing province-wide assessments are needed to ensure full understanding of changes in agricultural suitability.[140] Adaptation will involve irrigation that embraces conservation practices, and research into alternative methods would be helpful,[141] while studies of the impact on energy production of increased water use in agriculture would also be valuable. Outreach to the agricultural community is key to facilitate discussion amongst stakeholders. Investigation of food sources and new crop opportunities for remote communities and First Nations is needed, as is education for city-dwellers regarding the Agricultural Land Reserve and actions individuals can take to develop and support BC's food security. Urban agriculture such as community gardens, green roofs, etc. should be promoted and incentives offered as ways to improve urban food resiliency. Incentives can include tax reductions, subsidies, grants, discounts on utility bills, and promotions for urban agriculture, expedited permits for green projects, and density bonusing.[142] The City of Portland, which is considered a North American leader in green roof initiatives, has a stormwater discount program under which building owners receive discounts on their water and sewer bills if they have ecoroofs.[143]

Health Risks

The IPCC states: "Public health will be humanity's ultimate sacrifice as a result of climate change."[144] Direct threats include increases in injuries, illnesses and deaths related to air quality, natural hazards, extreme weather and heat; indirect threats include exposure to air-, water- and vector-borne diseases and declines in ecosystem health.[145,146] Respiratory symptoms will be aggravated by forest fires and increased ground-level ozone.[147,148] The ranges of disease vectors such as mosquitoes, ticks and rodents,[149] and exotic invaders such as *Cryptococcus gattii,* a potentially deadly tropical fungus,[150] are expanding. Extreme weather constitutes a significant risk to public safety through injuries, disease exposure and stress-related mental health effects.[151,152] Coastal community research links deteriorating ecosystem, economic and social conditions with health problems.[153] Risk of death due to heat waves is growing.[154] Rising ocean temperatures are likely to increase impacts of harmful algal blooms.[155,156] Increased health professional workloads combined with more frequent emergencies may reduce the resilience of the health system itself.[157] Certain populations face greater than average risks due to increased exposures, existing sensitivities or low adaptive capacity,[158] and the disadvantaged are likely to be disproportionately affected. The lack of incorporation of human health considerations into land-use planning, infrastructure development, emergency preparedness, environmental management, and transportation planning due to insufficient resources and approaches based on past climate trends also increases vulnerability.[159]

Actions on health adaptation vary widely. Public Safety and Emergency Preparedness Canada, for example, has developed a Community-wide Vulnerability and Capacity Assessment for communities.[160] London, UK's Health Inequalities Strategy notes that climate change is likely to increase dramatic inequalities that already exist in the health of Londoners and recommends action to address this.[161] King County Public Health is pursuing a multi-sectoral collaborative approach to enhance understanding and visibility of climate impacts to public health, reduce risks, develop response protocols, minimize exposure to toxics in water, and

address the health implications of flooding.[162] Toronto has developed two extreme weather alert plans designed to protect the city's most vulnerable populations from extremes of heat and cold.[163]

Public health adaptation requires cross-sectoral approaches and development of more accessible information on prevention, protection and treatment of climate-related diseases.[164] In developing adaptation schemes, authorities in the health and emergency management sectors would benefit from access to improved regional-scale climate-change forecasts; information on best-practice adaptation measures used elsewhere; infrastructure adaptation planning; careful monitoring of heat events and related impacts;[165] and improved identification of factors that make regions, communities and populations vulnerable, as well as data on the distribution of such groups.[166] Most Canadian emergencies are managed municipally or provincially; however, some adaptations such as emergency management initiatives require input from higher levels of government;[167] therefore, coordination at and among all levels is key. Mainstreaming information about climate-related health risks into existing risk management plans may be a more practical approach than creating new, stand-alone initiatives. As protecting health will require adaptation by sectors such as transportation, tourism, fisheries, forestry, agriculture, industry and energy, it would be ideal for the health sector to build close working relationships with these to promote awareness.[168]

Sea Level Rise

Sea-level rise is an important BC issue, potentially threatening billions of dollars in infrastructure such as highways, sewer systems, waste treatment facilities, residential housing in areas like Richmond, shipping and ferry terminals, and the Vancouver International Airport. A one-metre rise would inundate more than 4600 ha of farmland and more than 15,000 ha of industrial and residential urban areas in BC.[169] Approximately 220,000 people live near or below sea level, currently protected by 127 km of dykes not built to accommodate sea level rise.[170] Coastal communities are vulnerable to erosion and storm surges, and extreme high-water events are increasing.[171] Coastal tourism will be affected by increased coastal erosion and flooding hazards,[172] and associated impacts on infrastructure and services.[173] Sea-level rise also has the potential to affect the quality and quantity of fresh water supplies.[174,175]

MoE, DFO, and NRCan are reviewing dike standards and coastal development guidelines in view of projected sea level rise.[176] MoE and DFO have developed a forecasting model to help prepare for major storm events,[177] and the Water Stewardship Division has advocated new dikes and coastal development standards for flood protection that consider long-term sea level change.[178] Wetlands interfacing with marine areas may provide important buffers; Delta's Burns Bog is already providing both adaptive and mitigative benefits.[179] Delta is participating in an innovative visioning project that shows the community under alternative climate futures and planning scenarios, such as sea level rise and changing land and energy use, and the Corporation's Flood Management Plan includes a seawall/dyke improvement strategy.[180] All of these studies are critical as BC moves to take action on the threat that sea level rise presents to the Province within this century.

A number of relevant actions elsewhere are appropriate for consideration in a BC context. For example, New Zealand has produced a guidebook to help coastal communities cope with climate change-related coastal hazards.[181] Holland's Living with Water program notes the potential for new infrastructure such as floating houses and glasshouses, but also the

importance of new management approaches such as flexible coastlines instead of static ones in which water is kept out by dyke and dam constructions.[182] The EU acknowledges the importance of threats to coastal zones and the dangers entailed by rising seas combined with more violent storms,[183] and is funding development of a tool to assist planners to develop better safety assessments and measures.[184] The Confederation Bridge, which connects Prince Edward Island to the Canadian mainland, takes into account the possibility of a one-metre sea-level rise due to climate change.[185]

The extended timelines required for incorporation of sea level rise and other long-term climate change issues into planning presents communities with more complex risk analysis and higher levels of uncertainty than normal,[186] highlighting the need to devote resources to key community consultation-oriented planning studies such as the Delta visioning project. BC should follow the lead of Washington State, where the Coastal PAWG is promoting: education programs; improved access to information; coordination within and across agencies; assignment of staff to these issues; enhanced protection and resilience planning for coastal systems and human communities;[187] review of policies and permit processes to assess the best options for protection of near-shore facilities and low-lying urban areas;[188] and imposition of zoning measures that avoid putting facilities and residences into relatively undeveloped areas where they face significant risks from sea level rise.[189]

Population Displacement

Climate change may result in population displacement on an unprecedented scale internationally, with consequent implications for Canada. There are three principal drivers: temperature extremes will reduce agricultural potential and undermine ecosystems; extreme weather events will increasingly affect more people; and sea level rise will destroy extensive highly productive coastal areas that are home to millions of people who will have to relocate permanently.[190] While natural hazards such as hurricanes and floods can affect entire nations or regions, the impacts typically fall disproportionately on the most vulnerable. Researchers estimate that there are already several million environmental migrants, and that this number will rise significantly in the coming decades.[191] Although work has yet to start on valid estimates of potential migration and correlation with climate models and predictions,[192] one study predicts that the number of environmental refugees due to climate change will increase over the next 50 years to 200 million.[193]

Of the three major drivers, one presents a primary risk to BC's Lower Mainland: approximately 220,000 people live near or below sea level in Richmond and Delta;[194] and many other coastal communities will also be affected. The prospect of eventual evacuation is real, albeit decades into the future – planning must nevertheless take this into account. Moreover, resettlement of populations displaced internally in BC may threaten the prime farmland that surrounds many of our cities,[195] while imposing additional pressures on natural ecosystems in such areas as the Georgia Basin. Regional jurisdictions elsewhere are planning for such eventualities; Alaska's Climate Change Sub-Cabinet, for example, includes an Immediate Action Workgroup that is identifying steps to prevent loss of life and property due to climate change in coastal Alaskan communities that must relocate. Their considerations include erosion control, establishment of community evacuation plans, and provision of funding to help communities begin relocation planning.[196]

Canada has traditionally been receptive to the plight of the "political refugee," and environmental refugees might expect Canadian policy to be at least as sensitive. BC, which currently has the second highest immigrant population in Canada after Ontario,[197] is a likely destination for international environmental migrants. The complex interdependencies between climate change, environmental degradation and migration highlight a need for more collaboration at the regional, international and global levels. In response to this imperative, the Climate Change, Environment and Migration Alliance (CCEMA) was established in April 2008 in Germany and is working to enhance understanding of the challenges and opportunities that this issue presents.[198] BC must give this issue deliberate consideration, despite its long-term nature.

New Technologies

The global market for environmental products and services is projected to double by 2020.[199] Half of this market is in energy efficiency, with the balance in sustainable transport, water supply, sanitation and waste management.[200] Sectors that will be critical in terms of their environmental, economic and employment impact are energy supply, buildings and construction, transportation, agriculture and forestry. Clean technology is already the third largest sector for venture capital after information and biotechnology in the US;[201] green venture capital in China has shot up to 19 per cent of total investment.[202] Projected investments of US$630 billion by 2030 will translate into over 20 million renewable energy jobs, and 2.3 million people already have new jobs in this sector;[203] a worldwide transition to energy-efficient buildings alone would create millions of jobs. Recycling and waste management employs an estimated 10 million in China and 500,000 in Brazil; this sector is expected to grow rapidly in many countries in the face of escalating commodity prices.[204]

The debate around climate change has started to shift away from issues of cost and risk toward the question of how to capitalize on investment strategies that span a vast array of asset classes and industries,[205] and the time is ripe for research of this kind in BC. Incentives, financial instruments and institutions to develop new technologies to adapt have already been mainstreamed through BC's LiveSmart program and Energy Plan, which looks to all forms of clean, alternative energy in meeting British Columbians' needs.[206] BC's advanced energy sector currently has over 250 companies, and its environmental technology industry, worth $1.9 billion, employs about 18,000 people.[207] BC is investing in research through initiatives such as the Innovative Clean Energy Fund; a Bioenergy Network encouraging R&D in areas such as wood-waste cogeneration, bio-fuel and wood pellet production; hydrogen and fuel cell technology; eco-friendly pulp and paper; and carbon capture and storage.[208] BC Hydro is moving towards a SmartGrid network, which will improve system resiliency and restoration efforts.[209] The BC Transmission Corporation has announced investments of $3.2 billion in BC's transmission assets over the next ten years, focusing on increasing the power transfer capability of existing assets, extending the life of assets, and improving system reliability and security.[210]

Other notable initiatives include: the ICLR and the Canadian insurance industry's collaboration on the development of homes designed to withstand increasing weather-related catastrophes.[211] New "passivhaus" design offers an alternative to energy-intensive heating and cooling systems that will come under strain and threaten emissions increases under increasing weather extremes.[212] Sustainably managed wood can be used as flood-resistant material for construction and replace construction materials that require more fossil fuel input.[213] The

federal TEAM program supports technologies that tackle the problem of climate change and encourage collaboration.[214] New Zealand's Sustainable Land Management and Climate Change Plan of Action aims to identify ways its primary sector firms and industries can position themselves for economic growth and advantage.[215] Germany is launching a collaborative high-tech strategy that explicitly addresses technologies for climate change adaptation, linking climate protection with innovations that create jobs and ensure prosperity, and inviting investment from partners in business and industry.[216] The Dutch have identified a number of flood- and sea level rise-resistant dwelling designs,[217] including floating houses.[218]

Multi-disciplinary conferences have a major role to play in promoting current and future opportunities. PICS is ideally placed to host events of this kind that will focus on the intersections of policy, technology, investment and entrepreneurship. Such efforts should stimulate research into adaptive technologies that will stimulate BC's economy while contributing to international knowledge transfer.

OVERARCHING RECOMMENDATIONS

Jurisdictions around the world are rising to the adaptation challenge. However, there is a significant disjoint in BC between public awareness of the issues and the content of this paper, partly due to the fact that *large-scale* climate responses have almost entirely focused on mitigation. While each issue explored above has specific characteristics and solutions, the complex linkages between them and a wide spectrum of sectors only serve to underscore the urgent need for smart adaptation planning. Given the threats and the uncertainty inherent to climate change data, we must begin a publicly visible shift to a more flexible way of managing and legislating that acknowledges that ongoing change will be inherent to all sectoral and governance processes as climate impacts increase. This section outlines a number of actions BC can take to facilitate smart adaptation in concert with the section recommendations already described:

Knowledge Mobilization/Outreach

The Government of BC, via the CAS, should actively promote smart adaptation. Workshops that frame adaptation in terms of its potential to stimulate industry and economy, and diminish the perception that it is a threat to lifestyles, would be a useful outreach tool, and PICS can play a lead role in this regard.

Communities with the least resources are often the most vulnerable while having the lowest access to expertise; nevertheless, some are already dealing with the challenge. The Columbia Basin Trust, for example, is achieving excellent results with its competitive community engagement process;[219] PICS could do a similar open call for proposals on smart adaptation, in which communities receive support to write proposals and create teams. To ensure a positive response, this call would be best framed as an opportunity to augment planning rather than highlight vulnerabilities. Given the reach and complexity of the issues we have outlined, it is crucial that some of these proposals be multi-year, and that they reward inter-disciplinary team-building as well as long-term commitment.

New Data/Tools

Detailed studies of the economic and physical impacts of climate change will assist assessment of the effectiveness of adaptation options. To be effective, these will require development of new methodologies for the projection and assessment of impacts that should include scenario damage reports, and employ variables such as economic policy instruments, managed retreat, land use in OCPs, and the like.

It would also be beneficial to develop change indicators – perhaps bi-annual – and build in related adaptive mechanisms to existing legislation such as EBMs and OCPs, which should be revisited at opportune times to include mainstreaming of climate change considerations. Rather than creating new mechanisms for delivery, studies that incorporate mitigation strategies and assessment of adaptation options, and that take into account bio-physical and socio-economic risks, will help to guide the mainstreaming of results into existing legislation. To facilitate this, there is therefore also an urgent need to develop assessments of the consequences of acting or not acting.

In exploring the transition to an ecosystem-based economy that recognizes and values environmental goods and services, it will be useful to develop new valuation methods and initiatives, as well as examine ways the economy can benefit from new financial instruments; e.g. those related to emerging emissions markets.

PCIC and other resources should be engaged to develop the best information possible on climate trends and models, and produce customized, accessible, online databases for the province and regions, to be incorporated into the assessments outlined above. However, it is important for these studies to move ahead regardless with extant data; new tools can be built in as they are produced.

Build Expertise

The universities can—and should—play a major role in raising awareness and increasing capacity in the field of adaptation planning. This can be accomplished by establishing multi-disciplinary courses in adaptive and mitigative science that address the cross cutting nature of the issues.

It would also be useful to develop frameworks for institutional capacity analysis, and develop awareness of – and training in – adaptation approaches suited to dealing with uncertainty.

It is important to note that adaptation is not synonymous with sustainability; smart adaptation requires expertise in variables and methodologies not yet familiar to sustainability professionals. Fostering career development and training of new personnel in this area, partly through new university courses, will benefit the initiatives described above, while helping BC capitalize on the inherent potential for significant job growth.

CONCLUSION

Adaptation planning is essential to bolster the resilience of BC's communities, key resource sectors, and critical infrastructure. There is potential for such planning to stimulate our economy while offering the side benefits of knowledge transfer and leading by example; the provincial government's proactive stance on climate change has positioned BC to take full advantage of emerging markets for new technologies and robust energy sources. BC has an extraordinary suite of resources it can draw on to achieve this shift, and knowledge already exists both regionally and worldwide to help us move quickly towards smart adaptation. The strength of our local and regional organizations, the leadership in our municipalities, the innovation in our private sector, and the wealth of knowledge within our universities combine to position BC at the head of the pack in addressing the challenges outlined in this paper. While it is prudent – and necessary – to acknowledge BC's vulnerabilities to climate change, this transition can credibly be framed as a compelling opportunity for BC to move forward as a national leader on issues that affect all Canadians.

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