FUTURE VISIONING OF LOCAL CLIMATE CHANGE SCENARIOS: CONNECTING THE DOTS AND PAINTING PICTURES TO AID EARTH SYSTEM GOVERNANCE

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ABSTRACT

Emerging 3D visualisation tools and associated future visioning processes offer new ways to **make climate change explicit** to local communities, and perhaps to accelerate local policy implementation that proactively addresses climate change. Research has shown that realistic landscape visualisations (pictures of places under alternative future conditions) can improve community engagement and awareness on environmental and planning issues. Conceptually, such visualisation, if applied to climate change impacts and responses, could yield several benefits: 1) facilitating pragmatic new processes to integrate impacts, adaptation, and mitigation in plausible holistic scenarios that can be visualized for local government and stakeholders; 2) testing the social impacts of (and barriers to) alternative policies on climate change, eg. opposition to windfarms or adaptation strategies; and 3) helping build awareness and a constituency for policy change needed to accelerate climate change solutions.

This presentation provides an update on new Canadian research to test these ideas, and develop a framework and prototype process for **Local Climate Change Visioning,** to present policy choices in a clear and compelling way. The project's aim is to **spatialize, localize, and visualize** climate change effects and policy consequences at a **neighbourhood or community level**, based on regional climate modelling, GIS mapping, scientific advice, planning assumptions, and local stakeholder involvement. It seeks to articulate the possible consequences of different levels of response to climate change, "connecting the dots" between global scenarios and local storylines, and cutting across institutional boundaries. This paper describes the conceptual framework devised for generating and presenting four alternative scenarios out to 2100, together with resulting visualisations, with the aid of local stakeholders and scientists. Supported by the GEOIDE research network and all levels of government, the project is working with case study communities in the Greater Vancouver Regional District, including a rural coastal community facing sea-level rise, and a mountain environment with reduced snowpack and water supply.

1 Introduction

In developing the concept of earth system governance as an approach to global stewardship, Bierman (in press) has stressed the need for participatory governance which is legitimate, effective, and fair, including stakeholders from the global to the local levels. This calls for credible information and processes to build awareness, capacity, and agency in all sectors of society. One way to promote these aims at the community level is through emerging computer visualisation tools and associated future visioning processes. In particular, these offer new and compelling ways to **make climate change explicit** to local communities, to envisage possible solutions, and perhaps to accelerate local policy implementation that proactively addresses climate change. Such methods may address two other challenges described by Bierman (in press):

- Bridging the gap between formalized analytical models and fuzzy social realities, by making the formal and scientific more salient to affected stakeholders, and helping to 'harden up' the experts' understanding of community perceptions and attitudes; and
- Helping to recouple the costs of mitigation born by the current generation with the benefits of avoided harm accruing to future generations, by offering glimpses of possible future scenarios in the community, using visual media which can make the future seem more 'real'.

Any process for building awareness of climate change faces issues stemming from the overwhelming scale of the problem, massive uncertainty, scientific abstraction, and the predominantly global nature of the available modelling and scenarios (Moser and Dilling, 2004; Nicholson-Cole, 2005). There is an acknowledged need for better tools and processes to help agencies and communities become more informed on local impacts and policy choices related to climate change. Visual communication media in general, and scientific visualisation in particular, have been shown to increase engagement, enhance learning, and strengthen conceptualization of even complex environmental issues (Winn, 1997). The form and framing of the information provided can significantly affect awareness levels and even attitudes and emotions (Nicholson-Cole, 2005). Using realistic 3D landscape visualisations (pictures of local places under alternative future conditions) can provide greatly increased local salience, linking to people's attachment to place, perceived quality of life, community identity, and other cherished values (Sheppard, 2005; Lewis and Sheppard, 2006). In theory, realistic landscape visualisations (, if applied to climate change impacts and responses, could yield several benefits: 1) facilitating pragmatic new processes to integrate impacts, adaptation, and mitigation in plausible holistic scenarios that can be visualized for local government and stakeholders; 2) testing the social impacts of (and barriers to) alternative policies on climate change, eg. opposition to windfarms or adaptation strategies; and 3) helping build awareness and a constituency for policy change needed to accelerate climate change solutions (Sheppard, 2005).

This paper provides an introduction to a new Canadian research programme to test these ideas, and develop a framework and prototype process for **Local Climate Change Visioning,** in order to present policy choices in a clear and compelling way to affected communities. The project's aim is to **spatialize, localize, and visualize** climate change effects and policy consequences at a **neighbourhood or community level**, based on regional climate modelling, GIS mapping, scientific advice, planning assumptions, and local stakeholder involvement. It seeks to articulate the possible consequences of different levels of response to climate change, "connecting the dots" between global scenarios and local storylines, and between actions (or inaction) and consequences (from both direct climatic impacts and indirect socioeconomic effects). The current study, funded by the GEOIDE Research Network Centre of Excellence and various levels of government in Canada, is evaluating the effectiveness of visioning techniques in building awareness of both climate change impacts and options for adaptation/mitigation response. The *Local Climate Change Visioning Project* is working with case study communities in the Greater Vancouver Regional District, including the rural coastal community of Delta and the mountainside environment of North Vancouver facing reduced snowpack and water supply issues. Current research is assessing, for example, whether time lapse visualisations of rising sea levels or diminishing snowpack in the community influences perceptions of risk and urgency, by effectively 'telescoping time' out to 2100 in the community's 'backyard' (Figures 1 and 2).

Figure 1 LiDAR-based visualisations of sea-level rise scenarios with and without flooding in the Fraser Delta. (Credit: David Flanders (CALP), Phil Hill (Natural Resources Canada)

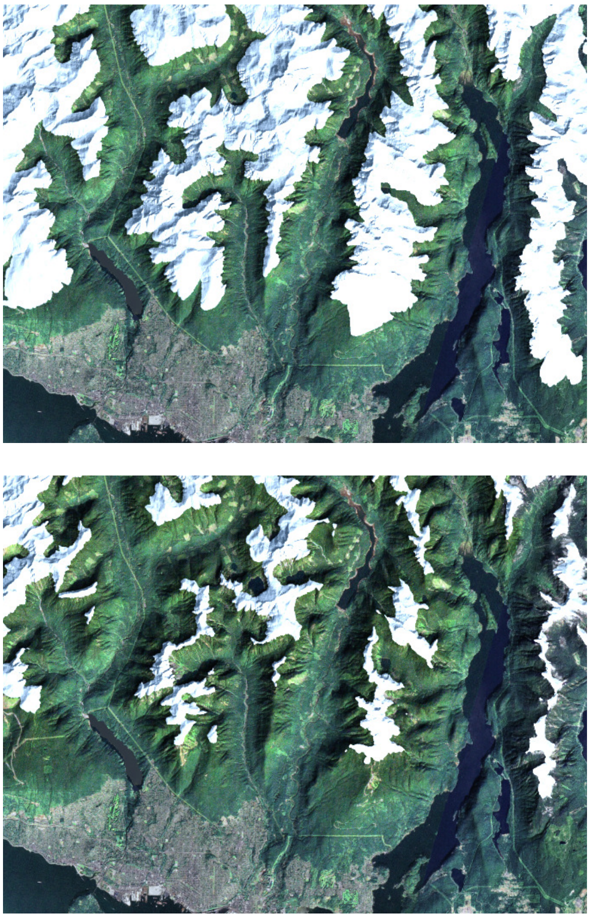


Figure 2 3D visualisations of statistically downscaled snowpack data for Vancouver's Northshore mountains, showing April 1st median snowline in 2000 (current conditions) and 2100 (Tier 1 [A2] scenario). (Credit: David Flanders (CALP), Environment Canada)

This paper describes the conceptual framework devised for generating and presenting four alternative climate change and socioeconomic scenarios, together with resulting visualisations, in collaboration with local stakeholders and scientists. It provides the overview rationale for the framing and selection of the climate change scenarios that will provide the global context for the emerging regional and local storylines and corresponding climate change visualisations. It addresses the selection of global scenarios to be used, and the selection of indicators/narratives for those scenarios.

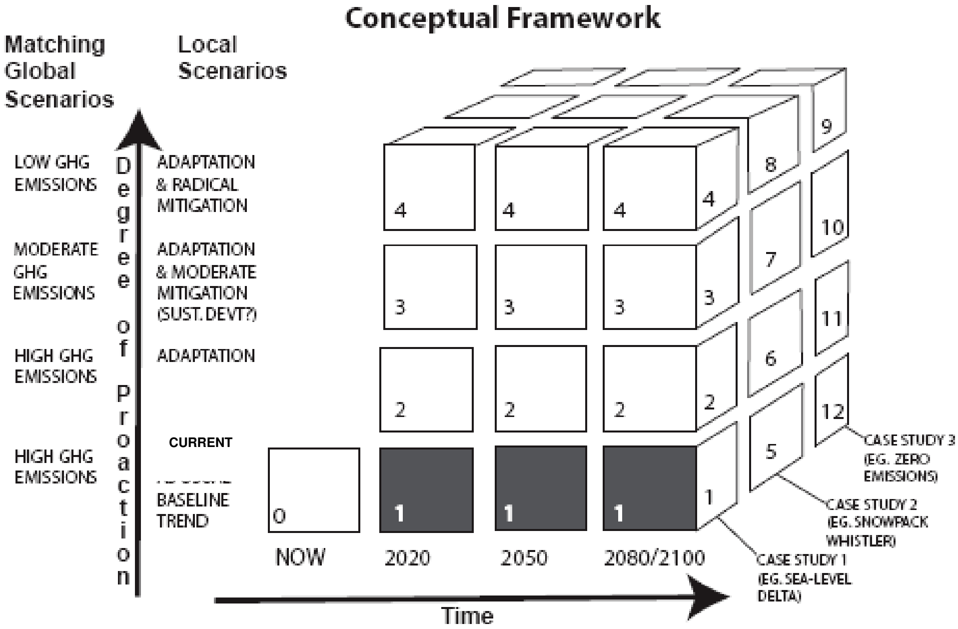
2 The Conceptual Framework

The GEOIDE SII study will test new methods of visualizing local climate change scenarios for their impact in informing and motivating lay-people, and for their value to policy-makers. It is therefore essential that a range of future scenarios/conditions be considered to provide choices for action with definable consequences, that these choices be simple to understand; they should be distinctly different, represent a wide range of plausible alternative scenarios, but be few in number to avoid unmanageable complexity. As shown in Figure 3 ("the cube"), three key dimensions are considered:

1) Time: the scenarios need to extend over a medium to long range to be able to represent escalating impacts of climate change, some of which have considerable time lags. The standard time-scales used by the IPCC (2001) are 2020, 2050, and 2100, covering a span of about 3-5 generations.

2) Levels of climate change related to anthropogenic GHG emissions, together with associated human response (integrating both mitigation and adaptation measures which could jointly affect local communities – see below).
3) A range of local conditions representing typical landscape and community types within the GVRD (eg. rural coastal, mountain, and urban case studies).

Figure 3 Conceptual framework for generating local climate change scenarios and communicating them to stakeholders



The framework also needs to provide clear and consistent linkages across geographic scales, ranging from the global level where much climate change scientific information is available, to the local community level where visioning packages are needed to personalize the information. The regional level is considered to be a bridging device, linking global climate change scenarios for which modelling and quantification has been conducted extensively, through reference to national, provincial, regional and local models, planning activities and policies, to local conditions where the study can integrate any (rare) existing climate change studies and generate new inputs to scenario generation via local stakeholders. The framework should help articulate how policies with which the public might be familiar at different political levels,(eg. Kyoto, the former Canadian One Tonne Challenge programme, etc.) might relate to emerging scenarios. The framework should also enable broad assumptions to be made regarding equity and geographic responsibility for GHG emission reduction across geographic scales; for reasons of simplicity, the assumption here in this study is that local scenarios can be linked to global scenarios through a fair-share mechanism ("if we locally do something equivalent to what the rest of the world does about GHGs, this is what would happen"). A variant of this is to align with existing agreements on the greater contribution of Kyoto Annex 1 countries (the more developed western nations such as Canada) to the global fight against climate change.

3 Selection of Global Scenarios

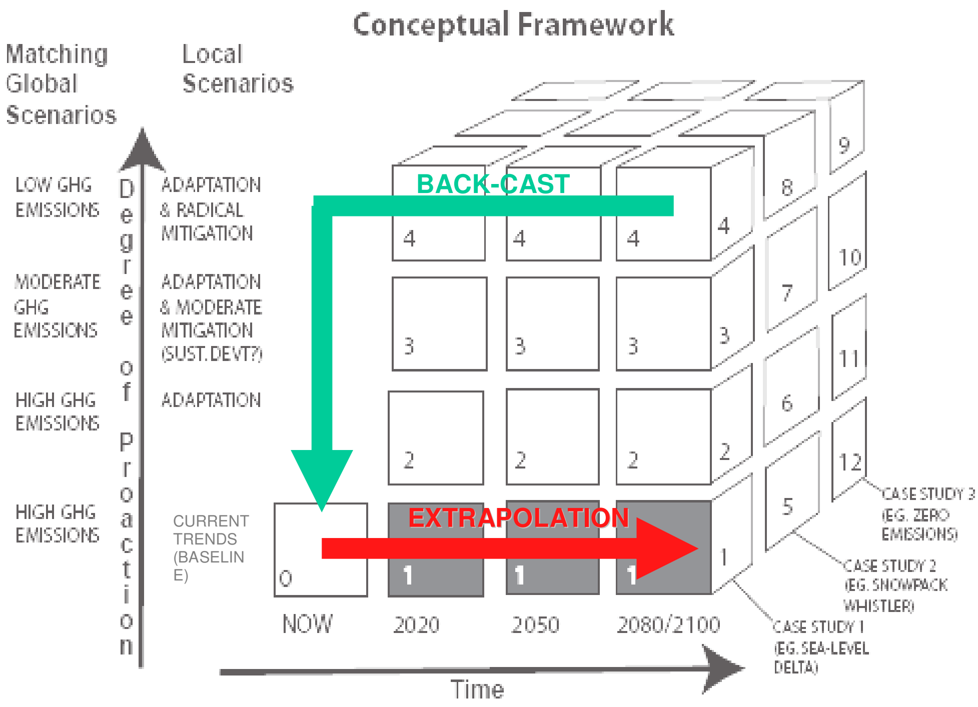
Study constraints and the need ultimately to present to lay-people in a limited time period, limit the number of scenarios (or tiers in the cube diagram in Figure 3) effectively to four. These also have to reflect different levels of mitigation and adaptation.

In terms of mitigation, the need for scientific credibility and to economize on effort requires substantial usage of existing, previously accepted global scenarios of GHG emissions and associated socio-economic conditions. Essentially, this means drawing on the extensive work of the IPCC over many years in developing recognised families of scenarios, with attendant quantitative information on various climate change parameters based on multiple models. However, it was also determined that the range of scenarios should make sense from a public perceptions standpoint in the local study context, and need not therefore necessarily be limited to existing scenarios as commonly used in scientific circles. For example, many previous scenarios studies rely exclusively on the most commonly used IPCC SRES scenarios (IPCC, 2000) which do not explicitly factor in climate change mitigation policies, or discuss levels of potential climate change stabilisation as crucial societal options.

Consequently, the most important framing dimension (the y axis shown in the cube diagram (Fig 3)), which distinguishes between the 4 planned scenarios, needs to demonstrate the effects of different levels of climate change related to anthropogenic GHG emissions, in order to make explicit the links between human choices (ie. responses to climate change) and key consequences of those choices over time. This appears to be one of the main missing components in the climate change story available to the public and decisions-makers, at the local level at least. Since future climate change is strongly related to the level of carbon emissions we choose, this axis of the framework needs to span a wide spectrum of potential emissions, to keep them distinct and to capture the range of possibilities. This would in turn suggest that at least some of the potential candidate scenarios at the "lower level of climate change" end of the range would include explicit mitigation policies for GHG emissions reduction. For this reason, it is considered indefensible (if not irresponsible) only to consider the IPCC reference range of SRES scenarios, none of which explicitly consider mitigation policies (ref). Further, it is considered untenable (and publicly unsupportable) not to include at least one scenario which aims at climate change stabilisation or eventual reduction/reversal. Lastly, it is considered essential to enable this study to be related to the policy moves and development proposal already in existence around the world (and in the public consciousness) which call for low-carbon or zero carbon development patterns (eg. Sweden policy, BEDZED development, carbon neutral communities in the UK, CIRS building).

Accordingly, the horizontal tiers in the 'cube' reflect three different levels of climate change at the global scale, which can be associated with clearly different levels of emissions and negatively correlated with degree of effective mitigation. While these associations are of course very complicated and not necessarily always consistent, in general terms the patterns are clear and results to date suggest they resonate with both non-experts and experts in climate change. The 'cube' framework thus begins conceptually with a baseline (default) scenario at the lowest tier, reflecting current global trends (rapid growth and rapidly increasing carbon emissions globally), with little or no climate change policies, extrapolated over time. At the middle level, significant reduction in the rate of carbon emission (relative to the baseline tier) occurs as a result of global or local trends, including moves towards sustainability, perhaps with limited or implicit policies for climate change, leading to slower climate changes. The highest level portrays a more proactive set of policies and actions on climate change, leading eventually to greatly reduced climate change emissions relative to today and a pre-determined target of a stabilized concentration of CO2 in the atmosphere; this scenario therefore reflects a 'backcast (Robinson, 2003) from desired conditions in 2100, rather than an extrapolation of existing trends as in the lowest level in the framework (Figure 4).

Figure 4. The role of extrapolation and back-casting in generating study scenarios.



The actual scenarios chosen to represent these emission levels in the framework are described in depth below, and reflect combinations of major scenario systems available in the literature (primarily the Millennium Ecosystem Assessment (MEA) and Tellus Institute's Global Scenarios Group (GSG) refs), though based on the IPCC core scenarios as follows:

1) Lowest level: SRES A2 (high carbon world)
2) Middle level: SRES B2 (moderately high carbon world relative to natural levels)
3) Highest level: Post-SRES B1 450ppmv and related or similar mitigation scenarios (achieving a relatively low carbon world)

The choice of actual scenarios to be used reflects both the fit with the conceptual framework described above as well as practical considerations such as:

- The desirability of including both 'global' and 'regional" alternative futures as embedded in the IPCC scenarios (ref) and other scenario systems;
- The need to include both quantified climate information and socioeconomic information (both quantified and qualitative storylines)

- The scarcity of climate change stabilisation scenarios with quantified climate change or socioeconomic information at CO2 levels below 450ppmv;
- The intent to link with the emerging Canadian Regional Climate Model for downscaling in the study area; this model currently provides data only for the A2 SRES scenario;
- The opportunity to take advantage of previous efforts (Tellus Institute) to create holistic scenarios/narratives for the GVRD which 1) link with global scenarios developed by Tellus (Global Scenarios Group) and 2) provide some quantified indicators relevant to climate change and GVRD futures, through the Georgia Basin QUEST modelling. These global scenarios can be related to the IPCC scenarios reasonably well.

4 Fitting adaptation into the conceptual framework

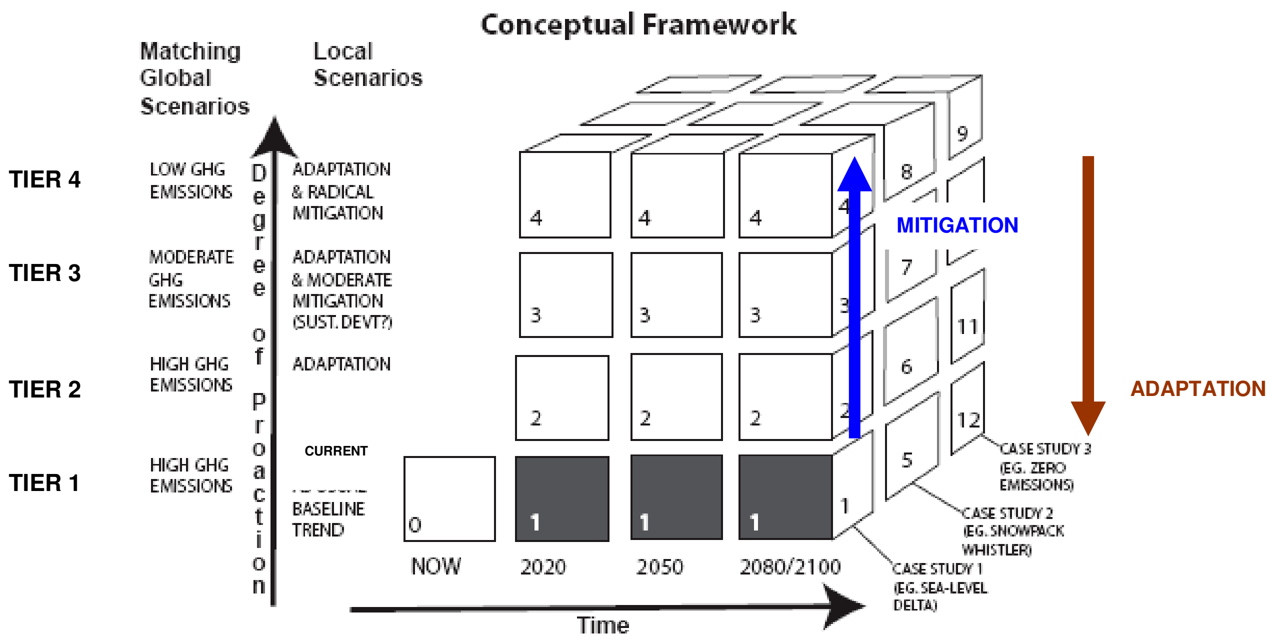
The need to integrate both mitigation and adaptation measures in response to climate change requires a more complex discussion of the tiers/scenarios considered within the 'cube' framework in Fig. 3. Adaptation has generally not yet been closely integrated into quantified modelling efforts for GHG emissions or indeed global scenarios descriptions (Robinson et al. 2006). The IPCC scenarios do not take technological, structural, institutional, and behavioral adaptation into consideration. Nevertheless, adaptation is of great importance in regional and local level planning for climate change, and the subject of intensive study and emerging policy development in communities and governments across Canada (ref Canada adaptation guidelines, etc). Therefore the need to consider various kinds and levels of adaptation is required within the framework. However, it is currently extremely difficult to relate local adaptation efforts to emission levels or climate change impacts, and so it is difficult to fit adaptation on to a simple y axis of emission or mitigation levels in the 'cube diagram'. Ideally, studies such as this would consider a range of adaptation measures at each of the emissions levels described above, as scenario variants or as the third dimension in the 'cube diagram', replacing the local case study dimension being used here. However, this was beyond the scope of the current study.

Pragmatically, it is already clear from community experience (within and beyond the study team) that some communities will develop adaptation responses as the threats of climate change become clearer, and probably with a higher priority at the local funding level than mitigation activities, which has less obvious local benefits. Therefore, it is logical to identify a tier in the framework which addresses an adaptation response without mitigation, which would illustrate benefits and other implications of adaptation at the local level in comparison with the baseline situation. This would then mean dividing the SRES A2-type scenario into two tiers at the local level: with and without adaptation (ie. the bottom two tiers in Figure 3). TIER 1 is therefore without effective climate change policies. TIER 2 targets local adaptation initiatives. Currently, there are no activities or GHG emissions modelling that we are aware of that accommodate global adaptation (although the possibility for this type of initiative exists).

For reasons of simplicity and lack of available information, it is assumed in this study that neither local nor global adaptation has a major effect on global climate change levels, in relation to other influences on emissions; in developing local adaptation initiatives in combination with mitigation, attempts have been made to avoid adaptation that seriously conflicts with mitigation functions. Where possible, the limited information in the socioeconomic descriptions of global scenarios which explicitly or by interpretation link to adaptation measures, has been factored into the scenario descriptions below. In general, however, it is anticipated that many of the drivers for adaptation will be locally specific and will be reflected in stakeholder input to local scenario generation.

Above the lower two tiers/scenarios in the framework, the adaptation relationship to the mitigation/emission levels may be broadly characterized as shown in Figure 5. The overall assumption here is that the more effective mitigation there is, the less climate change, and therefore ultimately the less adaptation needs to occur.[1] It is recognised that the time lag between changes in emissions and the earth's response (in terms of GHG concentrations and subsequent environmental effects such as sea-level rise) means that adaptation will be necessary in spite of immediate mitigation efforts. This study assumes that maximum levels of adaptation will be highlighted in TIER 2, and that strong mitigation in TIER 4 may reduce the need for adaptation in some areas but still requires considerable adaptation (with co-benefits) by 2100 to increase resilience and reduce vulnerability to inevitable climate change impacts. TIER 3 with moderate mitigation is likely to contain adaptations at levels between TIERS 2 and 4. Consideration of the synergies and/or potential conflicts between mitigation and adaptation measures in TIERS 3 and 4, and ways to plan in an integrated fashion will be a prominent part of the discussion at the local level. The choice of adaptation will in part depend on the local information and stakeholder/expert opinion. The range of case studies is also expected to illustrate a range of different adaptation types and needs.

Figure 5. The conceptual relationship assumed in this study between global mitigation efforts and adaptation efforts in terms of climate change.



Overall therefore, the y axis on the cube can be considered as a rough indicator of level of human proactivity in responding to both mitigation and adaptation imperatives,

[1] It is recognized that some impacts are unavoidable, and there are major time-lags in climate change impacts in response to GHG emission reductions.

acknowledging that more proactivity sooner (eg. upper tiers in the 'cube' diagram) leads to less adaptive action required over the long term.

5. Global scenario indicators and narrative format

Given the study scope , it is impossible to develop integrated multi-criteria models to generate or describe quantitatively the holistic climate change scenarios described above, at the regional or local level. The global storylines developed below, and their links to the regional storylines, represent a combination of quantitative and qualitative information, as conducted for the SRES scenarios and described in the Special Report on Emissions Scenarios (2000). These storylines incorporate a combination of:

- key drivers or input assumptions (including both levels of climate change and other socioeconomic or environmental drivers); these can be globally and locally determined with stakeholder input and categorized as both direct and indirect climate drivers (where indirect refers to socioeconomic responses to direct climate change, as in immigration by climate change refugees).
- relevant outcomes from the effects of these drivers;
- narrative descriptions which will help frame and 'personalize' these scenarios at the local level, and support visualisation of possible local conditions.

The range of indicators addressing both drivers and outcomes needs to reflect typical indicators used in the literature (both IPCC and other scenario systems) and for which information is available at global and/or other levels, be limited in number and complexity/detail for use with lay-people, be comprehensive enough to support holistic visualisations of local future conditions in the landscape, and be meaningful to local stakeholders. This requires that the framework can be linked tangibly to national, regional, and local policies that policy-makers and stakeholders may be familiar with, eg. BC's Weather Climate and the Future (2005), GVRD Livable Region Strategic Plan (1999), the GHG Reduction Strategy for the GVRD (2006), the COOL Vancouver Community Climate Change Action Plan (2005), etc.

Indicators described below are therefore grouped and summarized in the following categories:

- Climate change policy context or supporting assumptions broadly classified as climate policies which are explicitly included, implicitly included, or not included,. Where appropriate these policies are identified as mitigation, adaptation, or an integration of the two.
- Climate change parameters: carbon emissions, CO2 concentrations, and other meteorological/physical effects (eg. temperature changes, etc). In this regard it is considered that the simplest way to express to the public the specific climate change drivers for each scenario is to express the cut or increase in GHG emissions relative to 1990 levels, eg. 60% reduction by 2100. This is a device commonly used that allows individuals to translate global and local scenarios into their own personal climate change footprint.
- Drivers (and consequences) of climate change:
    - Population/demographics
    - Economic and social development
    - Energy and technology
    - Ecosystems and land use.

Further discussion of how these indicators have been used and linked to regional modelling with selected sub-indicators (eg. population densities, energy sources, vehicle miles traveled), is the subject of a forthcoming paper.

6 Conclusions

The *Local Climate Change Visioning Project* outlined above seeks to articulate the possible effects of different levels of response to climate change, “connecting the dots” between global scenarios and local storylines, and between actions or policies and their consequences under certain assumptions*,* Currently, the global, regional, and local storylines and supporting visioning packages with visualisations are being tested with local multi-stakeholder groups in the two case study communities. Preliminary results suggest there is substantial demand for this type of approach at the local level, not only in translating the global science of climate change into a more meaningful form, but alos in helping build community awareness and influence planning. This work has attracted considerable media interest in the visual products, in part due to the recent upsurge of public and political interest in climate change in Canada; this has highlighted the need for serious attention to ethical principles for effective visualisation (Nicholson-Cole, 2005; Sheppard, 2001), as well as issues of possible bias and risks of instilling fear or loss of agency in audiences. Nevertheless, there has so far been general acceptance of the conceptual framework of “the cube” with its four tiers of proactivity on climate change response, as a device to structure and integrate more detailed, local and diverse implications of climate change. Further testing, modification, and replication of this approach is needed; however, when grounded in and communicating the available science and local knowledge, the visioning process appears promising in providing legitimate, effective, and (it is to be hoped) fair mechanisms for including local communities in governance on climate change.

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