Chapter 7
Bringing Climate Change Science to the Landscape Level: Canadian Experience in Using Landscape Visualisation Within Participatory Processes for Community Planning

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Abstract This chapter addresses the role of visualisation tools within participatory processes in bringing climate change science to the local level, in order to increase people's awareness of climate change and contribute to decision-making and policy change. The urgent need to mitigate and adapt to climate change is becoming more widely understood in scientific and some policy circles, but public awareness and policy change are lagging well behind. Emerging visualisation theory suggests that landscape visualisations showing local landscapes in fairly realistic perspective views may offer special advantages in bringing the projected

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consequences of climate change home to people in a compelling manner. This chapter draws on and summarizes a unique body of research in Canada, applying and evaluating a local climate change visioning approach in five diverse case study communities across the country. This new participatory process was developed to localize, spatialize, and visualize climate change implications, using landscape visualisation in combination with geospatial and other types of information. The visioning process was successful in raising community awareness, increasing people's sense of urgency, and articulating for the first time holistic community options in mitigating and adapting to climate change at the local level. In some cases the process led to new local policy outcomes and actions. Such methods, if widely implemented in enhanced planning processes, could facilitate uptake of climate change science and potentially accelerate policy change and action on climate change. However, moving from more traditional types of science information and planning to an approach which can engage emotions with visual imagery, will require guidelines and training to address ethical and professional dilemmas in community engagement and planning at the landscape level.

Keywords Climate change visualization · Visioning processes · Landscape visualization · Visual imagery · Landscape planning · Community engagement · Community planning · Decision-support tools · Policy change · Public awareness · Climate change scenarios

7.1 Introduction

Global warming is fundamentally changing the context within which landscapes and communities have traditionally been planned and managed. There is an urgent need to mitigate and adapt to climate change (IPCC 2007), requiring communities to do their part in reducing greenhouse gases (GHGs) and plan for a range of possible energy futures, impacts on ecosystems, risks to infrastructure, and generally unfamiliar circumstances. However, action, policy change and the necessary public support are moving slowly in many parts of the world. Concerns have been raised by climate change scientists over their difficulties in achieving uptake of global modelling by practitioners and decision-makers at the local level (Kriegler et al. 2012). There is therefore a huge need for better communication and decision-support tools to enhance the sense of urgency and help accelerate informed, integrated, and effective responses to climate change.

In this context, realistic landscape visualisations may offer special advantages in bringing the potential consequences of climate change home to local citizens and decision-makers, in a compelling and useful manner. This chapter considers the role of science-based visualisation tools and processes in improving community planning and engagement on climate change; and particularly in making climate change science meaningful at the local level, increasing peoples' awareness of climate change, and possibly affecting policy and collective behaviour change. This chapter reviews first the theoretical basis for such effects, then describes a major research programme conducted in Canada to test the effectiveness of a visualisation-based participatory process in achieving some of these goals. It concludes with implications and recommendations for using such tools and processes in community engagement and planning for climate change internationally.

7.2 Theoretical Background on the Influence of Landscape Visualisation on People in Relation to Climate Change

Landscape visualisation exhibits several characteristics which could be powerful in bringing consequences of climate change home to people. Landscape visualisation attempts to represent actual places and on-the-ground conditions in three-dimensional (3D) perspective views with varying degrees of realism (Sheppard and Salter 2004). This amounts to a unique form of visual communication, conveying information in the dominant form to which the human species is genetically adapted (e.g. visual landscapes), but capable of showing future scenarios and conditions which people may not be able to imagine on their own.

Early evidence from research and practice, and emerging theory on 3D visualisations, provides some reasons for optimism. Human responses to environmental or visual stimuli such as landscape visualisations can be broadly categorized as follows: engagement (level of interest and attention); cognition (related to knowledge, awareness and understanding); affect (related to feelings, perceptions, and emotions); and behaviour (related to changes in behaviour of the viewer) (Appleyard 1977; Zube et al. 1982). In the collective sphere of community planning, related consequences such as capacity-building (to deal with climate change), policy change, and decision-making are also important (Sheppard 2008). There is considerable evidence of the effectiveness of visualisation as a planning tool (e.g. Tress and Tress 2003; Sheppard and Meitner 2005; Salter et al. 2009), and the advantages of interactive systems in particular for engagement, cognition, and awareness building (e.g. Winn 1997; Furness III et al. 1998; Salter 2005; Schroth 2007; Mulder et al. 2007). In this context, potential benefits of landscape visualisation include:

- Attractiveness to lay-people, due to the novelty of the medium, its dynamism and interactivity;
- Combining the predictive capabilities of modelling/GIS with the intuitive and experientially rich media of photo-realistic representation, providing 'windows into the future' with changing landscape patterns and meaningful socio-cultural associations;
- The ability to present alternative futures side-by-side and pose 'what-if' questions (Ervin 1998); and

- Transparency and flexibility: digital visualisation techniques can be augmented or modified to highlight or simplify almost any aspect of the 3D/4D modelling being conducted, such as underlying meta-data or different levels of realism selected by the user (Bishop and Lange 2005).

Less research has taken place on affective responses (e.g. Bishop and Rohrmann 2003), though there is evidence that visualisations can stimulate positive or negative emotional reactions in observers (e.g. Daniel and Meitner 2001). Nicholson-Cole (2005) documented the influence of popular visual media on people's mental imagery of climate change, and found that respondents were most emotionally affected by national, local, and personal imagery rather than international imagery, in part because it was easier to relate to and more salient (see also Shackley and Deanwood 2002). The ability of visualisations to localize information through detailed depiction of recognizable and familiar sites, as they would be seen by local residents or users (in contrast to a detached plan, aerial view, or abstract diagrams), would seem to tap into people's emotional attachment to place. Nicholson-Cole (2005) describes advantages of visualisation in conveying strong messages quickly and memorably, condensing complex information, and potentially arousing emotional feelings, which may motivate personal action on climate change. The perception literature however, warns that messaging that is too heavy on "doom and gloom" can be counter-productive (Moser and Dilling 2007; Nicholson-Cole 2005).

Very little hard evidence exists on behavioural impacts of landscape visualisation, either during exposure to the visualisation material or afterwards (Sheppard 2005a). Lowe et al. (2006) have evaluated behaviour of people who watched the film "The Day after Tomorrow" which contained extensive visualisations of supposed climate change effects, and found both attitude change and some limited changes in behavioural intent, especially immediately after the viewing. There is evidence from visualisation practice that use of computer visualisations has also led to significant action by decision-makers on policy changes to planning strategies and approvals (Sheppard 2005a; Sheppard and Cizek 2009).

It therefore seems possible that landscape visualisations, if applied to what is arguably the single greatest environmental issue of all (climate change), may be able to capture public interest, influence attitudes and support for climate action, or help trigger policy change, by "making climate change personal" in people's back yards. The actual effectiveness of visualisation in stimulating these responses may depend on many factors including: the delivery mechanism or process for presenting visual imagery to the public or decision-makers, including the role of other forms of available information; the type of audience; the socio-cultural and environmental context; the media employed; and the nature of the climate-change-related subject matter. It seems likely that a combination of techniques and influences would be required if action and policy on climate change is to be implemented at the local community level.

7.3 Research Results from the Local Climate Change Visioning Process

The issues described above have been explored in a unique research programme conducted over several years by researchers and partners that were coordinated by the Collaborative for Advanced Landscape Planning (CALP) at the University of British Columbia. Researchers worked as a trans-disciplinary team involving climate scientists, social scientists, planners, landscape architects, engineers, agency staff and stakeholder representatives in British Columbia and other locations in Canada. The goal was to develop a new approach that bridges the gap between global climate science and the local level, using realistic landscape imagery of alternative climate futures at the neighbourhood scale.

This body of Canadian research appears to be unique in combining the following attributes:

- Applying landscape visualization systematically to future climate change scenarios in real, specific locations.
- Drawing on hybrid modelling, climate change projections, spatial analysis, other locally available data, and local stakeholder opinion to develop scenarios, mapping, and 3D visualisations.
- Developing holistic alternative scenarios which addressed both adaptation, mitigation, and current land use trends.
- Embedding visualisation within a structured participatory process involving multiple stakeholders.
- Evaluation of the process, products, and their impacts on users such as community members, practitioners, and decision-makers.
- A sustained, coherent body of work conducted over the last decade in geographically diverse locations.

In reviewing a range of other scenario 'visioning' approaches, Sheppard (2012) describes various precedents that incorporate one or sometimes more of these attributes, but none that combine them all. The five case study processes described below all involved government partners from the Federal to the local levels, developed multi-stakeholder working groups, and were conducted by researchers from five universities across the continent. The range of environments and types of communities studied (including mild temperate coastal cities, a dry interior rural community, a major metropolitan centre, and a remote arctic hamlet), suggest that the findings apply to local level planning and community engagement in many regions and settlement types in North America and potentially beyond.

This section summarizes the approach and key findings of the Local Climate Change Visioning (LCCV) process, focusing particularly on the results of effectiveness evaluations on the early case studies carried out in the Metro Vancouver region, and contextualized through a brief review of more recent outcomes of related studies across Canada.

7.3.1 *Methods of the Local Climate Change Visioning Process in Metro Vancouver*[1]

This research aimed to develop and test a process for local visioning of climate change impacts and responses, using an integrated geomatics/visualization system as a prototype for improved community planning and engagement on climate change. More specific objectives, responding to practical and psychological needs of communities and citizens (e.g. Kriegler et al. 2012; Moser and Dilling 2007) included:

- Making climate change choices more explicit in order to build awareness and capacity for behaviour change, policy development, and decision-making: bringing climate change implications home to people and their local governments
- Addressing questions such as "what would your local landscape look like if everyone met specific carbon-reduction targets?" (e.g. BC's GHG reduction targets).
- Enabling the integration of diverse streams of information from the multiple sources and disciplines needed to address climate change somewhat holistically.
- Illustrating various adaptation and mitigation strategies that can be assessed against carbon reduction targets and other key sustainability/feasibility criteria.

The approach was to bring climate change science down to the local level through spatializing, localizing, and visualizing information on climate change, within an enhanced participatory process. The visioning approach harnesses the power of 3D landscape visualization of climate change, supported by Geographic Information Systems (GIS) data, downscaled climate scenarios, and environmental/land-use modelling. The process builds upon early precedents addressing more limited aspects of climate change (e.g. Cohen 1997; Dockerty et al. 2005; Snover et al. 2007), and other scenario-based, modelling-assisted planning processes using visualization (see Sheppard 2012, Chap. 13 for a review). It draws on the best available data, science, and best practices, as well as local knowledge and multidisciplinary expertise, through workshops with scientists, practitioners and community stakeholders.

Products included computer visualizations produced at a scale that matters to decision makers and the community: their neighbourhoods and backyards. These pictures of alternative climate scenarios over time show different levels of climate change causes, impacts, adaptive responses, and mitigation measures in combination. Through the images, people can see, for example, the effects on their community of unmitigated climate change (e.g. sea-level rise, drought, increased fire risk) in their lifetime, or of "complete" resilient low-carbon communities with renewable energy, walkable and more self-contained neighbourhoods, local food supply, and adaptations to more intense rainstorms (Fig. 7.1).

[1] Funded primarily by the GEOIDE National Centres of Excellence research network.

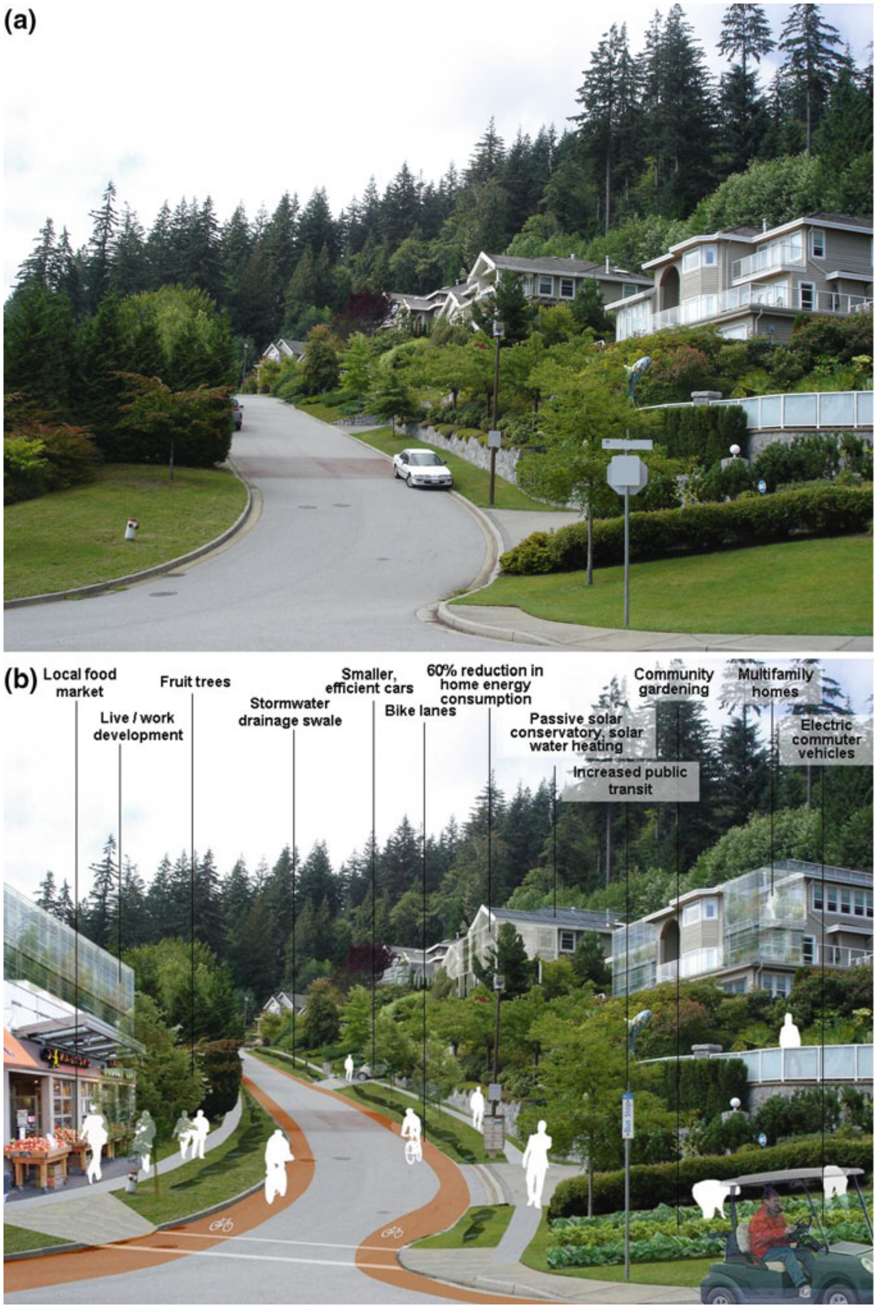

Fig. 7.1 **a** Existing conditions in a high-carbon urban landscape. **b** Conceptual visualisation of a low-carbon future with intensive mitigation (e.g. energy-generating buildings, increased transit, walkable neighbourhoods, live-work buildings, local shops, multi-family housing, etc.) and increased resilience (increased stormwater retention, local food production, local employment, etc.). *Credit* (a) *Photo* S. Sheppard. (b) Visualization: J. Laurenz, CALP, UBC. Reproduced from Sheppard (2012) "Visualizing Climate Change", Earthscan/Routledge

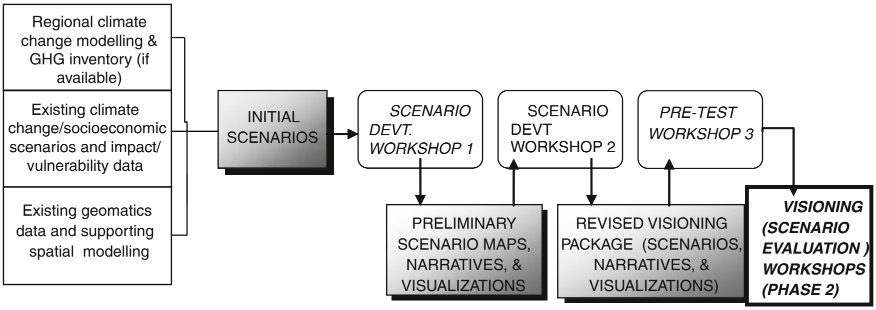

Fig. 7.2 Flowchart for the local climate change visioning process (Scenario Development). Reproduced from Sheppard (2008), "Local Climate Change Visioning", Plan Canada, with permission of Canadian Institute of Planners; and from Sheppard et al. (2008), "Can Visualization Save the World?" Digital design in landscape architecture 2008, 9th international conference Anhalt

The research team initially worked with two communities in south-west BC that represent different climate change challenges: the low-lying coastal community of Delta facing sea-level rise, and the urban fringe on the Northshore mountains, affected by reduced snowpack and increasing natural hazards. In Phase 1, we prepared visioning packages which illustrate four alternative scenarios or "worlds" out to 2100 in each case study area; these were based on assumed local conditions against the backdrop of global climate scenarios and regional modelling of integrated socio-economic and land-use factors in the Georgia Basin QUEST model (Shaw et al. 2009). Steps in this LCCV process (Fig. 7.2) included:

- Downscaling of global climate projections with regional climate change data from Environment Canada.
- Data collection on key land-use/environmental issues and natural hazards at the local level.
- Developing an initial set of plausible alternative climate change scenarios and storylines in the community, through research and workshops with a local working group to define and prioritize GHG sources, potential climate change impacts and vulnerabilities (e.g. snowpack reductions, increased fire and slope stability hazards), adaptation measures, and mitigation measures (e.g. biomass production, neighbourhood retrofitting).
- Mapping impacts and appropriate locations for mitigation and adaptation measures, using spatial analysis with GIS and remote sensing data, interpretation of available urban planning or resource management models, and hybrid modelling to link together various models addressing, for example, climate impacts, land uses, sea level, and energy use.
- Developing 3D models and visualization imagery/animations (in ArcScene, Visual Nature Studio, and Photoshop) for selected neighbourhoods (Fig. 7.3),

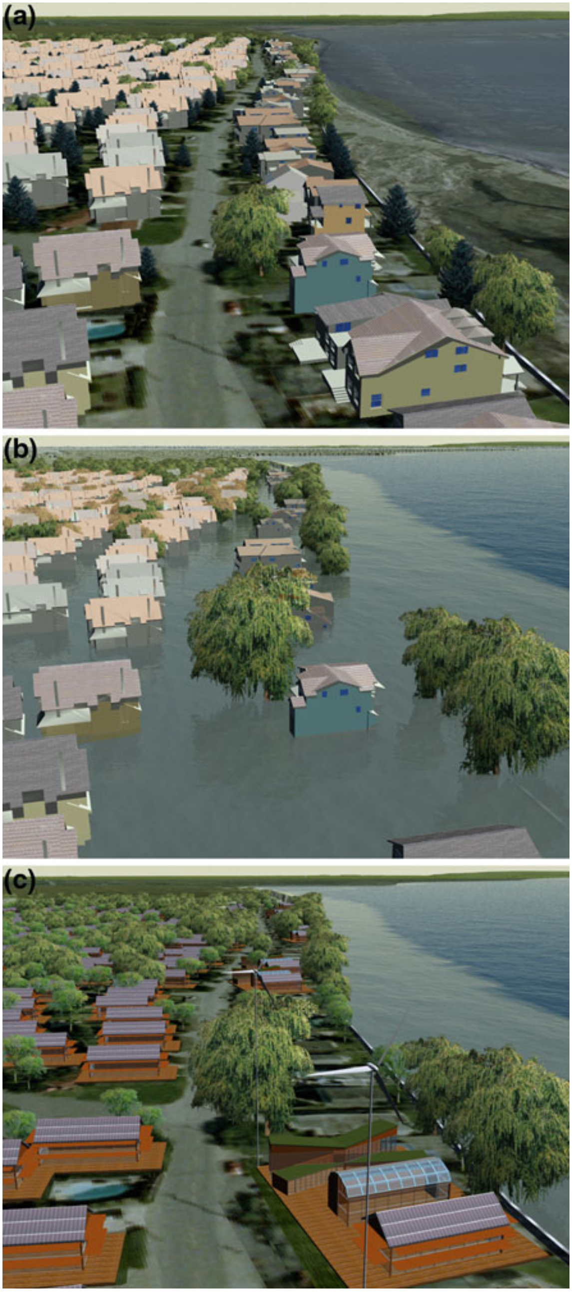

Fig. 7.3 3D visualisations of alternative conditions in a BC coastal community at risk of flooding: **a** Existing conditions in 2000. **b** Projection of same neighbourhood in 2100 with a +4 °C global warming scenario, storm surge, and no effective adaptation measures. **c** Projection of same area in 2100 with a low-carbon resilient scenario, storm surge, raised sea-wall, flood-proofed buildings, and on-site energy generation (intensive mitigation). *Credit* David Flanders, CALP, UBC; sea level data provided by Natural Resources Canada. Reproduced from Sheppard (2008), "Local Climate Change Visioning", Plan Canada, with permission of Canadian Institute of Planners; and from Sheppard et al. (2008), "Can Visualization Save the World?" Digital design in landscape architecture 2008, 9th international conference Anhalt

using available 3D datasets such as LiDAR data,[2] and following procedures to ensure accuracy to the data, representative view locations, and themes to be visualized (based on input from the local working group and experts).

- Generating visioning packages for working group review, illustrating possible future neighbourhood conditions through visualizations, profiles using key indicators, GIS mapping, and photographs of best practice precedents.

In Phase 2, the products of this process were tested with local policy-makers and representatives of the public. The evaluation was conducted with approximately 120 community members[3] in Delta and North Vancouver, plus a sample of Lower Mainland planners and engineers, and some local council members. Participants were recruited mainly through posters, web-postings, and key informants using the snowball contact technique. Visioning (scenario evaluation) workshops of 2–3 hours were held in each case study community, using a multi-media PowerPoint presentation with visualisations on two large screens, side-by side. Evaluation methods used standard social science assessment techniques (e.g. pre-post survey written questionnaire, written qualitative comments, participant observations, and some follow-up interviews) to determine changes in participants' attitudes and knowledge due to the presentations, and users' opinions on the process.

7.3.2 Results on Effectiveness of Visioning Tools and Process in Metro Vancouver

The project demonstrated that an integrated, visualization-based process is workable and effective in two very different BC communities. Compelling 3D visualizations of local climate change scenarios can be developed defensibly, despite the multi-disciplinary data/modelling needs, complexity and uncertainty involved. The results of the study suggest that participatory planning processes supported by geo-visualization and visual imagery can have a significant effect on both awareness and affective response. Key findings drawn from initial data analysis are described next (for more details, see Tatebe et al. 2010; Cohen et al. 2011; Sheppard et al. 2011).

[2] LIDAR: Light Detection and Ranging techniques using laser-scanning of landscape surfaces to create detailed 3D models.

[3] Approximately half of the Delta public sample were first shown a version of the visioning packages without visualisations, in order to distinguish the results of the overall visioning process from the specific impacts of the visualisations. The results of this comparison are reported elsewhere; in this chapter, the results described apply primarily to the visioning process including visualisations.

7.3.2.1 Participant Engagement

Based on observational data of audience response recorded during the evaluation workshops, it is clear that the extensive use of realistic visualisations maintained a high level of engagement among the public participants over a long and intense visioning session. Some of the most effective images were an animation of rising lea-levels and visualisation sequences with animated slide transitions (wipes) showing time-lapse effects over the 21st Century. Notable examples of the latter included flooding of an island depicted in an aerial view of a LiDAR/terrain model draped with an aerial photograph, and the transition to a higher sea wall blocking views from a back-garden in the community. Participants were also interested in certain other graphics, e.g. illustrative charts and pictographs showing the key indicators differentiating the four future worlds. Interest tended to flag somewhat with longer temporal visualisation sequences.

7.3.2.2 Credibility and Effectiveness

Credibility of the visualisation tools and effectiveness of the visioning process were rated generally as high, though some recommendations for enhanced or additional products were received. Planning and engineering professionals had generally similar responses to those of the public in finding the visualisations credible. Even where the visualisations showed peak events such as storm surge flooding of entire communities, it appears that we did not approach the limits of permissible drama with the participants. Some people commented that the visualisations were too benign, relative to actual storm/flooding conditions which they had experienced.

7.3.2.3 Cognition and Awareness

Professionals registered a substantial increase in the urgency of responding to climate change, after seeing the visioning packages. Using visualizations of alternative climate futures in local and familiar places substantially increased the public's awareness of local climate change impacts and of the response options available to communities. A number of participants remarked on the way the imagery and content of the Local Climate Change Visioning presentation demonstrated the local impacts, making "global warming more immediate, more real". Another participant made the impact of the visuals clear, "I learned how climate change could affect my community in a very graphic way. Numbers may not stay with me but visuals will", The use of photographs from precedents for adaptation or mitigation solutions implemented elsewhere seemed to work to suggest feasibility of future conditions; this and the range of response options visualized seemed to leave people with a sense of the constructive actions that can be taken.

7.3.2.4 Emotions

The analysis of the pre and post questionnaires suggest that, despite a fairly high prior knowledge of global climate change, many respondents' concern about the effects of climate change significantly increased. Many respondents noted that having information locally contextualized and visualized in alternative futures made the climate change information "hit home".

7.3.2.5 Motivation and Behaviour

Results show a significant increase among respondents in the belief that action taken can significantly reduce the impacts of climate change in the future. The visioning material increased stated motivations for behaviour change and altered community participants' attitudes. There was a significant increase in the number of respondents who personally plan to do something about climate change. Analysis of comments revealed that the majority focused on changes to personal auto use (e.g. use car less, walk/bike, use public transport, carpool, buy a hybrid) and the household (e.g. changing light bulbs, using less energy, upgrading appliances), rather than collective responses such as voting with an emphasis on a climate change platform or joining a community group. Willingness to support climate change policies (both mitigation and adaptation) at the local scale increased substantially. One participant from Delta's Environment Committee called the sessions "empowering".

This exploratory research thus offers compelling evidence to support the use of alternative climate change scenarios, downscaled climate information, and geomatics-based visualization techniques to generate significant cognitive and affective responses in community participants, and increase policy support on climate change action. It is difficult to disentangle the effects on participants of the visualisations from those effects arising from the overall participatory process. In a control group of Delta residents who were exposed to the visioning presentation without landscape visualisation but with otherwise similar content, many responses trended in the same direction as those of participants seeing the full presentation, but support for mitigation and adaptation policies was stronger with those seeing the visualisations (Sheppard 2012); engagement and interest levels appeared higher with visualisations also. In subsequent interviews with practitioners involved in the process, the majority of images most vividly recalled were landscape visualisations (Burch et al. 2010).

Broadly similar results from the full visioning process were obtained with both members of the public and practitioners (Tatebe et al. 2010). However, the self-selected nature of the citizen participation may mean that these participants represented an "interest" sample, and the incidence of recent climate change-related events (e.g. flooding in Delta in 2006) may help explain the fairly high levels of awareness on climate change. Accordingly, it cannot be assumed that other types of community would react similarly.

Fig. 7.4 Landscape visualisations showing projected sea level rise impacts and hypothetical adaptations in the year 2100 with 1.2 m sea level rise in South Delta, BC. **a** View in 2100 with current dike conditions and projected flooding from a nearby dike breach. *Visualisation Credit* D. Flanders, CALP, UBC. **b** View with raised dike in the "Hold the Line" scenario, *Visualisation Credit* D. Flanders, CALP, UBC

Beyond the formal evaluation, the visioning project has been well received by the public, politicians, planners, engineers, and international scientists. The resulting visual products have been sought after by local to national media, providing an expanded opportunity for public education and awareness building. The steadily growing number of invited presentations on the visioning methods and results, coming from local, provincial, national and international audiences, suggests a hunger for techniques and information of this kind. Longitudinal studies on the long-lasting impact of the visualisation-aided process are now underway.

Collaboration with the municipality of Delta in particular have continued to this day, drawing on the data and trust relationships previously established. Recent work adapting the LCCV process has focused on developing a range of adaptation scenarios responding to sea level rise though 2100, tied both to spatial analysis of land values and other outcomes, and to detailed landscape visualisations explaining specific adaptation measures and their implications (Fig. 7.4).[4] These

[4] Funded primarily by Natural Resources Canada and BC Ministry of Environment.

combined efforts have led to policy recommendations presented to local officials (Barron et al. 2012), and ongoing efforts to engage a wider community on these critical issues.

7.3.3 *Outcomes of Other Canadian Visioning Case Studies Using Landscape Visualisations*

Since the original visioning studies in the Metro Vancouver region, the Local Climate Change Visioning process using geospatial and landscape visualization tools has been adapted and applied in three other contexts across Canada.[5] The projects[6] all addressed climate-related issues at community to regional scales; used spatially-based approaches to integrate scientific data and modeling; conducted participatory processes where academic research teams collaborated with local stakeholders and inter-disciplinary experts; explored possible future pathways using scenarios or landscape design options; and applied 2D and/or 3D visualization tools (Pond et al. 2012).

7.3.3.1 A Case Study at Landscape Scale

In Kimberley in the BC Kootenays, the CALP research team applied the visioning process within a small, rural, less well-resourced community watershed (Schroth et al. 2009). This study was embedded in a local process within the Kimberley Climate Adaptation Project (KCAP), a community-driven project to identify local climate change impacts and vulnerabilities, and develop adaptation planning recommendations. The scenario method was simplified to two stakeholder-driven qualitative scenarios (integrated mitigation and adaptation versus adaptation only), supported by quantitative modeling, spatial analysis and 3D visualization of forest fire risks and mountain pine beetle susceptibility under climate change (Pond et al. 2009; Schroth et al. 2009).[7] Google Earth (Fig. 7.5) was chosen as one of the main presentation media because it allowed user interaction and is widely accessible to other smaller communities. Stakeholder interviews and feedback from process participants confirmed that the

[5] Funded primarily by the GEOIDE National Centres of Excellence research network.

[6] A fourth visioning study was conducted for the Elbow River drainage in Alberta, by a University of Calgary research team and partners, using an integrated set of geospatial modeling tools (see Pond et al. 2012); however, this project did not employ landscape visualisation and so is not discussed further here.

[7] Funded by BC Real Estate Foundation and BC Ministry of Community development, with support from the Columbia River Trust and City of Kimberley.

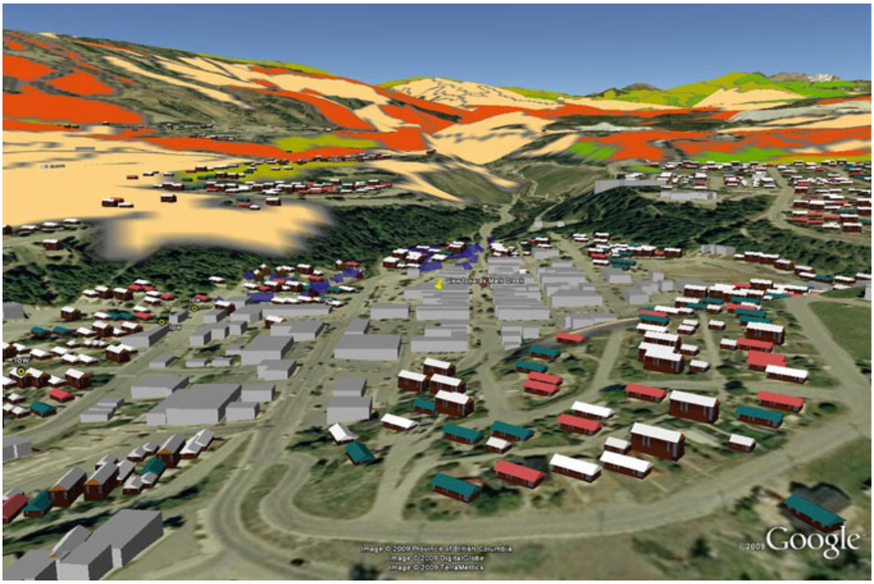

Fig. 7.5 Semi-realistic landscape visualization of the community of Kimberley showing high (*orange*) and moderate (*cream*) susceptibility to Pine Beetle infestation in the surrounding forested watershed due to warmer winters, with potential increased flood hazard (*yellow circles*) in town. *Credit* O. Schroth, CALP, UBC. Mountain Pine Beetle Data source: ILMB, BC Government. Background Image: © 2009 Google Earth. Image © 2009 Province of British Columbia; Image © 2009 Digital Globe; Image © 2009 Terra Metrics. Reproduced from Sheppard (2012) "Visualizing Climate Change", Earthscan/Routledge

visualizations raised awareness and facilitated understanding of climate change impacts and mitigation/adaptation options. Rankings of the various kinds of visualizations in order of importance to users (if involved in commenting on a planning proposal) revealed a bi-modal distribution for Google Earth, where the virtual globe was ranked first 16 times and ranked last 11 times, suggesting that some people really like the interactive tools whereas others preferred the more static media. Overall, the stakeholder workshops produced more than 70 recommendations for climate change mitigation and adaptation, some of which have since been implemented in policy (Schroth et al. 2011).

Based on the Kimberley project and the earlier Metro Vancouver projects, CALP produced a Guidance Manual on the LCCV process and tools (Pond et al. 2010) for interested practitioners. This was used during the next series of projects in a comparative national study (Pond et al. 2012). Over four years, researchers at the Universities of British Columbia, Toronto, Waterloo, and Calgary have collaborated with local partners to adapt LCCV processes to other contexts—from downtown Toronto, to a regional watershed in Alberta, to a Hamlet in Nunavut.

7.3.3.2 A Case Study at Community Scale

The Clyde River project in Nunavut used spatial planning, scenarios, mapping and SketchUp 3D visualizations in a participatory process with translators to bring together local and scientific knowledge, build social learning around planning issues, and visualize potential future resilient pathways for the community. Scenario development was based on four dominant concerns: landscape hazards; housing shortages (as well as how to plan for future population growth); walkability within the community and quality of life issues; and energy resilience (Fig. 7.6). Following review by Hamlet staff and members of the community, two spatially divergent scenarios were developed to explore spatially distinct development alternatives while incorporating more resilient energy production and

Fig. 7.6 Alternative scenarios and supporting analysis for development of the Arctic community of Clyde River, Nunavut, showing: **a** official plan overlaid with hazard areas in *red*, **b** potentially resilient redevelopment to increase housing, avoid hazard areas, improve walkability, and reduce dependence on imported diesel through renewable energy. *Credit* N. Sinkewicz, D. Flanders, K. Tatebe, and E. Pond, CALP, UBC. Reproduced from Sheppard (2012) "Visualizing Climate Change", Earthscan/Routledge

quality of life concerns in building design and arrangement. “Feedback from community partners suggests that the mapping exercises and 3D visualizations have fostered new conversations and understanding around the community’s future and growth options” (Pond et al. 2012), though significant challenges remain in terms of separation between official decision-makers and local community concerns, due to distance and limitations of conventional planning methods still in place.

7.3.3.3 A Case Study at Regional Scale

In Toronto, the case study applied geovisualization methods and tools to help policy-makers and, ultimately, the public, explore where planning policy and mitigation efforts can best be targeted. Two main research foci were identified: reducing heat island effects and increasing green energy production through rooftop photovoltaics. The visualization approaches were driven by a need to help decision makers (e.g. City staff, individual homeowners, etc.) to interactively explore spatial variability in heat and rooftop PV suitability, and to identify tangible linkages between policies and action strategies across multiple scales (Pond et al. 2012). This involved: mapping variations in surface heat using surface temperature variations represented as topographic surfaces on which orthophotos were draped to highlight correspondence between land use and heat effects (Fig. 7.7); development of a web-GIS application and solar modelling to explore

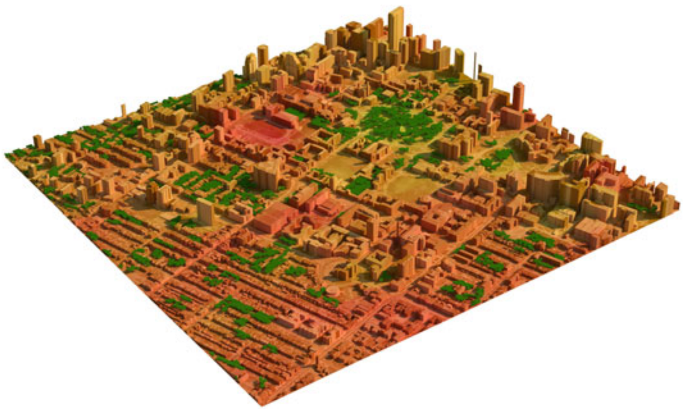

Fig. 7.7 3D model of urban heat island in Toronto: *colours* represent surface temperatures, showing the cooling effect of vegetation (tree canopy shown in *green*). *Credit* J. Danahy. *Data source:* Maloley, MJ. 2010. Thermal remote sensing of Urban Heat Island Effects: Greater Toronto Area, Geological Survey of Canada, open file 6283, 40 pages. doi:10.4095/26339; Behan, KJ, Mate, D, Maloley, MJ, Penney J 2011. Using strategic partnerships to advance urban heat island adaptation in the greater Toronto Area. Geological Survey of Canada, open file 6865. 1 CD-ROM. doi:10.4095/288755. Reproduced from Sheppard (2012) “Visualizing Climate Change”, Earthscan/Routledge

solar panel feasibility on individual buildings. This collaboration has led to on-the-ground decision-making in the design and construction of cooler, green parking lots as a heat island mitigation measure, centered on Pearson International Airport; and partnering with the Toronto and Region Conservation Authority (TRCA) to leverage the solar and heat mapping work for their Sustainable Neighbourhood retrofit Action Plan (SNAP) sites.

Local climate change visioning as an applied research program has thus contributed to longer-term outcomes on climate change awareness, policy, and action in several Canadian communities. Early evidence suggests that it may have contributed to a culture of change in thinking about and planning for climate change among the practitioners and policy-makers involved. The next section discusses the implications for practice and further research, within and beyond Canada.

7.4 Implications for the Use of Visualization in Responding to Climate Change

Participatory, iterative processes, involving stakeholders throughout, have led to credible outputs (Moser 2009), based both on underlying science, local knowledge (Rantanen and Kahila 2009), and trust relationships with the research team. Participatory processes have also provided local capacity on the local impacts and response options related to climate change (Shaw et al. 2009). However, evaluation has shown that participatory processes which systematically incorporate visualisations can effectively convey salient information, and help to encourage discussion and informed consideration of local climate change issues, risks, trends, and response/policy options (Schroth 2007; Sheppard et al. 2008; Tatebe et al. 2010; Burch et al. 2010). The process and the tools taken together have had measurable impacts on participants, including increased awareness, understanding, and motivation to support policy change (Sheppard et al. 2008; Schroth et al. 2009; Cohen et al. 2011).

Experience to date with Local Climate Change Visioning processes in Canada suggests a hunger among communities for more detailed and salient information on climate change impacts and response options, a void not being filled at present by any one discipline or conventional planning processes. There are few actual climate change scientists available to communities, and very few if any local governments are using visual learning tools to accelerate awareness and build capacity on climate change among practitioners, policy-makers, or the public. Local planners and engineers are increasingly tasked with forging a response on climate change, but in North America at least there are as yet very few roadmaps and no proven planning processes in place enabling communities to address, holistically and practically, multiple climate change issues at the local level. Adaptation and mitigation responses are often dealt with separately in silos within responsible agencies. How then will these challenges and associated climate change targets be met?

Clearly, there is major potential for the use of visualizations with participatory processes in filling this void. The Local Climate Change Visioning processes described above move beyond current practice. They represent a prototype for improved planning and engagement processes, which could be used to operationalize climate change science into conventional decision-making and design procedures. They show that it is possible to carry out an inclusive, multi-criteria process based on visualizing holistic future conditions, backed by scientific spatial modelling, and supporting structured decision-making. The initial process that was successful in Metro Vancouver has indeed been adapted to fit diverse conditions, data constraints and team capabilities (see Pond et al. 2012) in three other locations. What began as an experimental stand alone research technique has since been embedded in municipal climate change planning processes (Kimberley), applied to several planning and design interventions across a major city (Toronto), and used to formulate alternative northern development strategies that are more sustainable and culturally responsive than official community plans (Clyde River).

Such tools and processes could be central to resolving difficult dilemmas in contested landscapes, e.g. the impacts of wind power on areas of sensitive landscape character, or the opposition to increased urban density in existing neighbourhoods. We will need good communications, fair processes, and excellent design if we are to resolve problems and preserve quality of life during the transition away from high carbon energy sources and as climate uncertainties increase.

However, using powerful techniques like landscape visualisation as both an objective decision-making tool and a way to motivate changing attitudes and policy, requires a credible and ethical stance with sound methodologies for preparing valid visualisations of climate change. Sheppard (2001, 2005b) has proposed a Code of Ethics for use of landscape visualisation, which identifies the following principles or criteria that may be relevant to climate change applications:

- accuracy of visualisation relative to expected conditions;
- representativeness of views in space and time, relative to the context;
- visual clarity of presentations;
- interest and engagement of the audience/users;
- legitimacy or accountability of the visualisation, including transparency of data and the production process; and
- accessibility of the visualisations to the public and potential users.

Mulder et al. (2007) expanded these to include a range of quality criteria for visualisation, and Sheppard (2012) has outlined principles for defensible use of various visual media, including landscape visualisation, in engaging people on climate change specifically. Development and presentation of visualisations by a trusted source would appear to be an important aspect of defensibility (Nicholson-Cole 2005; Sheppard 2012). A strategy that has worked in the LCCV studies was to secure effective stakeholder participation in the development of socioeconomic scenarios and the application of decision-rules for visualising the scenarios.

Another possible strategy would be to allow the doubtful or skeptical user to freely navigate, interact with, or interrogate the visualisation imagery and underlying databases (Furness III et al. 1998; Sheppard and Salter 2004).

Capacity-building and training of practitioners on structured and ethical preparation and use of visualisations in participatory planning processes for climate change is needed across a range of climate change issues affecting communities, working with other extension agents in the government, regional agencies, industry, and NGOs to transfer knowledge to and from communities. Initial guidance on learning, planning, and implementing these processes already exists, in the form of a Visioning Manual (Pond et al. 2010) and review of visual media techniques, principles, and examples in Sheppard (2012). It is also possible that the audience or receiver of information from visualisation-based processes (e.g. the public or local councils) may need training in order to absorb and correctly interpret the meaning of sometimes novel or unfamiliar visual imagery or tools.

Visual imagery is to some extent a universal language, transcending linguistic and sometimes cultural differences. Landscape visualisations have been shown to be effective in a variety of social groups and community types, including aboriginal communities in BC (Lewis and Sheppard 2006) and Nunavut (Pond et al. 2012). This suggests that the visioning processes tested in diverse Canadian communities may also be applicable in other countries and community types.

Further research is therefore needed to test the effectiveness of visioning processes in various environments and community types internationally. It is also important to conduct more evaluations of the impact of visualisations relative to the larger participatory process. Lastly, it would be instructive to evaluate and compare visioning processes which are researcher-driven versus those conducted by practitioner and embedded in official planning processes.

7.5 Conclusions

Communities all over the world face an urgent need to choose between possible climate change strategies with far-reaching consequences, while keeping their public involved and supportive. Experience gained through a decade of Canadian research suggests that landscape ecologists and practitioners can employ powerful science-based visual tools capable of improving understanding, influencing people's perceptions, and helping to motivate action at the landscape or community level. Such approaches could help fill the void in developing practical, holistic, collective solutions to climate change problems, using defensible visual imagery of future low-carbon resilient communities. Participatory visioning processes can dramatically bring the impacts of climate change home to people, making it 'personal' through realistic visualizations of their familiar landscape under future scenarios informed by climate change projections. The Canadian community case studies described in this chapter suggest that this novel approach, combining various scientific, geomatic, communication and psychological techniques, represents a better way to inform community dialogue and decision-making on climate change mitigation and adaptation. Practitioners and professional associations internationally should consider enhancing conventional community planning methods along these lines, in order to test or adapt methods such as those applied in Canada, to address growing issues of climate change at the local level everywhere.

If visioning processes and visualisations are to be used more systematically in planning and engagement on climate change, training and guidance are needed. Because landscape visualisations help to engaging emotional responses, strong ethical procedures will be key. Visualisation tools are too powerful to be ignored, but also to be used without careful consideration of defensibility. Scientists and practitioners should adopt better standards for using visualisation and visioning processes to convey the science, acknowledge the uncertainties, engage stakeholders, and ultimately help local communities to develop their own solutions to climate change.

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