Climate Change Visualization: Using 3D Imagery of Local Places to Build Capacity and Inform Policy

Sarah Burch, Alison Shaw, Stephen Sheppard and David Flanders

Abstract

Linking global science to locally significant places with visioning processes and visualizations represents a powerful tool for decision-making in the context of climate change responses. The Local Climate Change Visioning Project in British Columbia, Canada, builds on recent advances in backcasting and scenario-building to bridge the divide between predictive, quantitative approaches and narrative-based qualitative methods. The Visioning Project incorporates novel 3D visualization techniques with elements of participatory integrated assessment to explore visions of the future under climate change for the Lower Mainland community of Delta. This study illustrates that addressing climate change in a participatory way, with credible but easily accessible visuals, and at a scale that matters to people, may be critical in building capacity for climate change action. Furthermore, this project demonstrated that compelling 3D visualizations of local climate change scenarios can be developed defensibly, despite the multi-disciplinary data/modelling needs, complexity and uncertainty involved.

Introduction

Climate change has recently emerged as a defining political, economic, and environmental issue as a result of increasing levels of awareness, mounting scientific evidence, and high profile instances of innovative political leadership. Nevertheless, climate change remains a complex issue characterized by deep uncertainty, and has failed to stimulate pervasive and transformative shifts in behavior and policy (Nicholson-Cole 2005).

The Intergovernmental Panel on Climate Change (IPCC) has been instrumental in framing the problem of climate change. Using global emissions scenarios, the IPCC has projected future impacts of climate change while also communicating various response strategies available to policymakers, primarily at the international and national scales (IPCC 2007a). The latter scenarios include ways to adapt to projected impacts and to reduce overall vulnerability to climate change via mitigation. With these goals driving the IPCC assessment process and becoming the foundation for its credibility in the policy sphere (Shaw, 2005), the IPCC has taken an approach that is targeted at an improved *understanding* of climate change.

Following the IPCC's lead, climate change is still largely addressed by an expert-driven process including the 'communication-as-transmission' concept – knowledge is best generated by scientists, and simply needs to be transmitted to decision-makers and the public for subsequent action (cf. Lubechenco 1998 p. 491). Despite substantive critique (e.g., Gibbons 1999), the concept seems to persist in the climate change discourse.

All three features of this approach to climate change, namely being global in focus, aiming at enhanced understanding, and being expert-driven, seem to be insufficient to anchor climate change *action* in regional and local contexts. Yet, a number of recent studies demonstrate new ways to holistically communicate climate science (cf. Moser and Dilling 2007). First, *contextualizing* climate change impacts on the regional and local level by means of iconic

locations allows people to 'encounter' the possible impacts of climate change and make them more meaningful (Leiserowitz 2004; Balmford et al. 2004). Second, *visualization* seems to be a viable aid to link the understanding of climate change impacts to behavioral change and action, in some cases through emotional involvement (Nicholson-Cole, 2005; Sheppard, 2005a). Finally, studies on the science-policy interface have provided evidence that ownership and social robustness of problems and solutions requires co-production of knowledge (Gibbons 1999; Shackley and Deanwood 2002; Shaw 2005; Robinson and Tansey 2006). Engagement of non-academic stakeholders does not simply mean transferring information, but needs to occur through an iterative participatory process to create ownership, accountability, and a willingness to act (UKCIP 2009). In sum, progress towards climate change mitigation and adaptation seems to be more likely if credible information is localized, visualized, and co-constructed (Lorenzoni et al. 2007, Shaw et al. 2009).

The Local Climate Change Visioning Project in British Columbia, Canada, represents one approach that may assist local decision-making. Building on recent advances in backcasting and scenario-building to bridge the divide between predictive, quantitative approaches and narrative-based qualitative methods, the Visioning Project incorporates novel 3D visualization techniques with elements of participatory integrated assessment to explore visions of the future under climate change for the Lower Mainland community of Delta.

This paper provides a brief introduction to the methods used by the Local Climate Change Visioning Project, with a particular focus on the creation of 3D visualizations (as opposed to the participatory scenario development aspects of this project, for instance). These methods have been explored in greater detail elsewhere (Shaw et al. 2009), along with their impact on public awareness, decision-making, and behavioural intent.

Methods and Approach

The Local Climate Change Visioning Project developed a methodology of translating the science of climate change into credible, ethical computer visualization imagery. It achieves this in a 3-step process:

i. Localize: translate or downscale global climate data to regional and local scales in a transparent, understandable manner for local policy makers and the public;

ii. Spatialize: describe the potential impacts of climate change in the landscapes where people live and work, and adaptation and mitigation options in these places, through spatial modelling and/or interpretive mapping at the local level;

iii. Visualize: communicate this information in an ethical, scientifically defensible, and dramatic manner (using 3D simulation of recognizable places) that not only educates viewers on the realities of climate change but also emotionally motivates behavioral change at the individual and community level (Conroy 2004; Sheppard 2005a).

We visualized the local scenarios based on decision rules and ethical standards (Sheppard, 2005b), addressing data availability, expert and local input, clear and compelling visual information, and fit with the local narratives. These visualizations were created to test whether defensible, compelling depictions of climate change and responses to it would add value to existing approaches to climate change communication and planning (Nicholson-Cole, 2005; Sheppard, 2005a). The scenarios were designed to be used in subsequent perception studies; therefore emphasis was placed on providing a range of common styles, levels of realism, and types of imagery that have been shown to be effective in previous participatory studies (eg. Tress & Tress 2003; Sheppard 2005b). A deliberate decision was made to reduce

somewhat the realism of the developed areas in close-up views, in order to avoid possible adverse reactions from participants and potential legal repercussions around individually recognized property in the area (cf. Mendez 2008).

The first phase was the development of a conceptual framework which allowed for the organization of a plethora of qualitative and qualitative data, bridging from the global to the local level (Sheppard and Shaw 2007). Key biophysical and socioeconomic drivers were collated from the Intergovernmental Panel on Climate Change's Special Report on Emissions Scenarios (Banuri et al. 2001; Nakicenovic and Swart 2000), the Millennium Ecosystem Assessment (Raskin 2005), and the scenarios of the Global Scenario Group (see for example Raskin et al. 2002). These scenarios were downscaled by integrating national, regional, and local impact assessment with climate-related policy information. The framework development also involved the use of a pre-existing socio-economic model, GB-QUEST (see for example: Robinson et al. 2006; Tansey et al. 2002), to match regional and global emission assumptions while maintaining internal consistency for socio-economic drivers (see Figure 1). Regional storylines and narratives were developed which utilized the combined data provided by global models, regional assessments, local expertise, and GHG emission assumptions (Shaw et al. 2009).

The conceptual framework outlined four alternative global change scenarios based on GHG emissions and response options, from a 1990 baseline over the time steps 2020, 2050, to 2100. The first scenario entitled "Do Nothing" is a high emissions scenario with no effective adaptation or mitigation activities. The three other scenarios implement different proactive response strategies with different effects on emission profiles. The 'pure' adaptation scenario entitled "Adapt to Risk" still remains a high emissions scenario (no significant effect on emissions). The scenario entitled "Efficient Development" employs adaptation but also limited mitigation measures resulting in a moderate emissions profile. Finally, the fourth scenario entitled "Deep Sustainability" is based on the assumption that strong mitigation responses, coupled with adaptation, would significantly reduce the emissions trajectory over time (approximately 60% reduction by 2050, relative to 1990), and lead to stabilization of climate change.[1]

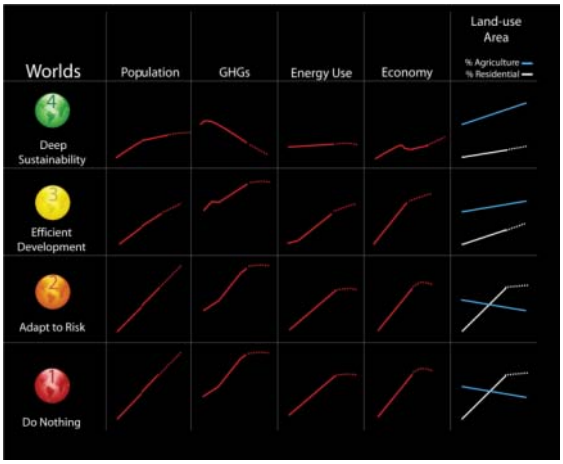

Figure 1. GB QUEST modelling input (GHG emissions) and outputs (drivers), combined with impacts (partly regionalized) and response adaptation and mitigation measures.

Two- and three-dimensional landscape visualizations were supported by Geographic Information Systems (GIS) and climate/environmental modeling. We applied visualization tools ranging from 2D photorealistic graphics editing (*Photoshop*) to 3D tools including *ArcSCENE*, *Google Earth*, *SketchUp*, and *Visual Nature Studio*. We processed a high-resolution 3D dataset (*LiDAR* data) for accurate visualization of the shorelines. The generated visuals were reviewed by the extended research team which included approximately a dozen scientists across a range of disciplines, levels of government and academia, as well as by the local working group composed of residents, practitioners and stakeholder group

1 Stabilization here refers to remaining under a 450 ppmv atmosphere CO2 concentration by 2100 (and subsequently remaining below a projected 2ºC global average surface temperature warming), considered the threshold of dangerous anthropogenic interference (IPCC, 2007b).

representatives. These were subsequently revised by the core research team, a smaller group of UBC researchers, in an iterative process. The visual material (which also included GIS mapping, charts, and photographs of precedent response options elsewhere) were finally combined with data and narratives to produce 'visioning packages'. These were used in testing sessions in the second phase of this project, to establish local public reactions (cognitive, affective, and motivational) to the visioning presentations in community workshops.

Figure 2 illustrates the four scenarios in one well-known local neighbourhood, providing an understanding of what each of the four scenarios look like in one location. Figure 3 demonstrates the use of multiple spatial scales for contextualizing climate impacts while at the same time exploring detailed, localized adaptive and mitigative solutions.

Figure 2 a-d. (from top left to right, to bottom left to right) a. Scenario 1 illustrates more frequent flooding and abandonment of houses; b. Scenario 2 shows a berm as an adaptation strategy; c. Scenario 3 includes incremental retrofits of stilts and solar panels; d. Scenario 4 depicts a new urban design with low-carbon, energy and food producing clusters with integrated resilience to projected impacts. (Credit: David Flanders, CALP/DCS, UBC).

Figure 3 a-d (from top to bottom). Impacts and adaptations from Scenario 2 shown at a. Larger sub-regional scale with sprawling future sub-urban development into high-flood-risk agricultural areas; b. Neighbourhood scale demonstrating existing community risk to sea level rise; c. An "in-my-own-backyard" view of adaptive housing necessary due to the risk of a dike breach; d. A detailed depiction of sea-wall raising to the height sufficient for protecting homes under this climate scenario. (Credit: David Flanders, CALP/DCS, UBC).

Preliminary Results and Discussion: The Influence of Visualizations in The Public and Policy-Making Realms

The Local Climate Change Visioning Project incorporated strong elements of public participation – from the development of the images in conjunction with staff and policymakers within the municipality, revision of the images with the help of local experts and stakeholders, and testing of these images with a public audience. Even among municipal experts, the mere provision of information was deemed unlikely to address concerns

regarding the uncertainty of local climate futures, the portfolio of response options available, and effect of regional, provincial, and federal policies on local spaces. The project therefore went beyond conventional information provision, using visualization and an 'analytic deliberative process' (Stern and Fineberg 1996), which "combines sounds science and systematic uncertainty analysis with participatory deliberation by an appropriate representation of affected parties, policy-makers, and specialists" (Pidgeon et al. 2005). The project demonstrated that such a holistic process is workable and effective at the local community level. Compelling 3D visualizations of local climate change scenarios can be developed defensibly, despite the multi-disciplinary data/modelling needs, complexity and uncertainty involved.

This deliberative process of scenario and visualization design may be an important means of overcoming barriers to municipal climate change action (Burch 2009) for three reasons. First, communicative partnerships were forged between politicians, municipal staff and scientists. These partnerships may improve the legitimacy and effectiveness of the climate change response discourse in the municipality of Delta, and may lead to locally-specific and integrated adaptation and mitigation policies. Second, the development of four iconic, highly localized, and meaningful scenarios aided in the explicit incorporation of values into an alternative mode of deliberation – namely storytelling using visual media. These media provide a common language with which experts from disparate disciplines may communicate and express anticipated climate change impacts and desirable responses, and thus help to overcome the barrier of miscommunication. Finally, the Local Climate Change Visioning Project, through a series of iterative consultations with various municipal groups and advisors, provided a mechanism by which the fruits of the participatory visualization development process may be fed into decision-making procedures. Collaboration with the Project was officially endorsed by the Delta City Council, and the products of the process were presented to the Council upon completion. This served the purpose of allowing Delta's political leaders to explore the implications of future climate change impacts in their region, obtain valuable technical advice from their staff in a focused and highly effective manner, and explore linkages between climate change responses and other policy priorities.

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 (Sheppard et al. 2008). 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. The research offers compelling evidence (see Shaw et al, 2009; Sheppard et al. 2008) to support the use of alternative climate change scenarios, downscaled climate information, and geomatics-based visualization technology to generate significant cognitive and affective responses in community participants, and increase behavioural intent to take action on climate change. Community members reported increased awareness of local climate change impacts and of the response options available to communities. Despite a fairly high prior knowledge of global climate change, many respondents' concern about the effects of climate change significantly increased. Some respondents noted that having information locally contextualized and visualized in alternative futures made the climate change information "hit home". The visioning material increased stated motivations for behaviour change and altered community participants' attitudes: there was, for example, a significant increase in the number of respondents who personally plan to do something about climate change (Sheppard et al. 2008).

It has not been possible in this initial study to measure actual behavioural changes, so the overall impact (if any) of the visioning process on action cannot be gauged. Discussions with

the Municipalities are still continuing and impacts on policy remain possible. The Local Climate Change Visioning process has since been replicated in other Canadian communities and is the subject on ongoing research evaluation.

Conclusion

Recent studies have paved a way to anchor climate change action in regional and local contexts. The scenario study presented here was a collaborative effort by the University of British Columbia, communities within Metro Vancouver, and numerous agencies and organisations, utilizing participatory methods of capacity building for climate change. Emphasis was placed on closing the gaps between global climate change on the one hand and local impacts and action on the other, by integrating global climate science, different scales of governance, local planning, and public engagement. A key component was to visualize climate change scenarios and response options at iconic local places, offering a new way of enhancing relevance to decision makers and community interests. This study illustrates that addressing climate change in a participatory way, with credible but easily accessible visuals, and at a scale that matters to people, may be critical in building capacity for climate change action. The effects of visualizations on increasing understanding, emotional engagement, and motivating behaviour change have been initially demonstrated with community members, and are the subject of a more in-depth analysis to be presented elsewhere.

Linking global science to locally significant places with visioning processes and visualizations represents a powerful tool for decision-making in the context of climate change responses. In the future, providing an integrated and concise assessment of the ways in which the results of the testing sessions could be built into concrete and effective climate change response policies represents the final link in closing the loop between municipal governance, scientific expertise, and public participation.

References

Balmford, A., Manica, A., Airey, L., Birkin, L., Oliver, A., Schleicher, J. (2004). Hollywood, climate change and the public. *Science* 305, 1713.

Banuri, T., Weyant, J., Akumu, G., Najam, A., Pinguielli Rosa, L., Rayner, S., Sachs, W., Sharma, R. & Yohe, G. (2001). Setting the Stage: Climate Change and Sustainable Development. IN METZ, B., O. DAVIDSON, R. SWART, AND J. PAN (ed.) *Climate Change 2001: Mitigation, Report of Working Group III, Intergovernmental Panel on Climate Change.* Cambridge, Cambridge University Press.

Burch, S. (2009). In pursuit of resilient, low carbon communities: An examination of barriers to action in three Canadian cities. *Energy Policy* DOI: 10.1016/j.enpol.2009.06.070.

Conroy, M.M., S. I. Gordon (2004). Utility of interactive computer-based materials for enhancing public participation. *J. Environ. Planning Manage* 47, pp. 19–33.

Gibbons, M. (1999). Sciences new social contract with society. *Nature* 402, C81-C84.

IPCC (2007a). Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. M.L. Parry, O.F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (eds.). Cambridge University Press, Cambridge.

IPCC (2007b). Climate Change 2007 – Fourth Assessment Report. Synthesis Report. Cambridge, UK: Cambridge University Press.

Leiserowitz, A. (2004). Before and after “The Day After Tomorrow”: A U.S. study of climate risk perception. *Environment* 46, pp. 22–37.

Lorenzoni, I., Nicholson-Cole, S., Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change* 17, pp. 445–459.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science* 279, pp. 491–497.

Méndez, R. (2008). Inmobiliarias acusan a Greenpeace de hundir los precios de La Manga. El Pais, June 10, 2008. Retrieved July 2008 from http://www.elpais.com/articulo/espana/Inmobiliarias/acusan/Greenpeace/hundir/precios/Manga/elpepuesp/20080610elpepinac_11/Tes.

Moser, S. C., Dilling, L. (2007). Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change. Cambridge: Cambridge University Press.

Nakicenovic, N., Swart, R. (eds.) (2000). Special Report on Emissions Scenarios (SRES). A special report of Working Group III of the IPCC. Cambridge: Cambridge, UK: University Press.

NRCan (Natural Resources Canada) (2006). Climate Change Impacts and Adaptation: A Canadian Perspective (Coastal Zone Summary). Retrieved September 27, 2006 from http://adaptation.nrcan.gc.ca/perspective/toc_e.asp.

Nicholson-Cole, S.A. (2005). Representing climate change futures: a critique on the use of images for visual communication. *Computers, Environment and Urban Systems* 29, pp. 255–273.

Pidgeon, N. F., Poortinga, W., Rowe, G., Jones, T. H., Walls, J. & O'Riordan, T. (2005). Using surveys in public participation processes for risk decision-making: The case of the 2003 British GM Nation? public debate. *Risk Analysis*, 25**,** pp. 467–479.

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammon, A. (2002). Great Transition: the Promise and Lure of the Times Ahead. A report of the Global Scenario Group. Boston: Stockholm Environment Institute.

Raskin, P.D. (2005). Global scenarios: Background review for the Millennium Ecosystem Assessment. *Ecosystems* 8, pp. 133–142.

Robinson, J., & Tansey, J. (2006). Co-production, emergent properties and strong interactive social research: The Georgia Basin Futures Project. *Science and Public Policy* 33, pp. 151–160.

Robinson, J., Carmichael, J., Tansey, J. & Vanwynsberghe, R. (2006). Sustainability as a Problem of Design: Interactive Science in the Georgia Basin. *The Integrated Assessment Journal* 6**,** pp. 165–192.

Shackley, S., Deanwood, R. (2002). Stakeholder perceptions of climate change impacts at the regional scale: Implications for the effectiveness of regional and local responses. *Journal of Environmental Planning and Management* 45, pp. 381–402.

Shaw, A., Sheppard, S. R. J., Burch, S. Flanders, D., Weik, A., Carmichael, J., Robinson, J., Cohen, S. (2009). How futures matter – synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building. *Global Environmental Change*, In Press.

Shaw, A. (2005). Imbued Meaning: Science Policy Interactions in the IPCC. Dissertation Manuscript, University of British Columbia, Vancouver, B.C. Canada.

Sheppard, S. R. J. (2005a). Landscape visualisation and climate change: The potential for influencing perceptions and behaviour. *Environmental Science and Policy* 8, pp. 637–654.

Sheppard, S. R. J. (2005b). Validity, reliability, and ethics in visualization. In: Bishop, I. & Lange, E. (eds.) Visualization in Landscape and Environmental Planning: Technology and Applications. Taylor and Francis, London. Chapter 5, pp. 79–97.

Sheppard, S. R. J,, Shaw, A., Flanders, D., and Burch, S. 2008. Can visualization save the world? Lessons for Landscape Architects from visualizing local climate change. Conference Proceedings, Digital Design in Landscape Architecture 2008, 9th International Conf., Anhalt University of Applied Sciences Dessau/Bernburg, Germany.

Sheppard, S. & A. Shaw (2007). Future visioning of local climate change scenarios: Connecting the dots and painting pictures to aid Earth System Governance. Conference Proceedings, 2007 Amsterdam Conference on the Human Dimensions of Global Environmental Change "Earth System Governance: Theories and Strategies for Sustainability", 24-26th May 2007, Vrije Universiteit, Amsterdam. (12 p).

Stern, P. C. & Fineberg, H. V. (1996). Understanding Risk: Informing Decisions in a Democratic Society. National Research Council: Washington, D.C.

Tansey, J., Carmichael, J., Vanwynsberghe, R. & Robinson, J. (2002). The future is not what it used to be: Participatory integrated assessment in the Georgia Basin. *Global Environmental Change* 12, pp. 97–104.

Tress, B., Tress, G. (2003). Scenario visualisation for participatory landscape planning: A study from Denmark. *Landscape and Urban Planning* 64, pp. 161–178.

UKCIP (United Kingdom Climate Impacts Program) (2009). User Consultation. Retrieved on March 10, 2009 from

http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=256&Itemid=350.

Biography

Sarah Burch, **Alison Shaw**, **Stephen Sheppard** and **David Flanders** are part of the Collaborative for Advanced Landscape Planning at the University of British Columbia, led by Stephen Sheppard. They specialize in landscape visualization, inter-disciplinary approaches to climate change and community planning, and environmental perception.