Climate Change
Impacts and Adaptation Program

Programme sur les impacts et l'adaptation liés aux changements climatiques

Weathering Climate Change: Community Adaptation to Inland Flooding

Introduction

Some exciting research has been undertaken to understand climate change impacts on coastal communities. Specifically, Sheppard (2008) has shown that coastal communities are projected to face dramatic flooding, mainly of waterfront residential properties and public amenity space.However, little work has yet been undertaken to look at the planning and community design adaptations that could address the increased inland flooding impact due to climate change. Riverine communities, of which there are many located across Canada, may face flooding impacts that are relatively more dire than those located on the coast. In most riverine cities, a river runs right through the most intensely developed part of the downtown core. Therefore, the increased risk of riverine flooding due to climate change threatens the very heart of these communities.

As a test case, we chose to focus our attention on Uptown Waterloo. Laurel Creek runs through Uptown in a culvert sized for a 100-year storm. Given that climate change is projected to result in more frequent, intense rain events, we suspected that this culvert would be undersized to handle the huge increase in run off associated with a major storm (500-year). We therefore undertook to determine the extent of potential flooding and to envision the types of adaptations that Uptown Waterloo may need to undertake to "weather" this particular climate change impact.

Adaptation is Necessary

Although it will be possible to slow climate change and the process of global warming, it is inevitable that some change will occur, and therefore we must be able to both mitigate and adapt to the unavoidable changes that will result from climate change. Adaptation is defined by the IPCC as "adjustments in ecological, social, or economic systems in response to actual or expected climactic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC, 2001).

Smit et al., 2001: Adaptation to climate change in the context of sustainable development and equity. Cambridge University Press, 880

Our goal is to develop a series of conceptualizations of adaptation responses to potential climate change impacts that are relevant to cities across Canada on how to adapt to the increased threat of inland flooding due to a changing climate (e.g., higher peak runoff from intense storm events, changing spring runoff and snow melt). Conceptual adaptation designs were developed to promote thought on the changes cities may have to undergo in the future to respond to a changing climate and to further increase awareness on the potential severity of the changes to come across the country.

Methodology – (Identifying Issues and Developing Adaptation Strategies/Design Principles)

1. Literature Review

To generate potential adaptation design concepts, an extensive literature review of adaptation initiatives/research in Australia, Europe and North America was undertaken to identify impacts on communities and propose adaptation strategies that could guide our design directions.

2. Local Site Analysis

Local site analysis in the Kitchener-Waterloo area was undertaken to determine possible sources of change, and in turn adaptation that could be necessary. As is the case in most of southern Ontario, the Waterloo Region has an extensive network of streams, creeks and rivers, many of which run directly through the major concentrations of population. This threat, or opportunity for adaptation in our eyes led us to begin considering how cities may begin to change, grow and manage their rivers and water networks and more importantly the cities build around them.

3. Scenario development for Calculation of potential elevated flood levels and extent of expanded flood plain

In an initial climate change assessment, "what if" scenarios have been used to undertake an initial scan of sensitivity, impacts and adaptation.We developed a "what if" scenario based on a British research that suggested "design flood magnitudes can be increased by 20% to reflect possible effects of climate change" (Richardson, 2002). We then developed impacts and adaptation options for flooding in the downtown core of the City of Waterloo. Our established floodplain under a changed climate resulted in an increase of 26% reflective of inaccuracies in data, and the inaccuracy of maps and terrain models. We used this flooding scenario as a starting point or "what if" scenario to vision potential changes to come and the adaptations Waterloo may need to undertake.

Richardson, D., 2002: Flood risk: the impact of climate change. Pt. Civil Eng. Civ. En., 150, 22-24

4. Preparation of Visualizations

A combination of Visual Nature Studio, Photoshop, Sketch up and Artlantis were used to generate graphics of the flooded area and four potential adaptations. These graphics demonstrate the potential of inland flooding and the processes, changes, and alterations cities across Canada are beginning to face.

Scenarios and Considerations

Based on our "what if" scenario, a number of options were developed to explore potential adaptation responses including:

- The Do Nothing Approach (No Adaptation)
- Green Swath
- Embanked City
- Boardwalk / Raised City
- Floating city

Each of these scenarios have associated challenges and potential benefits; the first 4 scenarios were modelled (excluding the 5th as it had more to do with coastal flooding).

Scenario 1: No Adaptation

This scenario simulates flooding under a changed climate. It shows the extensive area within the flooded zone and the massive requirement for changes to be made and precautions to be taken. The street level view and aerial view show the extensive new area of flooding in Uptown Waterloo. Failure to adapt to changing conditions could lead to financial burden on the city, strain on infrastructure and the failure of the downtown area as a suitable place for business.

Scenario 2: Green Swath

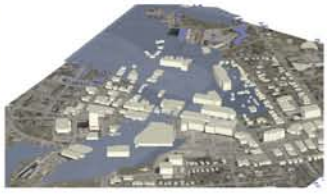
The development of a green swath, or restored natural riparian area would require removal of numerous buildings within the changed climate floodplain. However such an adaptation would alleviate damage, financial burden and the serious potential danger. A series of linkages as raised roadways or as curb-less roads, which could easily be cleared after a flood event would need to be maintained to properly connect the city. This green swath would not only restore a safe perimeter around potential flooding areas, but would restore natural diversity and natural linkages.

Scenario 3: Boardwalk/ Raised City

Development of a raised city within floodplain limits would maintain current linkages and uses. Although this option would be costly it would significantly reduce the amount of unusable land within the floodplain. Areas not raised for continued use could be established as natural areas or park systems accessible to the public in low risk times and dry seasons. This would essentially enable the city's functionality to remain in place while reintroducing a natural system through the city. Surfaces and treatment techniques for park systems would need to be simple and hardy ad withstand flooding in high water seasons.

Scenario 3: Embanked City

Development of levees, dykes and embankments in the flood plain throughout the city could reduce damages and channel the floodwaters through the city to reduce the number of buildings required for removal. However, embankments will further channelize rising waters and produce negative effects for communities further downstream. If floodwaters exceed the embankments, clean up would become costly and buildings would be mal-prepared because of the false sense of safety. Further an effective way of crossing these embankments would be needed.



Considerations

Flooding will cause a wide array of damage across the world. It will be vital to avoid this risk and to retrofit those buildings already at risk. To do so we have incorporated all of the following into our scenario preparation:

Principles include:

- avoid building on a flood prone sites
- exceed minimum floor levels
- consider multi-storey construction
- design and construct buildings for flooding occurrences
- use water-resistant materials
- design to ensure water can easily escape once flooding has subsided (especially for cellars and foundations)
- install essential, vulnerable equipment as high as possible
- the wider issue of designing access routes if flooding occurs and education about these routes
- raise or move the building
- building a second or multiple stories and using the lower storey as non-living or 'non productive' space
- moving services (hot water, meter board) above flood levels
- And many others (ask for further information)

Conclusions and recommendations

Although mitigation of Climate Change by reducing emissions of greenhouse gases is necessary it is now inevitable that some changes in climate will occur and cities must be able to adapt. Development of these design scenarios has been a starting point for exploring adaptation and it identifies further research, visioning and planning, that trys to determine what courses of action are best, both socially and environmentally. The built form will be crucial in years to come. How we plan our cities, design our buildings and locate our communities will determine their success. Throughout the design of adaptation scenarios it was obvious that some land will need to be returned to its natural state. This will not only help to reconnect ecosystems and natural linkages but will promote outdoor pathways for community members. These green corridors will act as natural floodplains, free of human constraint and able to slow the runoff and aid communities further downstream in times of peak discharge.