A CASE STUDY OF 100 RESILIENT CITIES: DOES THE 100 RESILIENT CITIES MODEL PROVIDE FOR A ROBUST DECISION-MAKING FRAMEWORK?

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Abstract

Case Study of 100 Resilient Cities: Does the 100 Resilient Cities Model Provide for A Robust Decision-Making Framework?

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Background: Rapid urbanization continues to occur on a global scale with the majority of the world's population residing in cities of various sizes and scales. Cities and their residents are becoming increasingly vulnerable to climate change and its impacts. Cities will continue to face social, political and economic impacts which particularly affect the most vulnerable populations. Municipal governments have focused upon resistance and control when dealing with complex problems such as natural disasters and their impacts. This research focuses on the 100 Resilient Cities Model to assess its robustness as a decision-making framework in relation to resilience and adaptive governance.

Methods: This researches relies upon 100 Resilient Cities as a case study. This project utilizes qualitative analysis of the 100 Resilient Cities model and critical assess its robustness through review of ecological and social-ecological resilience literature.

Conclusions: This paper concludes that the 100 Resilient Cities model is well-grounded in ecological and social-ecological systems literature. There is potential for the 100 Resilient Cities model to provide urban planners and policymakers with an effective decision-making tool in order to solve complex problems which exist within municipal governance structures.

Key Words: Resilience, Governance, Social-Ecological Systems

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Dedication

This paper is dedicated to a very special person and my best-friend. Patricia, without your continued support over the period of my graduate work I could not have achieved the results I have achieved. You were my guiding beacon and have always been there for me in the most challenging times. Words cannot express the appreciation and gratitude I have for you in my heart. Thank you.

Te quiero.

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1.0 Introduction

What is 100 Resilient Cities?

The 100 Resilient Cities(100RC) model—developed and financially supported by the Rockefeller Foundation—is a non-profit based initiative, which aims to support international cities in their quest to develop resilience to social, economical and physical impacts from natural disasters and climate change (Arup, Rockefeller Foundation, n.d; Rockefeller Foundation, 2017). The 100RC model intends to aid municipal governments in their response to environmental *shocks* ie. earthquakes, floods, fires etc. but also the smaller, more prevalent *stressors* which impact the urban environment on regular occurrences ie. inefficient public transportation, ageing infrastructure, housing affordability crises, unemployment, rioting and endemic violence as well, chronic shortages of food and water (Rockefeller Foundation, 2017). The end goal of the 100RC model is to promote discourse and collaboration amongst member cities while facilitating the development of municipal resilience through a singular, decision-making tool. (Rockefeller Foundation, 2017)

Why The 100 Resilient Cities Model?

The 100 Resilient Cities model presents an important case study to analyze. The 100RC model is currently being implemented in more than 100 cities across the globe with the goal to help municipal governments cope and deal with complex problems resulting from climate change but, also which result from social, economic and political problems. In doing so, 100RC proposes a decision-making framework grounded in the concept of resilience in order to help a city adapt and cope with these complex problems as they evolve. By using the idea of resilience, municipal governments should have the capability to assess their programs and policies at a system-wide scale in order to understand the necessary actions required to become resilient (Flax, Armstrong, Lee, n.d). 100RC has developed their own unique definition of resilience, specifically focusing on how it applies to cities, or as they coin *urban resilience,* which is important to critically review as it gains traction (Rockefeller Foundation, 2017).

Why This Project?

This project will use the 100RC model as a case study to critically analyze and compare 100RCs definition of resilience to that of other resilience literatures. Specifically, this project will focus upon the ecological and social-ecological aspects of resilience with the goal to demonstrate that the 100RC model is a 'robust' decision-making tool for municipal governments to utilize in order to become resilient to shocks and stressors. In this case, robustness can be defined as a framework that is well-grounded in literature, shows strong similarities to resilience qualities found in literature and, has the ability to be effective in developing and implementing decisions to solve complex environmental, social, political and economical problems with the goal to develop resilience.

Why Now

Rapid urbanization continues to occur on a global scale with the majority of the world's population residing in cities of various sizes and scales (Lister, 2016). Cities and their residents are becoming increasingly vulnerable to climate change but, also to the wider disruptions which emerge from a major impact (United Nations, 2011). With climate change, cities will continue to face social, political and economic impacts which particularly affect the most vulnerable populations (Bulkeley, Betsill, 2003; Selin, Van Deveer, 2009; Rockefeller Foundation, 2017). Municipal governments, and governments in general, have focused upon resistance and control when dealing with complex problems such as natural disasters and their impacts (Lister, 2016). Now is the time for a new decision-making framework to be considered in order to plan for these large-scale impacts. The 100RC model presents an opportunity for change in the way in which governance occurs at the municipal scale by using dimensions and drivers of resilience to inform planners and policymakers.

At a more local context, the City of Toronto, now a 100RC member as of 2016, is about to welcome its *Chief Resilience Officer* and undertake the development of its municipal *Resilience Strategy.* This project will provide evidence that the 100RC model is a robust decision-making framework, well-suited to spark debate and dialogue amongst municipal staff in how they view resilience and its relation to the 100RC model.

Why This Project is Applicable to Planners?

This project provides planners the information to develop an informed opinion regarding 100RCs model and its relation to the development and implementation of a robust, wide-scale, decision-making tool. To understand the 100RC model, it is important for planners to have, at the very least, a limited understanding of why resilience is important in city-building, how it applies to complex social, economic, and political systems and what role planners can take in developing a resilient city. The goal from this project is to inform planners, policy-makers and stakeholders on the opportunity to dive deeply into the municipal governance structure; its complex and highly structured hierarchies, and by using the *City Resilience Framework* to track their city's ability to deal with shocks and stressors which will then inform further resilience building efforts through policy and implementation.

In terms of planning policy, provincial policy such as the Provincial Policy Statement (2014), and the proposed changes to both the Greenbelt Plan (2016) and Growth Plan (2016), utilize the term resilience as an overarching vision for the Ontario and the Greater Golden Horseshoe area by building strong, healthy communities, and planning for climate change through resilient infrastructure. In the context of Toronto, the City of Toronto (City of Toronto Chief Corporate Officer, 2016) has developed a Resilient City document that discusses resilience and priorities for cross-collaborations in planning and decision-making frameworks. Finally, as a member of 100RC, Toronto will create its Resilience Strategy within the next two years, or by 2019.

100RC is intended to be implemented at a very large-scale across the globe. This project does not strictly focus upon one 100RC member city, rather it focuses

upon the entirety of the 100RC model and its structure. With this in mind, this project may be applied to any 100RC member city, or future 100RC member, as it provides for a general discussion on the 100RC model. This project is also highly applicable to municipal governments as they study a multitude of social, political and economic systems which are complex and dynamic across numerous scales. Further, as climate change is at the very real stages of impacting our social, political and economic environments, as well as, the natural environment, municipal governments will continue to face increased shock and stressors. The time to prepare is now, and this study will inform municipalities about the challenges and opportunities that the 100RC model presents to municipal governance structures in their quest to adapt and manage the impacts from climate change.

2.0 Literature Review: Perspectives of Ecological Resilience

Theme 1: Resilience and Stability

During the 1970s and 1980s, the theoretical understanding of ecological systems, its dynamics and process moved to recognize ecological systems as flexible, adaptable and open-ended with alternative states which exhibit threshold behaviours rather than, systems which were thought to be linear, predictive and stable with a general state of equilibrium (Clark, Jones, Holling, 1979; Folke, 2006; Holling, 1973; Lister, 2016; Ludwig, Jones, Holling, 1978).

Previously, ecological systems were assumed to "generally persist in form and function and that a system would recover to its former equilibrium state after disturbances" (Gunderson, Allen, Holling, 2009, p. xv). However, this changed during the 1970-1980s where ecological behaviour was argued to be defined by two distinct properties: **resilience and stability** (Holling, 1973). In this case, resilience can be described as "the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables and parameters and still exist" (Holling, 1973, p.17). This definition refers to the ecological aspect of resilience which differs from the engineering perspective of resilience. Ecological resilience—which can provide for a more complete measurement of ecosystem dynamics— focuses on the amount of variability or perturbation to move a system currently maintained by a specific set of processes and structures to a different type and set of processes and structures (Holling, 1973, Gunderson, Allen, Holling, 2009; Gunderson, Pritchard, 2002; Peterson, Allen, Holling, 1998). Ecological resilience, in this case, focuses on positive feedbacks of non-linear systems which are in states of non-equilibrium with high, internally generated variability and, their ability to absorb disturbance; a system that is largely unstable can still be highly resilient (Gunderson, Allen, Holling, 2009; Holling, 1973).

Stability, on the other hand, is defined as the ability for an ecological system to rapidly return to a normal state of equilibrium following a disturbance; the more rapid the return, with the least impacts, the more stable the system (Gunderson, Allen, Holling, 2009; Holling, 1973). This argument is supported by strong statistical analysis evidence through ecological systems such as grasslands, and forests (Ludwig et al, 1978; Holling, 1973; Walker, Ludwig, Holling, Peterman, 1981). Holling (1973) points to data collected across Canada over a 30 year period to compare forests which experience highly variable climatic conditions to those which experience relatively limited variability. Holling concludes that insect populations in highly variable climatic conditions widely fluctuate, however they present a strong ability to absorb extreme fluctuations and thus are highly resilient (Holling, 1973).

During this time period, Holling (1986) also presented the idea that resilience could be tied to a better understanding of how ecosystems might respond to global climate change and the possible connection between ecological and social systems at various scales (Gunderson, Allen, Holling, 2009; Holling, 1986). Gunderson, Allen and Holling (2009) argued that ecological systems demonstrate a wide variety of responses to large scale variabilities such as climate change. In this sense, if an ecological system does not present an ability to adapt or be flexible, it would be in a constant state of disarray which is inherent in the system's ability to be resilient. Further, Holling (1986)—through an understanding that positive feedback is essential to maintain human dependent systems—argued for the strong possibility that resilience, on a global scale, could be "exceeded, resulting in very sudden and effectively irreversible regime shifts" (Gunderson, Allen, Holling, 2009, p.7; Pimm, 1984; Yodzis, 1981). This demonstrates that with large scale, global variabilities—which are tied to human made impacts—would require adaptive changes across social, economical and ecological systems (Gunderson, Allen, Holling, 2009, Holling, 1986).

Research at this period also demonstrated that ecological systems have more than one stable state; multi-equilibria or, *nature-engineered, nature-resilient and nature-evolving* (Holling, 1973,1986). This aspect of ecological systems stems from two resilience concepts. First, empirical resilience, where a system becomes perturbed

and its ability to absorb the perturbation and return to a relatively similar state; *nature-engineered* accounts for variables to remain away from 'dangerous' in a fixed landscape (Gunderson, Allen, Holling, 2009; Holling, 1986; Lister, 2016). Second, the idea of *nature-resilient,* which focuses more upon a heuristic concept of resilience, where a system's experience of instability actually aids in the general stability of its structure and its behaviour (Holling, 1986; Odum, Barret, 2005). Last, *Nature-evolving,* as labelled by Holling (1986), defines a system's parameters by multiple processes which relate to behaviour, genetics and competition which influence value as variables become present in the system. If these natural variables drastically change, the outcomes reflect a system which has a lowered ability to absorb impacts, with a smaller stability domain (Holling, 1986). The key point from this research is that ecological systems are constantly evolving; there is no correct state where the view of how natural systems behave, and the surprises which can erupt, present the ability to understand the connectedness of systems which as Holling (1986) argues: "such developments are an essential part of any effort to understand or adapt to global change" (p.75).

This time period of ecological research is paramount to understanding functions of natural systems, particularly through Holling's research as it demonstrated that natural, ecological systems have an ability to bounce back from variability and defines ecological systems to have two key behaviours: resilience and stability (Holling, 1973, 1986). Further, research demonstrated that systems do not necessarily require a return to their original state of equilibrium. Rather where high variability occurs in a system, that system may have the ability to adapt and become more resilient and thus, a system can have more than one state of stability. Finally, in the 1970s and 1980s ecological research began to identify the interconnectedness of systems where Holling (1986) recognized that positive feedbacks are extremely important in the maintenance of human relied upon systems which demonstrated, quite early on, that global systems may have an ability to surpass resilience which could result in extreme and irreversible variabilities (Gunderson, Allen, Holling, 2009; Pimm, 1984, Yodzis, 1981).

Theme 2: Complex Adaptive Systems (1990s-2000s)

Overview

Research in the late 1990s into the early 2000s moved to understand ecological systems as complex and adaptive, distinguished through features such as non-linearity, uncertainty, self-organization, scale and emergence (Berkes, Colding, Folke, 2003; Gunderson, Pritchard, 2002; Folke, 2006; Rapport et al, 1998). Constanza states that complex systems "are characterized by strong (usually non-linear) interactions between the parts, complex feedback loops that make it difficult to distinguish cause from effect, and significant time and space lags, discontinuities, thresholds and limits" (1993, p.545). The importance of qualitative analysis of these complex systems became to be recognized as an important tool in understanding how complex systems behave as they present a "multiplicity of perspectives" (Berkes et al, 2002, p. 8) Further, a cohesive understanding began to emerge in terms of the relation between resilience and ecological and societal systems amongst scholars (Berkes et al, 2002; Constanza, 1993; Folke, 2006). The integration between ecological and social aspects of systems can be applied directly to complex adaptive systems where, from a general operational sense, it becomes critical to view resilience as maintaining a system's health through competition and co-operation, redundancy, diversity and stability and accounting for a natural evolution process. Finally, Walker, Holling, Carpenter and King (2004) put forth the argument that resilience could be broken down into four critical factors: *latitude, resistance, precariousness, and panarchy*, which applies to whole and sub-systems and built off Holling's early idea that systems can exhibit multiple states (Holling, 1973). These key attributes—which can be placed into two overarching themes of complex adaptive systems; namely, ecosystem health and cross-scale dynamics—are integral to understand resilience and, form the foundation of literature during this time period (Berkes et al, 2002; Elmqvist, Folke, Nyström, Peterson, Bengtsson, Walker, & Norberg, 2003).

Ecosystem Health in Complex Adaptive Systems

In order for a complex system to have resilient abilities, it is essential that it be in a state of good health where Rapport et al (1998) argue that a healthy system "comprises of a comprehensive, multi-scale, dynamic, hierarchical, measure of system resilience, organization and vigor" (p.232). Further, they promote the idea that the overall health of complex systems revolves around its behavioural attributes where a system must exhibit vigor, organization and resilience and that a system's natural integrity or health aids in the development of variability, and the complexity of the ecosystem (Rapport et al, 1998).

Diversity, stability, competition and co-operation are four key attributes which ensure a high quality ecosystem health (Elmqvist et al, 2003; Gunderson, Pritchard, 2002; Folke, 2006; Rapport et al, 1998). Diversity, ensures that a complex adaptive system can appropriately respond to perturbation where Elmqvist et al, state "biological diversity appears to play a substantial role in ecosystem resilience and in sustaining desirable ecosystem states in the face of change" (2003, p.1). Stability, relates to the overall health of an ecosystem and its ability to be resilient (Berkes et al, 2002l; Folke, 2006). However, stability in this sense, does not necessarily require a system to be stable or resistant to change, rather, it refers to variability and the ability for a complex adaptive system to be fluid and open to perturbations (Folke, 2006; Rapport et al, 1998). A complex adaptive system has the ability to be resilient through continuous development, that is dynamic and allows for new trajectories to stem from the perturbation or variability (Folke, 2006; Gunderson, Pritchard, 2002). This aspect of stability also refers back to the organizational capabilities of a complex system, where the ability for a complex adaptive system to be resilient depends upon the system's ability to self-organize (Berkes et al 2002; Elmqvist et al, 2003; Folke, 2006; Rapport et al, 1998). Further, when a complex adaptive system presents strong competition and co-operation amongst its structure, the system has a higher level of tolerance, and thus becomes more resilient through the sustainment of well-functioned, self-regulating systems (Rapport et al, 1998).

Cross-Scale Dynamics

Critical to understanding complex adaptive systems and ecological organization is cross-scale dynamics. Cross-scale dynamics and ecological organization indicate resilience through various transitions within an ecosystem (Berkes et al, 2002; Gunderson, Pritchard, 2002). The importance of scale and hierarchy are fundamental to comprehend a complex adaptive system's ability to achieve resilience at not just one but, multiple scales as it evolves (Berkes et al, 2002; Gunderson, Pritchard, 2002). In terms of resilience and scale, Gunderson and Pritchard (2002) argue that "resilience derives from functional reinforcement across scales and functional overlap within scales. Resilience derives from both a duplication of function across a range of spatial and temporal scales and a diversity of different functions operating within each scale" (p.17). Hierarchies, in this case, are an extremely important attribute to complex systems where they are asymmetric with interactions between multiple levels (Gunderson, Pritchard, 2002).

Complex adaptive systems undergo various adaptive renewal cycles which transform their hierarchical structures from an established structure to one that is more flexible and able to adapt. However, in doing so, the structure of the system becomes extremely vulnerable to any type of perturbation (Berkes et al, 2002; Holling, 1986; Gunderson, Pritchard, 2002).

With the adaptive renewal cycle, systems have the ability to be dynamic and adapt to perturbations at specific life-cycles rather than strictly functioning in a conventional, stable and linear process-cycle. In this sense, the term panarchy is used in the literature as "it emphasizes the dynamic and transient nature of connection between scales" (Gunderson, Pritchard, 2002, p.15). Within this adaptive renewal cycle or panarchy, multiple phases of development occur (Berkes et al, 2002; Folke, 2006; Gunderson and Pritchard, 2002). The conservation stage reflects a relatively stable system as it has a strong interconnectedness, however, eventually it becomes increasingly brittle and thus, has limited resilience as a minute disturbance has the potential to create catastrophe and

spread rapidly throughout the system destabilizing its entirety (Folke, 2006; Gunderson, Pritchard, 2002).

Rapid and explosive change occurs during both the exploitation period as well as, the reorganization phase. During the reorganization of a system there is a limited amount of stability yet, the system can transform easily into another state since its resources are not well connected to processes that promote and control growth (Folke, 2006; Gunderson, Pritchard, 2002). Thus, within this unstable system, rapid growth has the ability to occur by utilizing the available resources within the system. By establishing various organizations, the system is able to effectively cope and adapt which demonstrates that gradual and rapid change is part of the development process.

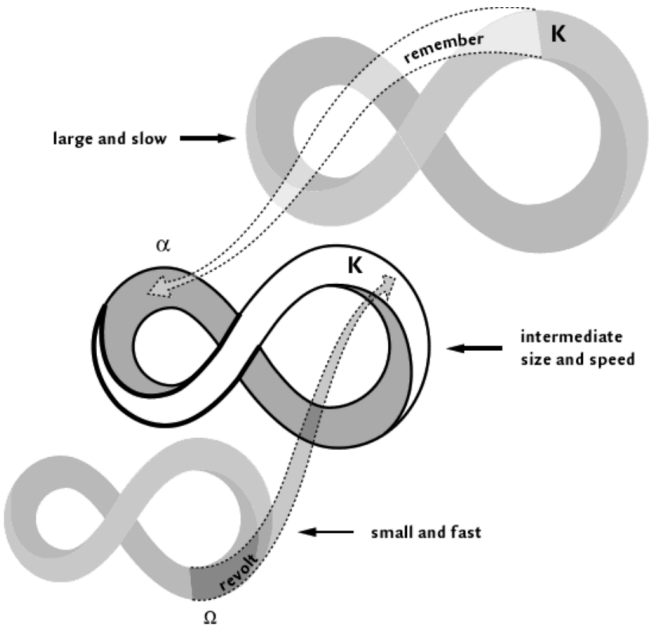

Fig. 1. Adaptive Renewal Cycle Nestled in Panarchy (Berkes et al, 2002).

The adaptive renewal process also demonstrates that resilience, in complex adaptive systems, relates to the system's ability to learn and remember (Elmqvist et al, 2003; Folke, 2002). Berkes et al, (2002) demonstrate the cross-scale dynamics of remembrance within the reorganization or 'renewal' stage, where the system's ability to renew and reorganize is based upon its ability to remember. They provide an example of a forest ecosystem which recently experienced a fire where the system utilizes "the seed bank, physical structures and surviving species that had accumulated during the previous cycle of growth and those from outside" (Berkes et al, 2002, p.19).

Theme 3: Social-Ecological Systems and Governance

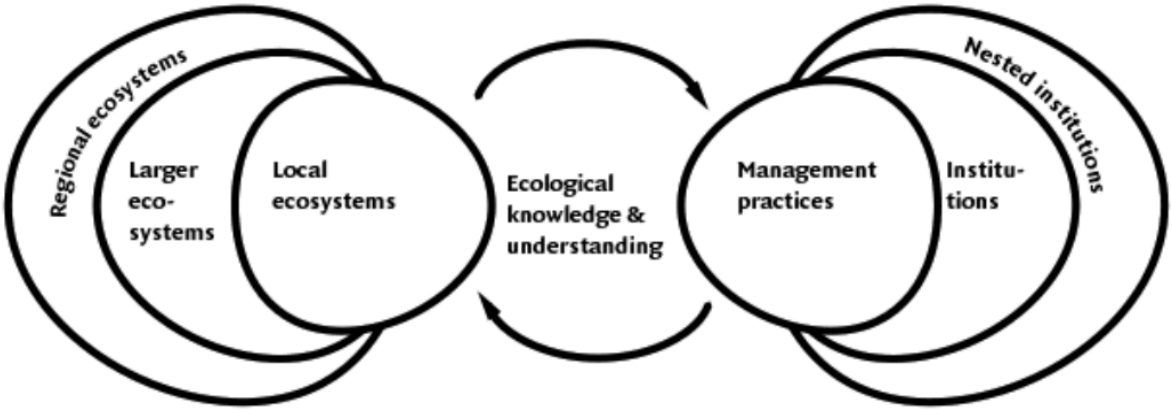

Fig. 2.Conceptual Framework of Linked Dynamics of Social-Ecological Systems (Berkes et al, 2002).

As the study of resilience continued following the two eras discussed prior, researchers began to understand the idea of social resilience and its relation to the natural environment. Resilience literature outlines the importance to understand how social systems interact with ecological system. Research concludes that social-ecological systems are thought to be intrinsically linked rather than separated and delineated based on complicated social and ecological structures (Berkes et al, 2002; Deppisch, Hasibovic, 2010; Folke, 2006; Garmestani, Benson, 2013; Perz, Cabrera, Carvalho, Castillo, Chacacanta, Cossio, Costa Silva, 2012, Waltner-Toews, 2004). These interactions, accompanied with disturbances, may provide for an opportunity to learn and try new methods for innovation and development in a resilient social-ecological system (Berkes et al, 2002; Folke, 2006).

Research led to “a conceptual foundation for linking human action, social institutions and market dynamics (‘the social’) to strategies for natural resource management via livelihoods (‘the social-ecological)’ in order to better understand complex feedbacks from […] ecosystems” (Perz et al, 2012 p. 39-40). Berkes et al,

(2002) proposed that in order to fully understand social-ecological systems, it was essential to consider that there are multiple dimensions to social-ecological resilience, as these systems are not only complex and non-linear, but also that they are "complicated structures involving many social-ecological components" (Perz et al, 2012 p.40). Berkes et al, (2002) argue that in dealing with the various dynamics of nature, the dimensional approach of social-ecological systems can be broken into four categories: *"leaning to live with change and uncertainty; nurturing diversity for reorganization and renewal; combining different types of knowledge for learning; and creating opportunity for self-organization towards social-ecological sustainability"* (Berkes et al, 2002; Perz et al, 2012). These four categories are seen as principles in resilience building and are argued to act as foundational drivers to building stability and sustainability within society (Berkes et al, 2002; Folke, 2006). Further, these four drivers act cohesively rather than independently within the social-ecological dimension and are argued to require "dynamic interplay between diversity and disturbance along with recognition of cross-scale dependencies" (Berkes et al, 2002, p.383).

Theme 4: Governance and Social-Ecological Resilience

In a very broad sense, governance is a fundamental challenge in dealing with complex adaptive systems; it is a complex network of systems in and of itself, with a hierarchical structure that encompasses multiple actors and institutions acting at various dynamics across numerous scales (Berkes et al, 2002, Carabine, Wilkinson, 2016; Folke, 2006). It is critical to view ecological and social systems as intertwined and interdependent in order to implement resilience theory into practice within governance systems (Garmenstani, Benson, 2013; Bulkeley, Betsil, 2003; Parkes, Morrison, Bunch, Hallström, Neudoerffer, Venema, Waltner-Toews, 2010). Research also points the "need for process to value, prioritize and engage with the multiple knowledge cultures within social systems […] as priority for social change in contexts as varied as public health and health promotion, environmental management, community development and sustainability" (Parkes et al, 2010, p.696). Parkes et al,

(2010) also provide the example of watershed governance and how health and well-being are directly impacted by how governance occurs within a watershed, or more of a regional scale rather than solely a municipal scale in terms of governance. These authors conclude from their research that governance systems that approach watershed governance with a focus upon health and well-being, may be able to aid in building social-ecological resilience.

Research demonstrates that the idea of adaptive governance is an appropriate approach to implement resilience by focusing on social and environmental concerns and linking those two concerns to the overall health and well-being of individuals, communities, cities and countries (Parkes et al, 2010). An adaptive approach allows for governance structures and their officials to account for constant change within systems Garmenstani and Benson (2013) put forth the idea that in order for adaptive management to work effectively, it must account for a continuous and evolving learning process that never diverges into separate processes such as ‘research' and ‘regulatory activities’. Boyd and Folke (2012) argue that “adaptive governance is a useful concept to understand how agents and institutions respond to crisis in new ways or are constrained by resistance to change, and how these responses and constraints interact across levels and scales” (p.4). Also, literature points to the idea of a transdisciplinary governance approach, through use of a bridging concept of social-ecological resilience which is argued to offer tangible advantages in dealing with and adapting to impacts from climate change (Deppisch, Hasibovic, 2010). Utilizing social-ecological resilience as a bridging concept allows for an in-depth and critical review of the norms and values of decisions which highlight important structures that should be preserved (Deppisch, Hasibovic, 2010).

Panarchy

Panarchy, discussed prior, is closely linked to the idea of resilience within complex adaptive systems and is highly transferable to the study of social-ecological systems, resilience and governance (Angeler, Allen, Garmestani, Gunderson, Linkov, 2016; Gunderson, Pritchard, 2002; Garmenstani, Benson, 2013). Research suggests

that the notion of panarchy is highly applicable for environmental science as it is a "multi-scale hierarchical concept that accounts for the dynamism of complex social-ecological systems, especially for those systems with strong cross-scale feedbacks" (Angeler et al, 2016, p.225). Further, panarchy is highly applicable to resilience in social-ecological systems, as it can account for 'surprises that emerge unbeknownst within the system which demonstrates how systems, in this case, social-ecological systems, respond to destabilizing and stabilizing feedbacks (Angeler et al, 2016; Garmenstani, Benson, 2013). Angeler at al. (2016) demonstrate that panarchy theory can be used to inform a qualitative and quantitate framework which can be developed to aid in understanding technical efforts in social-ecological systems and adaptive management practices.

3.0 Methodological Research

This research project follows research methods grounded in qualitative analysis based on a case study of the 100RC model (Neuman, Jacoby, Barr, 2003). Within research methods literature, a case study allows for the researcher to investigate a specific case based on in-depth analysis to consider the cases context and analyze how its parts are shaped (Neuman, Jacoby, Barr, 2003). Case studies are viewed in literature as a popular and influential method of research within numerous fields of research and allows for a distinct research paradigm to be developed (Gomm, Hammersley, Foster, 2013; Neuman, Jacoby, Barr, 2003). Stake (1995) argues that case studies have general relevance and allows for information to be demonstrated based on everyday experience which is a valuable asset in terms of understanding and learning.

Following a methodological case study analysis approach of the 100RC model, this project focuses on specific factors of the 100RC model which are as follows: the robustness of the 100RC model, the 100RC definition of resilience which in this case refers to their notion of *urban resilience* and the robustness of the *City Resilience Framework*. In this case, robustness can be defined as a framework that is well-grounded in literature, shows strong similarities to literature and has the ability to be effective in developing and implementing decisions to solve environmental, social, political and economical problems. This will be achieved based on comparative analysis of ecological and social systems literature to that of the listed factors above. In doing so, this project utilizes the definition of resilience based on multiple frameworks: resilience and its relation to stability within ecological systems, the complex, adaptive and hierarchical structures evident in ecological systems and the facts that influence a system's ability to become resilient, particularly, panarchy and cross-scale dynamics and finally, social-ecological systems which offers a transformative approach to understand social-ecological systems and social-ecological resilience. These methods are essential in understanding the complexities of resilience and

are necessary to analyze the 100RC model, its definition of resilience and the *City Resilience Framework.*

Finally, no formal professional interviews were used to inform this research. Within the context of Toronto, the 100RC model is only at its initial implementation stages within the municipal government, therefore, limited input would have been received. There is potential for future interviews to be held with municipal staff as well as, the new *Chief Resilience Officer* at the City of Toronto which, could potentially be incorporated into future work following research ethics board approval.

So What Does This all Mean?

Literature demonstrates that a high amount of uncertainty exists within ecological and social-ecological systems as discussed prior. 100RCs *City Resilience Framework* intends to account for the uncertainties within complex adaptive systems and provides planners and policymakers a robust tool in order to undertake and implement challenging decisions within complex, hierarchical governance structures to be resilient to impacts from variability and perturbation. However, the *CRF* intends to be utilized within a structure —that is 'government'—which is a structure already highly resistant to change. Further, the *Chief Resilience Officer* is an executive, political position that is based on a governance structure that is undertaken by 'top-down' planning approach in the context of Canada. This is a challenge for planners and policymakers as literature points that in social-ecological systems, adaptability and transformability are key factors in developing a resilient systems and in the face of variability. Literature points that systems do not necessarily have to return to their original state in order to be resilient yet, they can adapt and become more resilient under these circumstances. With these points in mind, it is important to analyze the 100RC model and compare it against resilience literature as discussed prior.

4.0 Analysis

The analysis section of this project will discuss key aspects of the 100RC model: the definition of *urban resilience* developed by Arup and Rockefeller Foundation (n.d; 2017) the 100RC *City Resilience Framework* (CRF)*;* the *Chief Resilience Officer (*CRO)*;* and 100RCs *Qualities of Resilience.* The idea in this section is to utilize the resilience literature discussed above and critically review the robustness of the 100RC model. It is important to ask thought-provoking questions in relation to the 100RC model as it continues to gain traction and is implemented as a complex decision-making tool for municipal governments. Specific indicators are as follows:

- Does the 100RC definition of resilience reflect that of literature, particularly in regards to complex adaptive systems and social-ecological systems?
- Does the *City Resilience Framework* indicate a robust decision-making framework that is grounded in resilience literature in relation to complex adaptive systems, and does it account for cross-scale dynamics and a dimensional approach to social-ecological resilience?
- Where and how are the seven qualities of resilience grounded in resilience literature?
- Does the role of the *Chief Resilience Officer* reflect an adaptive, integrative and transformative approach in governance of social-ecological systems?

100RC Definition of Resilience

100RC defines resilience through literature, case study analysis and fieldwork which informed their definition of urban *resilience* to be "*the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience"* (100RC City Resilience, para. 1, 2017). In Holling's (1973) seminal piece, resilience is viewed as "the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables and parameters and still exist" (p.17). Holling's (1973) idea of resilience and stability differ from those of 'survive, adapt and grow' put forth by 100RC. In this case, the 100RC definition is less focused on the resilience literature of the 1970s and more so upon complex adaptive systems and cross-scale dynamics as it focuses on the multitude of dynamics within a city or as Rockefeller and Arup (n.d) label a city as "systems in a system" (p.6).

Further, the 100RC definition closely reflects complex variabilities, non-linerarity and uncertainty within complex systems as they account for variabilities and perturbations or *'shocks' and stressors'* which can occur unpronounced at any given time. The definition also reflects that various adaptive renewal cycles occur within complex adaptive systems which can transform hierarchical structures as 100RC promotes an interconnectedness (Berkes, Colding, Folke, 2003; Gunderson, Pritchard, 2002; Folke, 2006; Rapport et al, 1998). In relation to cross-scale dynamics, 100RCs idea of not only the capacity of systems, but for numerous hierarchies which vary across different scales and dynamics—such as individuals all the way up to institutional systems—is a strong indication of how *urban resilience* is fluid yet, connected across numerous scales ie. individuals,

communities, institutions and, that resilience can adapt at various scales (Rapport et al, 1998).

In terms of social-ecological systems and resilience, the 100RC definition of *urban resilience* strongly reflects literature's argument that it is critical to view ecological and social systems as intertwined. This is critical to effectively implement resilience theory into governance systems or 'structures' (Garmenstani, Benson, 2013; Bulkeley, Betsil, 2003; Parkes, Morrison, Bunch, Hallström, Neudoerffer, Venema, Waltner-Toews, 2010). However, there is a strong gap in the 100RC definition of *urban resilience* as it does not explicitly account for a system's ability to learn. From a social-ecological systems standpoint, Berkes et al. (2002) argue that it is essential for these systems to be able to learn continuously from change and uncertainty. This can be achieved through various types of learning which aid in creating self-organizations to nurture reorganization and renewal (Berkes etl, 2002; Per et al, 2012).

Thus in comparison to the 100RC definition, there are strong similarities, especially in a systems-based concept of resilience. 100RC and Arup demonstrate thorough understanding of resilience and its characteristics as they classify cities as 'systems as systems' (Arup, Rockefeller Foundation, n.d, p.6). Based on presented literature above, this idea of 'systems of systems' is applicable since cities can be seen as complex adaptive systems. It is essential to view resilience, not only its ecological and engineering definition, but its applicability and relationship to social, economic and political systems which accounts for cross-scale dynamics and hierarchical structures, This notion forms a holistic and comprehensive approach to ecological and social-ecological systems.

Other identified gaps are evident in the 100RC definition of *urban resilience* particularly in a system's ability to remember and then process that remembrances through adaptation during change and uncertainty. This idea is not present within the *urban resilience* definition and is a critical factor of cross-scale dynamics as the ability for a system to remember influences its ability to renew and reorganize (Berkes et al, 2002; Elmqvist et al, 2003; Folke, 2002) Finally, the actual term *urban resilience* presents an

opportunity for critique. In developing their definition of urban resilience, 100RC does not make their reviewed literature available to the public. This presents a challenge as their definition cannot be analyzed by outside parities. If 100RC published their literature review, would this change their definition of resilience as outside parties would have the ability to critically analyze it? Further, their definition of resilience seems to be tailored as a marketing tool as it strictly relates to the *urban* environment. Is this a selling point for municipalities to become interested in the 100RC model?

100RC City Resilience Framework

The City Resilience Framework (CRF) which emerged from the earlier *City Resilience Index,* has been developed by Arup in partnership with the Rockefeller Foundation, and aims to provide an understanding of the complexities, intricacies and drivers of cities and their municipal governance structures which inform and contribute to a city's ability to become resilient. 100RCs idea is that this framework will allow for a common language in terms of resilience building and knowledge sharing, regarding municipalities experiences in undertaking capacity building in relation to resilience (Arup, Rockefeller Foundation, n,d; City of Berkeley, 2016; Rockefeller Foundation, 2017). 100RC believes that the foundation to understand the complexities and intricacies of urban resilience revolves around three identified *dimensions, drivers and sub-drivers* and, how these qualitative system frameworks are able to cope against chronic stressors, which impact and weaken the framework of cities along with acute shocks, that are sudden events which can directly threaten a city (Arup, Rockefeller Foundation, 2015). This analysis will critical assess the *CRF* based on the following questions: Does the *City Resilience Framework* indicate a robust decision-making framework that is grounded in resilience literature in relation to complex adaptive systems, and does it account for cross-scale dynamics and a dimensional approach to social-ecological resilience?

Fig 3.. City Resilience Framework, Rockefeller Foundation, (2017).

100RC *Dimensions* and *Drivers* of *Urban Resilience*

Based on resilience literature, the *CRF* has the potential to be a robust decision-making framework and measurement tool for municipal governments in becoming resilient. The *CRF* directly accounts for the complexities and intricacies present in cities by framing them into four specific *dimensions* (listed in grey in fig. 4) and their three respective drivers (listed in blue in fig 4). This dimensional approach to resilience shows strong similarities to complex adaptive systems which exhibit multiple scales and dimensions (Berkes, Colding, Folke, 2003; Gunderson, Pritchard, 2002; Folke, 2006; Rapport et al, 1998). The *CRF* also presents a strong understanding of the "multiplicity of perspectives" (Berkes et al, 2002, p. 8) which is evident in complex adaptive systems as 100RC breaks down *urban resilience* into four overarching themes accompanied by 12 specific influential factors or *drivers* which then inform 50 *sub-drivers* (Arup, Rockefeller, n.d). This framework reflects a strong, comprehensive, multi-scaled measurement of system resilience which also reflects the ecosystem health approach within complex adaptive systems and thus, reflects robustness in resilience (Carabine, Wilkinson, 2016 Rapport el al, 1998; Waltner-Toews, 2004). The *CRF* bares striking similarities to that of Carabine and Wilkinson's (2016) work as pictured above which lists governance characteristics with resilience outcomes where a collective decision-making framework is argued to be founded on the "complex social

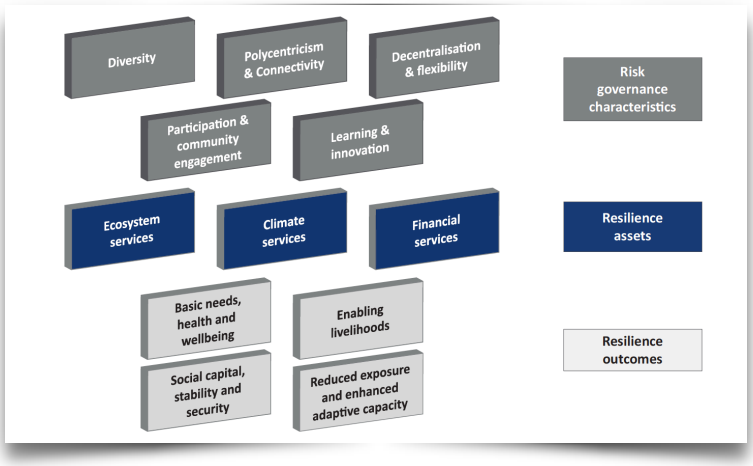

Fig. 4. Conceptual Framework of governance and resilience outcomes (Carabine and Wilkinson, 2016).

interactions between firmly embedded social structures and the choices and individuals" (Carabine, Wilkinson, 2016, p.63).

In development of the *CRF,* 100RC found that "a comprehensive, holistic framework is missing that combines the physical aspect of cities with the less tangible aspects associated with human behaviour" (Arup, Rockefeller, n.d, p.6). However, this type of framework is well-established within social-ecological systems literature (Berkes et al, 2002; (Carabine, Wilkinson, 2016; Deppisch, Hasibovic, 2010; Folke, 2006; Garmestani, Benson, 2013; Perz et al, 2012, Waltner-Toews, 2004). Barring the idea that this framework is missing, the *CRF* does reflect strong aspects of social-ecological systems. Its overarching pillars focus on the dynamics and interconnectedness of the economy and society, infrastructure and the environment, leadership and strategy and health and well-being which is a well-grounded aspect of social-ecological resilience (Berkes et al, 2002; Carabine, Wilkinson, 2016; Perz et al, 2012). In this case,100RC portrays a strong understanding of the interconnected nature of social-ecological systems through multiple *dimensions,* the complex feedbacks within and amongst these *dimensions ie.* the *CRFs drivers* and the non-linearity of the *CRFs sub-drivers.*

The *CRF* can also be tied to the notion of panarchy within social-ecological systems. The *CRFs* multi-dimensional, cross-scaled approach intends to account for the complex dynamics and the surprises that can emerge within social-ecological systems. A comprehensive framework also is applicable through use of panarchy within social-ecological systems. The *CRF* considers the systems, processes and functions of a city through a qualitative lens to help understand and inform socio-technical resilience as well as, adaptive and transformative management techniques through appropriate governance (Angeler et al, 2016). Based on this analysis, it is evident that the *CRF* is well-grounded in both ecological and social-ecological resilience. It has the potential to enable a municipality to establish a baseline assessment of their resilience in relation to shocks and stressors across multiple scales, focus on areas which need strengthening and share this knowledge with 100RC members.

Challenges

Overall, the *CRF* presents an appropriate decision-making tool in order for cities to understand the current and future capabilities in resilience capacity building. However, there are some strong gaps identified. First, it is important to note that the *CRF* and the entirety of the 100RC model primarily focus on a the municipal context of resilience building. However, in the case of Santiago, Chilé (a 100RC member) a regional approach has been developed (City of Santiago, 2017). Research points out that in watershed management, a regional dialogue, at the very least, is required to deal with appropriate flood mitigation strategies (Empey, Flanagan, Hanson, Hintelmann, Mason, Sgro, Lister, Boudreau, King, 2016; Parkes et al, 2010). Policymakers, planners and stakeholders are tasked with solely reviewing their own municipalities current and future capabilities in becoming resilient, yet what if the *CRF* could be applied at both a municipal and regional scale? Would this be a more effective decision-making tool for the Greater Toronto and Hamilton Area? Finally, how do planners, policymakers, stakeholders, and citizens, particularly vulnerable populations, institutionalize resilience into a system that is inherently resistant to progressive change?

Opportunities

Apart from gaps identified above, the *CRF* does present an opportunity for knowledge sharing of resilience at a global scale. The 100RC model is being pushed by Rockefeller across the globe, and as more and more cities join 100RC, it creates a platform for potentially unprecedented resilience planning within cities across the globe. In doing so, the *CRF* has the opportunity to become a common measurement tool and decision-making tool for resilience.

100RCs Qualities of Resilience

Within the inner circle of the *CRF* are the identified *seven qualities of resilience.* These qualities became evident through research conducted by 100RC and Arup which signify "the behaviour or performances of the urban systems in relation to resilience" (Arup, Rockefeller Foundation, n.d, p.22). The intention of these *seven qualities* is to aid in the assessment of a city's systems in relation to resilience. The idea is that these qualities can prevent and limit the collapse of a city's systems through integration with the *dimensions* and their key *drivers* (Lipper, 2016). These seven qualities are *Reflective, Robust, Redundant, Flexible, Resourceful, Inclusive* and *Integrated* outlined in the Fig. 5 below:

Accepting of Change		Organizing Resources			Engaged with other systems	
Reflective	Robust	Redundant	Flexible	Resourceful	Inclusive	Integrated
Learns from past experiences, recognizes uncertainty and change	Physical assets that are well-conceived, constructed, and managed	Systems that can accommodate disruption (spare capacity)	Willingness and ability to change the plan based on new evidence or circumstance	Achieves the same goals through alternative processes or methods if necessary	Engages all relevant people and places	Coordination across systems including institutions, areas of work and communities

Fig. 5. 100RC Qualities of Resilience, (100RC Toronto, 2016

Overall, these seven *resilience qualities* are well-grounded in resilience literature particularly in relation to ecological, social-ecological systems and the dimensional approach in understanding the dynamics of nature and adaptive governance (Berkes et al, 2002; Garmenstani, Benson, 2013). Discussed prior, Berkes et al. (2002) identify four key categories that stem around the ability of a social-ecological system to learn and adapt through uncertainty, utilize renewal and reorganization, learning through knowledge sharing

and the ability to self-organize. As 100RCs *resilience qualities* consider change, organization and engagement within systems, they are accounting for the cohesive interactions in social-ecological systems which reflect an understanding for the cross-scale dynamic and interdependencies of these systems (Berkes et al, 2002; Waltner-Toews, Kay, Lister, 2008).

In terms of *Flexibility,* it is critical that ecological systems present an ability to be fluid as they undergo variable impacts where, if the systems do not present an ability to be flexible, they will be in a constant state of disarray which strictly limits its ability to be resilient (Gunderson, Allen, Holling, 2009). This notion of *Flexibility and Redundancy* also reflects an understanding of the adaptive nature of governance which is essential in order to construct and implement resilience within social-ecological systems (Gunderson, Pritchard, 2002). 100RCs quality of *Redundancy* reflects an understanding that ecological systems are constantly evolving and have an ability to 'bounce back' from variabilities (Holling, 1973). 100RC argues *Redundancy* to reflect a system's ability to accommodate disruption, and a understanding that a system does not necessarily require a return to its original perceived state of equilibrium. Panarchy, represents that multiple phases of development occur within complex adaptive systems and in order to allow for a system to undergo this adaptive, renewal process, it is essential to allow for flexibility as the system is able to cope and adapt as it undergoes the development process (Berkest et al, 2002; Folke, 2006; Gunderson, Pritchard, 2002).

It is also important to analyze the quality of both *Inclusivity* and *Integration* in relation to resilience. The idea of *Inclusive* and *Integrated* is a key aspect for a measurable approach to the development of a resilient complex system (Waltner-Toews, Rapport et al, 1998). In order for a system to be resilient, it is essential that in be in a good state of health by exhibiting a "comprehensive, multi-scale, dynamic, hierarchical measure of system resilience, organization and vigor" (Rapport et al, 1998, p.232). Further from the 100RC

perspective, inclusivity, intends to ensure a joint vision of resilience building by focusing upon broad public engagement strategies, particularly with the most vulnerable groups of a city (Arup, Rockefeller, n.d). This is a critical factor in establishing an understanding of a complex adaptive system's hierarchy, dynamics and cross-scale interactions with aids in outlining a system's ability to achieve resilience not only at one particular scale but upon multiple scales (Berkes et al, 2002; Gunderson, Pritchard, 2002; Parkes et al, 2010).

Integration, in relation to resilience, is also a fundamental factor in adaptive governance which influences resilience within social-ecological systems and complex adaptive systems. The integration of multiple dimensions such as society, the economy, governance and the environment are paramount to maintain a systems health, which thus directly influences its ability to be resilient (Berkes et al, 2002; Constanza, 1993; Folke 2006. Again, this connects strongly back to cross-scale dynamics within complex adaptive systems and the ability for governance to adapt. Complex decisions will not impact one dimension—but as literature demonstrates—they will impact multiple dimensions, since interactions within complex adaptive systems are non-linear and exhibit complex feedback loops (Berkes et al, 2002; Constanza, 1993; Elmqvist et a, 2003).

Challenges

100RC identifies seven qualities of resilience based on their internal research and intends that these qualities be transferable to all 100RC members (Arup, Rockefeller Foundation, n.d). In doing so, each *quality* may be equally weighted when a 100RC member undertakes their resilience analysis. Cities are unique, complex systems which can exhibit very similar but also very different characteristics. Although these *resilience qualities* are well-grounded in literature based on this analysis, are they equally viable within each unique 100RC member? If these seven qualities are not met, does this mean that a city has not been successful in implementing the 100RC resilience model? The three overarching themes in relation to the *resilience qualities: Accepting of Change, Organizing*

Resources and Engaged with other Citizens seem to be highly transferable and based on analysis, are important themes that are required to ensure resilience in complex adaptive systems and social-ecological systems. However, it is unclear if these seven qualities can truly reflect the uniqueness of each 100RC municipality's challenges in becoming resilient.

Further, the *seven qualities of resilience* directly inform a large-scale decision-making framework but one of the largest challenges will be implementing these specifically tailored *resilience qualities* at a very large-scale. Dale (2001) argues that in order for rapid change to occur at a very large-scale, a new form of discourse will be required. Also, Dale (2001) argues that this will require changes in our education systems, our societal values and our political governance structures, basically an entire transformation of our society. How does this occur? Do educators begin to teach the seven qualities of resilience within coursework? How do planners, politicians and policy-makers begin to follow these qualities and ensure that planning policy reflects the qualities of resilience? Is this role placed onto the planner through a communicative planning model? Is this the task of the *Chief Resilience Officer* to inform and direct the implementation of these seven qualities at a societal scale? This is a major challenge and further analysis is needed in order to understand the evolution of these qualities and implementation strategies put forward by 100RC members.

Opportunities

Overall, the *seven qualities* of resilience represents a robust incorporation of resilience literature and the qualities that are necessary to develop and sustain resilience within complex systems and social-ecological systems. If implemented correctly, these qualities have the opportunity to ground complex decisions in resilience. Further, *qualities* such as *Robust*, *Flexible* and *Reflective* may place the idea and parameters of resilience into more simple terms and provide for an adaptive, integrative and collaborative approach to resilience building. Overall these *qualities* provide for an opportunity to asses and

ground city systems in resilience—when utilized within the *CRF*—and provide for robust definitions of resilience in relation to complex adaptive systems and social-ecological systems.

Chief Resilience Officer and 100RC Resilience Strategy

The *CRO* and the *Resilience Strategy* are the implementation tools in terms of resilience building. The 100RC model relies upon these two strategies to understand the municipality's strengths and weaknesses when it comes to resilience and builds off of the largely qualitative analysis under the *CRF* which directly informs the *Resilience Strategy*. This section will now analyze if the role of the *Chief Resilience Officer* reflects an adaptive, integrative and transformative approach in governance of social-ecological systems.

Chief Resilience Officer

The *Chief Resilience Officer (CRO)* is an integral aspect to the 100RC model and coupled with the *City Resilience Framework (CRF),* the *CRO* is one of the main tools in fostering a creative, integrated and collaborative municipal governance structure, In doing so, they aim to empower the development and implementation of urban resilience (Berkowitz, 2015; City of Toronto, 2016; Empey et al, 2016). The *CROs* main task is to act as the municipalities 'go-to' senior official who is responsible for leading and co-ordinating the municipality's resilience building efforts. In order to implement urban resilience the *CRO* follows four key outlined steps identified in Fig 6.

Fig. 6. Role of Chief Resilience Officer. (Rockefeller Foundation, 2015).

"Building social-ecological resilience also requires evoking change in social structures" (Berkes et al, 2002, p. 357). In doing so, Berkes et al, (2002) argue that leadership is required in order to activate change within social-ecological systems. In the first and second objective, the *CRO* is tasked with actively engaging the complex dimensions in this case (government departments, the public and a wide range of

stakeholders) in order to understand a city's challenges and its complexities in relation to resilience. This is one key factor in social-ecological resilience as social networks are perceived as instrumental factors in enabling a community to adapt to environmental impacts and in knowledge sharing and learning (Berkes et al, 2002). Further, Allen and Gunderson (2011) state that it is absolutely critical that stakeholder engagement be undertaken early in the adaptive management process. This notion shows strong resemblance to the role of the *CRO* in that, the *CRO* is immediately tasked with engagement at all hierarchical levels within the governance structure of the municipality, and both the public and private sectors which will inform the future *Resilience Strategy* via the *CRF* (Berkowitz, 2015).

The *CRO* is also tasked to work across government departments in order to address its complexities, improve collaboration and reduce duplication through effective communication, oversight and facilitation (Berkowitz, 2015). This bares strong resemblance to the cross-scale dynamics present within complex adaptive systems, especially in terms of scale and hierarchy, and the necessity to understand these factors in order to achieve resilience (Berkes et al, 2002; Gunderson, Pritchard, 2002).

Challenges

The *CRO* and *Resilience Strategy* present some very strong challenges which are important to breakdown and discuss in depth. The outcome of the entire 100RC model places strong reliance upon the *CRO*, especially in building and implementing key strategies within a governance structure that is inherently resistant to large-scale change. In doing so, the *CRO* must address resilience goals which surface through the *CRF*, however, resilience does not simply relate to one specific municipality or hierarchy, rather, it requires strategic change at multiple scales. With that in mind, how does a *CRO* develop a multi-sectorial, comprehensive and collaborative *Resilience Strategy* by simply focusing on one specific municipality? Earthquakes, epidemics and floods have the ability to quickly

spread across invisible borders, what happens when a neighbouring municipality is not a member of the 100RC model? Is that a detriment to the municipality that is 100RC member? What happens if neighbouring municipalities are 100RC members? Does a more cross-scaled, dynamic approach improve hierarchical responses in dealing with variabilities and perturbations? Further analysis is needed in the case of Santiago as it has approached the 100RC model at a regional scale. There is valuable insight to gain as it will allow planners, policymakers and 100RC members to compare and contrast a municipal and regional approach to the entirety of the 100RC model.

Further, *Resilience Strategies* across 100RC members do not demonstrate their effectiveness through quantifiable data. At this point, the *strategies* are simply a written document with outlined goals in terms of how a city proceeds resilience building. What would occur if the *Resilience Strategy* was incorporated into a regulatory document such as an Official Plan, rather than a strategy guideline? How does this different from current planning policy in Toronto and the *Greater Golden Horseshoe (GGH)?*

Finally, the *CRO* is a limited, two year placement. As discussed above, *CROs* usually come with some political traction and influence, however what happens after their two year term expires? In some cases, *CROs* move on and the position ceases to exist (Green, 2016). In other cases, municipalities decide to create a full-fledged resilience office and create a new, permanent *CRO* position within the municipal governance structure (City Of New Orleans, 2017). The limited nature of the *CRO* appointment is certainly a very large gap in terms of resilience building and the limited timeline of the *CRO* needs to be questioned in terms of its effectiveness. Complex problems such as climate change cannot be solved in a two year timeframe.

Opportunities

The *CRO* and the *Resilience Strategy* present a very real opportunity in planning for and mitigating shocks and stressors destined to occur to any city at any time. Specifically, the *CRO* has the opportunity to be a true integrative and adaptive governance champion

that bridges the fragmented, hierarchical systems inherent in our municipal governments. There is strong opportunity to achieved this through a profound collaborative effort with stakeholders, the public, especially vulnerable populations and government officials. The *Resilience Strategy*, although somewhat lacking in authority, provides for at the very least, an identified goal-oriented approach to resilience building. Further, the *Resilience Strategy* offers an educational and empowerment opportunity for both citizens and politicians in how they can better promote resilience through a grassroots oriented approach.

There is also opportunity for the Ministry of Municipal Affairs (MMA) and their Planning Policy and Innovation Branch to periodically review Toronto's successfulness in developing and implementing the *Resilience Strategy.* If strong results are evident, MMA could consider regulating the *Resilience Strategy* as a key planning document for the Greater Golden Horseshoe (GGH). This reflects proposed changes within the Greenbelt and Growth Plans (2016). Resilience is proposed to be a guiding planning vision for the GGH in building strong and healthy communities and in planning through climate change with green infrastructure. Could a regulated *Resilience Strategy* help further these initiatives? Would this enable planners and policy-makers to have another planning tool or, would its effectiveness be limited amongst the large amount of planning policy documents that deal, at various levels, with resilience building?

5.0 Recommendations

1) CRO Becomes a Longer-Term Position

In order for the entire 100RC model to gain strength, the CRO should be extended to remain in their role for a longer-term period. As discussed, Rockefeller provides full funding for the CRO for a two-year time period after which, in some cases, the CRO's role is dissolved in its entirety. Resilience building does not stop after a two year timeframe. In order for the 100RC to be more effective, the CROs position should be extended. Municipalities that do not have the financial means to fully fund an extended CRO position should receive financial support by Rockefeller Foundation and other non-governmental organizations. Those cities which do not have financial means could apply for further grants from Rockefeller and other environmental organizations. Further, a performance-based funding initiative could be implemented which tracks the process of the *CRO* and resilience building and based on performance municipalities could apply for grants if they are deemed to be succeeding in resilience building.

2) 100RC at a Regional Scale

Although it is essential to develop an effective decision-making tool in resilience building at the municipal level, it is only one piece to the puzzle to become truly resilient. Shocks and stressors, such as floods, fires, earthquakes, chronic disease outbreaks and food shortages do not simply stop at a municipality's border. The 100RC model should be expanded to encompass a regional resilience strategy. This could be done by utilizing an anchor city, in this case, Toronto, and then after the two year pilot period, the 100RC framework could be expanded to include municipalities within the Greater Toronto Hamilton Area (GTHA). Again, further financial support is required in implementing this

regional strategy however, it is is an absolute necessity to develop a cohesive, collaborative cross-scaled resilience framework in dealing with complex problems.

3) Open Data Framework

By utilizing the *CRF* and the *Resilience Strategy,* municipalities will be diving deeply into their governance structures. The information (data) collected based on *sub-drivers* of the *CRF* provide for an opportunity to understand how municipalities respond to current and future shocks and stressors, and the successes and failures in trying to achieve resilience. In doing so, the qualitative and quantitative data they obtain may be substantial in resilience building. 100RC intends for this data to be used as a common form of measurement in terms of resilience building and to enhance knowledge sharing within 100RC members. This data should be shared with municipal, provincial/state and federal governments that are interested and/or in the midst of developing a *Resilience Strategy.* By sharing collected data under the *CRF*, learning, remembering and adaptation may occur which are critical factors in resilience. Finally, this data should also be shared with academic institutions that deal with issues such as urban planning, international development, environment studies and so forth. There is a potential for great knowledge sharing and capacity building if 100RC and its members follow this recommendation.

4) A Strengthened Resilience Strategy

The *Resilience Strategy* is the 100RC model's tools in implementing resilience within a municipality however, it offers only guidelines. There is no real power in the strategy. From a municipal standpoint, there is opportunity for the *Resilience Strategy* to be included into a municipality's Official Plan or be implemented as a *resilience standard*, similar to Toronto's Green Standard. At the provincial level, Ministry of Municipal Affairs is near completion of the Co-ordinated Land Use Planning Review. The Planning Policy and

Innovation Branch of the Ministry of Municipal Affairs could view Toronto as a pilot 100RC member. If the Toronto's *Resilience Strategy*—through a review of its strengths and weaknesses—is deemed successful, there is opportunity for the Ministry of Municipal Affairs to consider incorporating the *Resilience Strategy* into provincial planning policy such as the Provincial Policy Statement Section 1.0 in Building Strong, Healthy Communities and require municipalities to develop a *Resilience Strategy* that is regulated by a municipality's Official Plan. This would provide more robust planning tools for provincial and municipal planners in the pursuit of resilience and provide legislative and regulatory stature to the *Resilience Strategy.*

6.0 Moving Forward

The 100RC model presents a real opportunity for a municipality to initiate a new way of decision-making. Grounded and and strongly connected to resilience, the 100RC definition and its *City Resilience Framework* offer planners and policy-makers an appropriate and substantial tool to dive deeply into their municipal governance structure and evaluate the city's strengths and weaknesses when experiencing shocks and stressors. Further, the 100RC model, which is based upon a global knowledge sharing approach, has the potential to be a successful and widely implemented framework. However, there are inherent gaps and challenges within the model. In particular the *Chief Resilience Officer* and their limited timeline of two years within a 100RC member. Further, the *Resilience Strategy*, which is only a strategy, is not backed by legislative authority, at least in the Province of Ontario. In the context of Toronto, it will be extremely important to closely follow the *CRO* and the development of the city's *Resilience Strategy*. Data sharing and quantitative analysis of the effectiveness of the *CRF* across member cities offers potential learning and future research opportunities for academics, municipal and provincial governments, as more members undertake a review of their governance structure and develop their tailored *Resilience Strategy*.

Is 100RC and the *CRO* a strategic marketing tool developed by Rockefeller? It is a strong model which aims to support cities, their citizens and governments in truly becoming resilient. However, it is an extremely complicated task to change a structure which is already so resistant to change and be able to effectively deal with complex problems at various hierarchies and scales. Time will only tell the outcomes of the 100RC model but there is strong hope. It is essential for politicians, stakeholders and politicians to engage in collaboration and discourse and utilize the 100RC model in order to tackle and solve the challenges facing our cities. The task starts at the local level and the time to act is now.

Bibliography

1. Arup., Rockefeller Foundation, n.d. City Resilience Index. Retrieved from: http://publications.arup.com/publications/c/city_resilience_index.

2. Allen, C. R., & Gunderson, L. H. (2011). Pathology and Failure in the Design and Implementation of Adaptive Management. Journal of Environmental Management, 92(5), 1379-1384.

3. Angeler, D. G., Allen, C. R., Garmestani, A. S., Gunderson, L. H., Linkov, I. (2016). Panarchy Use in Environmental Science for Risk and Resilience Planning. Environment Systems and Decisions, 36(3), 225-228.

4. Berkes, F., Colding, J., & Folke, C. (2003). Navigating Social-Ecological Systems Building Resilience for Complexity and Change. Cambridge University Press.

5. Berkowitz, M. (2015). Rockefeller Foundation 100 Resilient Cities: Chief Resilience Officer. Retrieved from: http://www.100resilientcities.org/blog/entry/what-is-a-chief-resilience-officer1#/-_/

6. Boyd, E., & Folke, C. (2012). Adapting institutions: Governance, Complexity, and Social-Ecological Resilience. Cambridge University Press.

Bulkeley, H., & Betsill, M. M. (2003). Cities and climate change: Urban Sustainability and Global Environmental Governance. Routledge.

7. Carabine, E., & Wilkinson, E. (2016). How Can Local Governance Systems Strengthen Community Resilience? A social-ecological systems approach. Politics and Governance, 4(4), 62-73.

8. City of Berkeley. (2016). 100 Resilient Cities Resilience Strategy. Retrieved from http://www.cityofberkeley.info/uploadedFiles/City_Manager/Resilient_Berkeley/Berkeley_Resilience_Strategy.pdf

9. City of New Orleans. (2017). Chief Resilience Officer. Retrieved from: http://www.nola.gov/resilience/chief-resilience-officer/.

10. City of Toronto: Chief Corporate Officer. (2016). Resilient City - Preparing for a Changing Climate Status Update. Retrieved from: http://www.toronto.ca/legdocs/mmis/2016/pe/bgrd/backgroundfile-98049.pdf

11. City of Santiago. (2017). 100RC Resilience Strategy (in Spanish). Retrieved from: http://www.100resilientcities.org/cities/entry/santiago-met#/-_/

12. Clark, W. C., Jones, D. D., & Holling, C. S. (1979). Lessons for ecological policy design: A case study of ecosystem management. Ecological Modelling, 7(1), 1-53.

13. Dale, A., & Hill, S. B. (2001). At The Edge: Sustainable Development in the 21st century UBC Press.

14. Deppisch, S., & Hasibovic, S. (2013;2011;). Social-Ecological Resilience Thinking as a Bridging Concept in Trans-disciplinary Research on Climate-Change Adaptation. Natural Hazards, 67(1), 117-127.

15. Elmqvist, T., Folke, C., Nyström, M., Peterson, G., Bengtsson, J., Walker, B., & Norberg, J. (2003). Response diversity, ecosystem change, and resilience. Frontiers in Ecology and the Environment, 1(9), 488-494.

16. Empey, T., Flanagan, C., Hanson, G., Hintelmann, L., Mason, G., Sgro, A., Webster, K., Yuen, C.Lister, N.M., Boudreau, S., King, L. (2016). Wet Infrastructure: Building Blue and Green- PL8109 Planning Studio. Toronto: Ryerson School of Urban and Regional Planning.

17. Flax, L., Armstrong, A., Yee, Liz. (n.d) Measuring Urban Resilience As You Build It: Insights from 100 Resilient Cities. Retrieved from: https://www.irgc.org/wp-content/uploads/2016/04/Flax-Measuring-Urban-Resilience-As-You-Build-It.pdf

18. Folke, C. (2006). Resilience: The Emergence of a Perspective for Social–Ecological Systems Analyses. Global Environmental Change, 16(3), 253-267.

19. Folke, C., Jansson, Å., Rockström, J., Olsson, P., Carpenter, S. R., F. Stuart Chapin III, (2011). Reconnecting to the Biosphere. Ambio, 40(7), 719-738.

20. Garmestani, A. S., & Benson, M. H. (2013). A Framework for Resilience-Based Governance of Social-Ecological Systems. Ecology and Society, 18(1), 9.

21. Gomm, R., Hammersley, M., & Foster, P. (2013). Case Study Method: Key Issues, Key Texts. Sage Publications.

22. Gunderson, L. H., Allen, C. R., & Holling, C. S. (2009). Foundations of Ecological Resilience Island Press.

23. Gunderson, L.H, Prictchard, L. (2002). Resilience and the Behaviour of Large-Scale Systems. Island Press.

24. Green, E. (2016). SF's Chief Resilience Officer Leaving Post. San Francisco Chronicle. Retrieved from: http://www.sfchronicle.com/politics/article/SF-s-chief-resilience-officer-leaving-post-10599706.php

25. Holling, C.S. (1973). Resilience and Stability of Ecosystems. *Annual Review of Ecological Systems* (4): 1-23.

26. Holling, C.S. (1986). Resilience of Terrestrial Ecosystems: Local Surprises and Global Change. *In Sustainable Development of the Biosphere,* ed. W.C Clark and R.E. Munn, 292-*317.* Cambridge: Cambridge University Press.

27. Lipper, B. (2016). Rockefeller Foundation 100 Resilient Cities: Resilience Strategy. Retrieved from: http://www.100resilientcities.org/blog/entry/how-to-develop-a-resilience-strategy#/-_/

28. Lister, (2016). Nature and Cities: Resilience Beyond Rhetoric in Urban Planning and Design

29. Ludwig, D., Jones, D. D., & Holling, C. S. (1978). Qualitative Analysis of Insect Outbreak Systems: The Spruce Budworm and Forest. Journal of Animal Ecology, 47(1), 315-332.

30. Ministry of Municipal Affairs. (2016). Co-Ordinated Land-Use Planning Review. Retrieved from: http://www.mah.gov.on.ca/Page10882.aspx

31. Ministry of Municipal Affairs. (2016). Greenbelt Plan Proposed Changes. Retrieved from: http://www.mah.gov.on.ca/Page13783.aspx

32. Ministry of Municipal Affairs. (2016). Growth Plan Proposed Changes. Retrieved from:

https://www.placestogrow.ca/index.php?option=com_content&task=view&id=420&Itemid=12

33. Neuman, W. L., Jacoby, J., & Barr, L. R. (2003). Social research methods: Qualitative and Quantitative approaches (5th ed.) Allyn and Bacon.

34. Odum, E. P., & Barrett, G. W. (2005). Fundamentals of Ecology (5th ed.) Thomson Brooks/Cole.

35. Parkes, M. W., Morrison, K. E., Bunch, M. J., Hallström, L. K., Neudoerffer, R. C., Venema, H. D., & Waltner-Toews, D. (2010). Towards Integrated Governance for Water, Health and Social–Ecological systems: The Watershed Governance Prism. Global Environmental Change, 20(4), 693-704.

36. Perz, S. G., Cabrera, L., Carvalho, L. A., Castillo, J., Chacacanta, R., Cossio, R. E., Costa Silva, A. (2012). Regional Integration and Local Vhange: Road Paving, Community Connectivity, and Social–Ecological Resilience in a Tri-National Frontier, Southwestern Amazonia. Regional Environmental Change, 12(1), 35-53.

37. Provincial Policy Statement. (2014). Ministry of Municipal Affairs. Retrieved from: http://www.mah.gov.on.ca/page10679.aspx

38. Peterson, G., Allen, C. R., & Holling, C. S. (1998). Original Articles: Ecological Resilience, Biodiversity, and Scale. Ecosystems, 1(1), 6-18.

39. Pimm, S. L. (1984). The complexity and stability of ecosystems. Nature, 307(5949), 321-326.

40. Stake, R. E. (1995). The art of Sase Study Research. Sage Publications

41. Selin, H., & VanDeveer, S. D. (2009). Changing climates in north american politics: Institutions, policymaking, and multilevel governance MIT Press.

42. Rockefeller Foundation. (2015). City Resilience Framework. Retrieved from: http://lghttp.60358.nexcesscdn.net/8046264/images/page/-/100rc/Blue%20City%20Resilience%20Framework%20Full%20Context%20v1_5.pdf

43. Rockefeller Foundation. (2017). 100 Resilient Cities Model. Retrieved from: http://www.100resilientcities.org/resilience#/-_/

44. Rodin, J. (2013). Rockefeller Foundation 100 Resilient Cities First Cohort. Retrieved from: http://www.100resilientcities.org/blog/entry/33-resilient-cities-announced#/-_/

45. United Nations Human Settlements Programme. (2011). Cities and Climate Change: Global Report on Human Settlements, 2011 Earthscan.

46. Waltner-Toews, D. (2004). Ecosystem Sustainability and Health: A Practical Approach. Cambridge University Press.

47. Waltner-Toews, D., Kay, J., & Lister, N. E. (2008). The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability. Columbia University Press

48. Walker, B. H., Ludwig, D., Holling, C. S., & Peterman, R. M. (1981). Stability of Semi-Arid Savanna grazing systems. Journal of Ecology, 69(2), 473-498.

49. Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, Adaptability and Transformability in Social-Ecological Systems. Ecology and Society, 9(2), 5.

50. Yodzis, P. (1981). The stability of real ecosystems. Nature, 289(5799), 674-676.

51. 100Resilient Cities. (2017). City Resilience. Rockefeller Foundation. Retrieved from: http://www.100resilientcities.org/resilience#section-1

52. 100Resilient Cities Toronto. (2016) Agenda Setting Workshop.