

Determining Individual Endorsement Levels for Water Resilience Principles – A Case Study of
the Town of Lincoln, Ontario.

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Thesis Abstract

The integrity of freshwater ecosystems is being challenged, mainly due to the failures of the traditional command-and-control governance approach. A social ecological resilience approach to water resources management (water resilience) has been proposed to help mitigate these challenges. To effectively implement this approach, individual endorsement and attitudes to water resilience and its underlying principles must be better understood; however, very little research has examined individual attitudes towards this concept. This thesis studied the extent to which individuals endorse (support and agree with) managing and governing water resources using a social ecological resilience approach. To explore and determine endorsement of water resilience, a quantitative vignette questionnaire was utilized in a single exploratory case study in the Town of Lincoln, Ontario. The vignette questionnaire was developed based on the seven underlying principles of social ecological resilience and elicited responses for both local and non-local water contexts. Demographic data was also collected to examine how they relate to endorsement scores. Overall, respondents indicated a medium level of endorsement for the water resilience principles, with lower endorsement for the local than the non-local context. However, the extent of endorsement for the resilience principles differed as a function of location, the type of water challenge, individual experiences, and the conceptualization of the resilience principles. Those with higher overall endorsement scores tended to be female, older and attached more meaning to water bodies. Sex, political ideology and attaching meaning to local water bodies emerged as important predictors of water resilience endorsement. The vignette questionnaire proposes a suitable methodological framework for determining and measuring endorsement levels for the resilience principles. A factor analysis showed the seven resilience principles as consisting of two major components: principles related to 'the system being governed' and

principles related to the ‘governance system’. The results of this thesis provide useful insights to policy makers/planners in developing more adaptive, integrative and resilient water governance approaches tailored to align with particular community perceptions and demographics. For future research, the nuances of endorsement, as well as additional factors like personality and psychological factors that may influence endorsement levels, should be considered.

Key words: water resilience; social-ecological resilience; resilience principles, individual agency; water governance

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List of Abbreviations and Definitions

Abbreviations

CAS	Complex Adaptive Systems
IWRM	Integrated Water Resources Management
NGO	Non-Governmental Organization
SES	Social Ecological Systems

Definitions

Definitions of key terms:

Complex adaptive systems (CAS): These are dynamic systems that respond to feedback by transforming over time. Thus, CAS have the ability to memorize and learn from their earlier responses to feedback and use this information to influence current and future system occurrences.

Endorsement: The act of supporting, approving, recommending or agreeing with something.

Resilience approach: This is a viewpoint that sees SES as complex adaptive systems capable of dealing appropriately with unanticipated shocks and changes.

Social–ecological systems (SES): These are integrated systems of humans and nature that constitute a complex adaptive system with ecological and social components that interact dynamically through various feedbacks (Berkes, 2017).

Water governance: This involves all the processes surrounding the management and delivery of water related services for the society. It involves the management of all relevant actors including the supply, delivery, and use of water in an efficient way without compromising the overall viability of water systems (Pahl-Wostl, 2015; Weik & Larson 2012)

Vignette: A short scenario, illustration or brief story (written, spoken, in visual images, video or audio) that describes hypothetical or real situations of concepts in specified contexts.

Chapter One: Introduction

1.0 Local and Global Water Issues/Concerns

Our world is in a water crisis. Our planet's water resources are increasingly being threatened by abrupt disturbances and exploitations on local to global scales (IPCC, 2018; Steffen et al., 2011; Vörösmarty et al, 2013), at a pace and intensity never experienced before (IPCC, 2018; Rockstrom et al., 2009; World Economic Forum, 2020). The most recent 'global risks report' by The World Economic Forum highlighted the top global risks over the coming decade, with water crisis being among the top five most alarming risks (World Economic Forum, 2020). In addition, the report showed that the top five risks in terms of likelihood and impact are all water related risks, which further emphasizes the severity of a water crisis and the importance and urgency in addressing water management issues (SIWI, 2020). These water challenges include, but are not limited to, intense floods, droughts, water pollution, decreasing water safety and quality, water shortages, declining freshwater habitats and increasing pressure on eco-hydrological systems, such as rivers, wetlands and groundwater (Gaines, 2016; Rockström et al., 2009; Rockström et al., 2014; Vörösmarty et al., 2013; World Economic Forum, 2020). To buttress this, the Intergovernmental Panel on Climate Change (IPCC) projected in a recent report that many countries will be faced with changing precipitation patterns, colder winters, warmer summers, as well as increased floods and droughts. Consequently, the sustainability of water has been highlighted as one of the most critical contemporary challenges worldwide (IPCC, 2018).

These unprecedented disturbances are worsened by our advancement into the Anthropocene age (Crutzen, 2002; Steffen et al., 2011), in which humanity has become a global geophysical force of change, with significant impacts on how the earth system functions. Some of the consequences of the Anthropocene include increased emissions of greenhouse gases, faster rate of climate change occurrence, and the challenge of adequately meeting the food, water and health services needs of the over nine billion people projected to be living on the earth by 2050 (UN, 2013). Several research and studies now clearly indicate that freshwater resources, lakes, rivers, and wetlands may be unable to meet increasing water demands and the continued production of critical ecosystem services that all humanity depends on (Rockstrom et al., 2014; UN Water, 2015; Vörösmarty et. al, 2013).

These disturbances are manifesting in Canada and all over the world, from the boil water advisories in North Canadian communities (Government of Canada, 2019), to acute water shortages in Cape Town and Western New South Wales, Australia (BBC 2018, City of Cape Town 2018; The Guardian, 2019), to the frightening prospect of India facing its worst water shortage in history (CNN, 2018).

In Canada, the integrity of local freshwater ecosystems are being threatened; for example, the situation with algal blooms in Lake Erie (IJC, 2014) and Lake Winnipeg (Environment Canada, 2011) associated with rising phosphorous and nitrogen levels; the significantly distorted environmental flows and the declining coldwater habitats in streams in the Lake Ontario basin (Niagara Peninsula Conservation Authority, 2013), and recent extreme flooding in Alberta (Global News, 2019). In general, the health of most of Canada's water resources have been largely jeopardized by these significant threats and challenges (WWF-Canada, 2012; 2015).

The implications of these water challenges are critical and far-reaching, with likely cascading impacts to local and global economic growth and human livelihoods, causing tremendous challenges for communities, societies, researchers, policy planners and governments worldwide (Baker, 2009; Rockstrom et al., 2014; Rodina, 2018a). The United Nations high level panel on global sustainability (United Nations, 2013) also emphasizes the gravity of these water problems and the need for the immediate and dedicated attention and action of policy planners and governments (Falkenmark, 2016). These disturbances expose the need for a better understanding of the best ways to handle, manage, and adapt to change with respect to water resources.

1.1 The Root Cause of Current Water Issues and The New Water Paradigm

Research studies and global policy discourses have now recognized that current water challenges are actually issues of governance rather than issues of resources or technological problems (Bucknall, 2006; United Nations World Water Assessment Programme, 2003). The Global Water Partnership (2000) asserted that the global water crisis is primarily a governance crisis; an assertion that was also recently echoed by the Organization for Economic Co-operation and Development (OECD, 2018). Indeed, new insights and changes in perspective now challenge the basic assumptions of the traditional water management.

Water governance involves all the processes surrounding the management and delivery of water related services for the society. It involves the management of all relevant actors including the supply, delivery, and use of water in an efficient way without compromising the overall viability of water systems (Pahl-Wostl, 2015; Weik & Larson 2012)

The traditional way of managing water resources using a command-and-control approach utilizes a centralized bureaucratic strategy that focuses too narrowly on the technical aspects of governance while ignoring the broader social-ecological elements and complex interactions that shape water resource systems (Cox, 2016; Rodina, 2018a; Holling & Meffe, 1996; Pahl-Wostl et al., 2010; Resilience Alliance, 2010). This approach views water systems as controllable individual parts rather than as a holistic system, and thus tends to manage the different components (social and ecological) separately rather than as one whole interacting unit. In addition, this approach largely excludes individuals in society as influencers in the governance process, hence disregarding a critical element for water governance. Such measures and interventions are inflexible and are inadequate for dealing with the current kinds of non-linear changes and unexpected system behavior of freshwater ecosystems (Berkes & Folke 1998; Carpenter et al., 2009; Holling & Meffe, 1996; Pahl-Wostl et al., 2010; Schoeman et al., 2014).

The recognition of the limitations of the command-and-control water governance approach exposed the need for a new, more effective, way of managing water resources, and over time, several different water governance approaches have been identified to advance management and governance approaches in a new water paradigm (Allan & Finlayson, 2014; Pahl-Wostl et al., 2010; Schoeman et al., 2014). Some noteworthy water governance approaches that have arisen in this regard include adaptive management (Plummer et al., 2014), adaptive co-management (Plummer et al., 2014) and the Integrated Water Resources Management (IWRM) approach (Galaz, 2007). The advancement of these water governance approaches has provided inroads and important windows of opportunity towards a more resilience-based governance approach of water resources (Galaz, 2007).

A social ecological resilience perspective to managing water resources (also referred to as water resilience), overcomes the failures of the command-and-control approach by embracing a complex system thinking perspective which views and manages freshwater ecosystems as coupled cohesive social-ecological systems rather than managing them in parts (Berkes et al., 2000a; Morin, 1992; Rockström et al., 2014; Rodina, 2018b). This approach acknowledges that freshwater ecosystems typically have strong interactions and feedbacks between the ecological and social system components that determine the overall dynamics of the social ecological system (Folke et al., 2010). Rather than trying to control complex, adaptive water systems, a water resilience approach emphasizes a system view thinking, increased awareness of complexity in water systems and broader stakeholder involvement (Gunderson & Light, 2006; Pahl-Wostl 2007; Schoeman et al., 2014). This recognition of the social and ecological elements will increase the system's resilience to disruptions and its ability to adapt successfully to disturbances and changes. (Folke et al., 2010; Resilience Alliance, 2010; Walker & Salt, 2012). Hence, applying a social ecological resilience perspective to water management has shown potential to overcome the weaknesses of the traditional command-and-control approach.

Biggs et al. (2012) propose seven broad principles, which could be applied in different management and policy contexts to access resilience, including water related social-ecological systems. The seven principles, which are interdependent and may not enhance resilience in a SES as stand-alone principles, include: (P1) maintain diversity and redundancy, (P2) manage connectivity, (P3) manage slow variables and feedbacks, (P4) foster an understanding of social-ecological systems as complex adaptive systems, (P5) encourage learning and experimentation, (P6) broaden participation, and (P7) promote polycentric governance systems (Biggs et al., 2012). These principles are applied in this study as a basis and mechanism to assess individual endorsement for water resilience.

This research focus is primarily on freshwater systems. Canada has significant freshwater resources, and with such abundance comes the growing awareness and responsibility to protect and safeguard freshwater resources. Indeed, freshwater is critical to the future of the Canadian economy and quality of life and that is why Canada's commitment to freshwater protection is now a national priority (WWF, 2012; 2015).

1.2 Individual Agency and Mindset for Endorsing Water Resilience

Given the current Anthropocene era, the implications of human actions and decisions on the sustainability of the environment, and the urgency required for transformation, it is important to understand the challenges and opportunities for implementing a water resilience approach (Olsson et al., 2008; Steffen et al., 2011). One of such opportunities is utilizing 'individual agency' by involving, engaging and getting the support of members of the public as active actors and partners in the water governance process (Betsill et al., 2020; Fischer et al., 2012).

Individual agency, which is the capacity or power of individuals to be the originator of action and to act purposely (Cleaver, 2007), has been recognized to have both potential and potency to effect transformational change (McNay, 2013; O'Brien, 2015). This agency, also referred to as an 'a priori' condition to action, is quite effective when individuals see themselves as resourceful and imaginative agents with a voice in how resources are administered and managed, rather than viewing resources as an inventory to be managed by politicians and bureaucratic experts (Dale,

2013; Ziervogel et al., 2016). Individuals in society can effect change through their votes, their support, their actions, their voice, advocacy, community-based actions and initiatives (Lubell, 2017; Khoury, 2015). As part of their agency, it is expected that individuals who endorse water resilience can be reasonably expected to accept and support policies based on the underlying water resilience principles and, in some cases, even advocate for them. Obviously, individual and societal support and cooperation is a very important element for effectively implementing a water resilience-based governance approach (Dale, 2013; Johannessen & Wamsler, 2017; Osterblom & Folke, 2013). Hence, the knowledge and understanding of the extent to which they are willing to endorse or support certain governance policies and plans can be valuable to policy planners in formulating policies and developing messaging that align with the views, values, and beliefs of individual actors in that context.

Despite its potential for transformational change, individual agency alone may not be sufficient to cause a resilience governance transformation. It is also important to align individuals' mindsets with resilience thinking for overall system transformational change (Abson et al., 2016). Understanding and utilizing the 'leverage point' (or point of power) of a system's mindset (the underlying goals, values, and views of actors that shape the emerging direction of a system), has the potential to effect fundamental change in the overall system (Meadows, 1999). The way in which people see, value, and relate with a system is critical in defining the overarching goals and paradigm of the system, and this influences the functioning and behavior of the overall system (Abson et al., 2016; Meadows, 1999; Wells & Lekies, 2006). Hence, individuals' mindset and their endorsement matter in implementing resilience-based water governance and management approaches.

Based on the rapidly worsening state of water resources, there is the urgent need for society to be involved in water governance and to endorse water resilience-based governance in order for the resilience principles to be reflected in related policies, plans, and actions at all levels of society. While the government is the key actor across all stages of the policy process, its role in governance has become more complex and interdependent. Hence, the government relies on the partnership of a broad range of actors including individuals in society to be successful in governance, and in many instances, this participatory approach has shown the ability for more successful governance outcomes (Betsill et al., 2020).

However, though water resilience research has given substantial attention to the predominant issues regarding water resilience especially in large communities, watersheds, provinces, regions, countries, continents, and the planet (e.g. Baird et al., 2016; Schuetze & Chelleri, 2013), an equivalent amount of attention has not been given to the role of individual actors, individual mindsets and perceptions with respect to this concept (e.g. Baird, Dale & Farhad, in press). Hence, this study focuses on the role of individual agency as a catalyst in shaping a water resilience-based governance and explores the demographic factors that influence individual mindset and endorsement towards the resilience principles, with a view to achieving transformational change in the management of water resources.

1.3 Research Purpose and Objectives

Gaining public endorsement (i.e., agreement and belief in importance) for water resilience and its underlying principles (Biggs et al., 2012) is critical for facilitating strategies and policies to

enable the substantive shift to water resilience-based governance systems (Eriksson et al., 2014). The successful implementation of this governance approach would require that individuals in society positively endorse water resilience in order to support related principles and this support has the potential to catalyze a water governance transformation (Meadows, 1999; Plummer et al., 2014). However, little empirical research has been devoted to this critical area to date (but see Baird, Dale & Farhad, in press). Currently, little is known about the extent of individual endorsement for the principles of water resilience, and there is also a paucity of research on how individual endorsement might be developed and even manipulated for accelerating the benefits of a water resilience governance approach. Addressing this gap is urgent and critical in the face of accelerating global water challenges.

Based on the argument that the influence of individuals, as actors with agency, can be powerful forces for change, the purpose of this research is to determine individual endorsement levels for the water resilience principles to enable government and policy makers to align policies and messaging accordingly. This research also aims to determine how key demographic factors (e.g., age, sex, education, income, religious attendance, importance of water bodies and political ideology) relate to individual endorsement of the resilience principles.

Accordingly, the following two objectives are associated with the purpose of this research: (1) Develop a data collection instrument and methodology to measure the level of resilience endorsement by individuals and determine the factor loadings of the resilience principles; and (2) Determine and measure the level of endorsement of the underlying principles of water resilience in a case study and examine how demographic factors relate to and predict endorsement levels.

1.3.1 Objective One

Develop a data collection instrument and methodology to measure the level of resilience endorsement by individuals and determine if the seven resilience principles have an underlying variance that is explained by a given factor.

1.3.2 Objective Two

Determine and measure the level of endorsement of the water resilience principles in a case study and examine how key demographic factors relate to overall resilience endorsement scores.

1.4 Organization of Thesis

This introduction chapter highlighted the current water sustainability related challenges in the world and in Canada specifically. It also summarized the importance of making a shift from a command-and-control water governance to a water resilience-based governance approach, while focusing on individual agency and mindset.

The remaining sections will be organized into four main chapters. Chapter Two is a literature review of the main concepts used in this research and describes the analytical and empirical framework on which the study is based. Chapter Three describes the development of a data collection instrument and methodology to determine and measure resilience endorsement. Chapter Four describes details of the research study carried out to determine and measure how individuals endorse the water resilience principles in the Town of Lincoln, Ontario. Chapter Five is a concluding chapter that synthesizes the overarching results of the study.

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Chapter Two: Literature Review and Analytical Framework

2 Overview

This chapter probes the literature to introduce the main concepts of this study (i.e., water governance, water resilience, individual agency and leverage points) and to discuss the empirical and theoretical research around them.

2.0 The Conventional Water Governance Approach

The command-and-control approach to managing freshwater resources utilizes a top-down centralized bureaucratic strategy that focuses too narrowly on the technical aspects of governance while ignoring the broader social-ecological elements and interactions that shape water resource systems (Cox, 2016; Holling & Meffe, 1996; Rodina, 2018a). It is largely focused on the engineering resilience perspective where elements of a system are seen as being predictable, supporting the perception that ecological systems can easily be controlled for productivity (Kay et al., 1999; Rodina, 2018a). The command-and-control approach ‘forces’ people in society to comply with a “standardized solution” rather than a solution being adapted to their specific ecological, social, and cultural conditions, bearing in mind the complex adaptive nature of the human-environment interactions, particularly in the Anthropocene (Cox, 2016; Holling & Meffe, 1996; Steffen et al., 2011)

This approach fails to recognize the complex interacting nature of the system being governed but manages it as individual parts rather than a holistic interacting system (Holling & Meffe, 1996). This approach displays a form of determined belief and confidence that science, technology, sustained linear progress and increasing control over nature will result in social progress in the society (Scott, 1998). In addition, it excludes individual resource users by not seriously considering their opinions and viewpoints in formulating policies and plans (Acheson, 2006; Scott, 1998). Rather, it overly relies on technical professionals who are usually incentivized to endorse certain technical solutions that entrench the command-and-control system, rather than more participatory solutions that involve other actors in the society (Acheson, 2006; Holling & Meffe, 1996; Scott 1998). The command-and control approach to maximize measurable productivity and growth without much concern for the trade-offs involved in the process of governance, usually leads to reduction in productivity and increased vulnerability of the systems being governed (Acheson, 2006; Holling & Meffe, 1996, Scott, 1998). Other concerns regarding the command-and-control approach include the significant costs of enforcement and compliance, regulatory associated conflicts, and the ineffectiveness in addressing the challenge of complexity and uncertainty. Hence, the command-and-control approach will not sustain water for ecosystems or humans in the future (Durant et al., 2004; Gleick, 2003; Holling & Meffe 1996; Pahl-Wostl et al., 2011).

However, in spite of the acknowledgement of these inadequacies and calls that control should no longer be the main focus in the management and governance of water resources (Milly et al., 2008), the command-and-control approach is still being utilized in water governance (Ziergovet et al., 2016). Making a complete shift from conventional control governance to more adaptive and inclusive water governance approaches has been challenging, due to the absence of clear and sufficient guidelines on how to practically operationalize this required shift. There is also a misunderstanding about the important requirements needed to make this shift possible (Gelcich

et al., 2010; Harris et al., 2017). It is crucial to implement a ‘new paradigm’ for managing and governing freshwater resources.

2.1 The New Water Paradigm

There has been increased discussions and debates for an urgent shift to a water management approach that overcomes the failures of the command-and-control approach, and that embraces a complex system thinking perspective which views and manages freshwater ecosystems as coupled social-ecological systems rather than managing them in parts (Berkes et al., 2000a; Morin, 1992). Indeed, there have been calls for a shift to a ‘new water paradigm’ (Pahl-Wostl et al., 2010; Schoeman et al., 2014). The dominant theme in the calls for a paradigm shift in water management is the importance of understanding the need for water policy strategies that are able to adapt, or cope with surprises and uncertainty in complex freshwater systems. This is key to the successful implementation of the new water paradigm (Galaz, 2007; Pahl-Wostl et al., 2011).

Over the years, the recognition of the limitations of the command-and-control water governance approach has led to the identification of different potential approaches for managing and governing water resources, such as adaptive management, adaptive co-management and integrated water resources management. Adaptive management was one of the first approaches that was promoted as a suitable adaptive resilience governance approach (Plummer et al., 2014). It emphasizes ‘learning by doing’ through experimenting with policies, implementing actions, and making adjustments in the light of monitoring and evaluation (Lee, 1993; Walters, 1997). The rise of adaptive management as a governance approach emphasized the importance of social learning in governing water resources (e.g., Ison et al., 2007; Pahl-Wostl et al., 2008). Adaptive co-management emerged from the concept of adaptive management and was proposed as being able to deal with complex environmental issues. It is a multi-scale approach that focuses on shared learning-by-doing between various actors in the medium to long term. Overall, it is focused on strengthening the power and capacity of all actors involved in the sustainable management and governance of natural resources (Plummer et al., 2012).

Another notable governance approach is the integrated water resources management (IWRM) approach, defined by the Global Water Partnership as “...a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Agarwal et al., 2000, p. 22). IWRM is an interactive governance approach that has a holistic view of water resources, covering economic, social and the eco-systems of nations and regions (Abdel-Magid & Ahmed, 2002). It gained global acceptance among water policy makers and researchers as a pathway to more effective governance of water resources, as it addresses the social, economic and environmental aspects of water challenges (Galaz, 2007). Generally, IWRM provided an important window of opportunity towards a more resilience-based governance approach of water resources (Galaz, 2007).

Obviously, significant progress has been being made in conceptualizing alternative water governance approaches that can address the complexities and uncertainties of freshwater challenges (e.g., Fish et al. 2010; Plummer et al. 2014; Plummer et al. 2017). This has given rise to the concept of a resilience-based governance as a new water paradigm (also referred to as water resilience). This approach requires a shift from a focus on controlling change for optimum results to accepting and embracing that change is the norm in social ecological systems like

freshwater ecosystems (Holling & Meffe 1996; Van der Leeuw, 2000). It involves recognizing that social-ecological systems (SES) are not infinitely stable and need to be able to sustain and enhance their capacity to manage and adjust to changes and surprises (Gunderson & Holling 2002; Berkes et al. 2003). The 'new water paradigm' also emphasizes a system thinking; increased awareness of complexity in water systems; recognition of the importance of human influence on freshwater and broader stakeholder involvement. This acceptance of complexity and uncertainty clearly indicates the potential of social ecological resilience as an approach for a new water management paradigm (Gunderson & Light, 2006; Pahl-Wostl 2007; Schoeman et al., 2014; Pahl-Wostl et al., 2010).

A water resilience approach recognizes the viewpoint of individuals in society. Influence and meaningful engagement are utilized instead of control. Intervention in issues no longer reside exclusively with the government or those with authority and power. Indeed, in the new water paradigm, there is a change from viewing the government as having primary decision-making power and authority, to embracing different levels of authority and decision-making power, where different actors and institutions also contribute to the development and implementation of policies in society (Pahl-Wostl et al., 2010; Schoeman et al., 2014). Resolving complex water issues requires a looser and less rigid management approach, that does not seek to predict and control the system, but instead encourages appropriate involvement from different actors in society (Pahl-Wostl et al., 2010).

Research findings however, have identified constraints like governance practices, institutional inertia and unwillingness to change that may limit the operations of a new water paradigm (Pahl-Wostl et al., 2010). Allan & Curtis (2005)'s Australian study reports that a new water paradigm could be constrained by deep rooted norms and institutional frameworks that value control and engineering and technological solutions despite their failures. Despite these challenges, a water resilience approach holds potential to solve the current and future water challenges and this study seeks to evaluate individual endorsement of this governance approach by evaluating the endorsement of its underlying principles.

2.2 Origins and Overview of Resilience

The term 'resilience' (*resiliency, resile*) has a long and diverse history, with interconnected meanings in the fields of literature, law, art, science and engineering dating back hundreds of years ago (Alexander, 2013). Resilience was introduced as an ecological concept by C. S. Holling in his 1973 paper on systems ecology. He hypothesized that ecological systems existed in multiple stability regimes that could change or shift due to system disturbances (Holling, 1973).

During that time, systems were predominantly viewed from the ecological stability lens, recognizing ecological systems as operating at, or near, a single equilibrium (Holling & Meffe, 1996; Gunderson, 2000; Folke et al., 2004). Holling (1973)'s exposition exacerbated the existing tensions between the divergent constancy and change perspectives and uncovered the necessity to change how ecological systems are defined and described. However, because it was against the dominant view at the time, Holling's conception was heavily criticized (Gunderson, 1999). Other researchers (e.g. May, 1977; Ludwig et al., 1978; Walker et al., 1981) have shown

empirical evidence of multiple stability domains covering a wide range of terrestrial, freshwater and marine ecosystems (Folke et al., 1996; Folke, 2016; Gunderson, 2000; Levin, 1998).

Over time, the resilience concept developed from being viewed as a purely ecological concept, to incorporating a social ecological conception of the understanding that humans and nature are inextricably intertwined to form a complex adaptive system (Armitage et al., 2007; Folke 2016; Folke et al., 2005; Levin et al., 2012). Also, in recent years, the ecological concept of resilience has rapidly permeated public policy discourses, becoming adopted by policy planners across disciplines including public health, disaster management and urban planning (Walker & Cooper, 2011). There is now an abundance of literature on resilience with several and even divergent definitions and meanings in different fields addressing different concepts and systems, making resilience a fashionable buzz-word with no agreement on a core definition (Rodina, 2018b; Park, 2011). This has affected the credibility of the resilience concept, with some researchers arguing that this absence of a core definition has done more harm than good to the study of resilience (Alexander 2013; Park 2011). However, Folke (2016) argues that attempts to integrate the varied resilience perspectives into a unified perspective may undermine the multi-disciplinarity of viewpoints essential to meet the challenges of current environmental issues especially with respect to social ecological systems (e.g., Arora-Jonsson, 2016; Bousquet et al., 2015; Folke, 2016). In the same vein, Alexander (2013) argued that resilience is a heterogeneous multi-dimensional concept that is adaptable to a range of uses and contexts in different ways.

2.3 Resilience Definitions

The term ‘resilience’ has become fashionable in different disciplines with a plurality of definitions, meanings, interpretations and usages that has led to confusion and criticisms (Manyena, 2006). It has become a catchphrase even among resource managers and policy makers, contributing to its fuzziness and making it open to different interpretations in different contexts (e.g., Benson & Garmestani, 2011; White & O’Hare, 2014).

The ecology literature has defined resilience by emphasizing three different dimensions of stability that have different consequences for ecological systems. The first is in line with the single equilibrium perspective of systems and thus focuses on stability near an equilibrium steady state where resilience is measured by the speed of return to a pre-existing equilibrium. This perspective is referred to as **equilibrium or engineering resilience** and focuses on efficiency and predictability of a system (Holling & Meffe, 1996; Pimm, 1984). Walker et al.’s (2004) definition of resilience as the level of changes and shocks a system can take while being able to continue its principal functions also reflects this perspective of stability. Other definitions that reflect this perspective include the definition of resilience as the ability to bounce back to a pre-shock state or equilibrium after a perturbation (Berkes & Folke, 1998), the capacity of a system to recover its shape after a disturbance (Norris et al., 2007), the capacity to survive disturbance (Folke et al., 2007) and the capacity of a system to undergo a disturbance, while still maintaining its functions and identity (Folke et al., 2010). The more rapidly a system is able to go back to equilibrium state, the more resilient it is seen to be.

The second dimension of resilience definition aligns with the perspective that systems are far from equilibrium, but have multiple stability domains, and can adapt to disturbances or changes as required. This perspective is called **ecosystem or ecological resilience** and emphasizes the

capacity of an ecosystem to recover rapidly from shocks and disturbances to its normal functioning state (Folke, 2006; Holling, 1973). In this case, resilience is a measure of the amount of disturbance that can be absorbed before the system needs to change its structure or behavior (Holling & Meffe 1996). The Resilience Alliance (2010) refers to resilience as the measure of shocks or disturbances a system can cope with without shifting to an alternate state with a different function or structure. If there is a decline in the resilience of an ecological system, then it becomes susceptible to regime shifts, which means the system can shift to another regime with different processes and structures (Garmestani et al., 2009). Some examples of such shifts between alternate states include transitions from grasslands to shrub-covered landscapes, from coral reefs to algae-dominated rocks and from clear to cloudy water in freshwater lakes (Resilience Alliance, 2010).

The third dimension of resilience builds on ecosystem resilience and aligns with the thinking that human systems and ecosystems are intricately linked to form a complex adaptive social ecological system that is dynamic and unpredictable (Plummer, 2010). This perspective is called **social- ecological resilience** and focuses on change and unpredictability. The definitions of resilience that highlight this perspective describe resilience as a system's capacity to absorb disturbance (Walker & Salt, 2012), to restructure and renew when there is disturbance and change (Carpenter et al., 2015; Walker et al., 2004). Social-ecological resilience is defined as the degree to which a system is able to innovate, incorporate change, learn and adapt in the face of change (Berkes et al., 2003; Carpenter et al., 2001; Folke, 2006; Holling, 1986). Resilience has also been described as the ability to adequately cope with uncertainties and to take advantage of change (Folke, 2016). In general, this perspective of resilience measures the ability of a system to continually adjust, thrive or transform in disturbance (Folke, 2006). This viewpoint of resilience highlights flexibility and diversity and offers a range of options and creativity in the face of disturbance, and it is this perspective of resilience that underpins resilience governance in complex social-ecological systems, especially in the face of wicked environmental issues like climate change and water issues (Davoudi & Porter, 2012; Holling, 1996).

Social ecological resilience takes a SES perspective that views humans and ecological systems as intricately linked. This perspective sees no delineation between the social and ecological systems, instead, humanity is embedded inside the biosphere and are actually reliant on the capacity of the biosphere to sustain humanity. At the same time, humanity is deeply involved in the development and shaping of ecosystems and the planet (Berkes & Folke, 1998; Folke et al., 2011). The acknowledgement and understanding of a SES concept is central to resilience thinking and resilience governance, because managing natural resources like freshwater ecosystems is not just a purely ecological or social issue, but instead such management issues involve an integrated mix of multiple social and ecological elements (Resilience Alliance, 2010).

Social ecological resilience is the definition of interest in this study, hence the use of the term 'resilience' for the rest of this thesis will refer to social-ecological resilience.

2.4 Overview and Definitions of Water Resilience

The term 'water resilience' is currently an emerging phrase in the resilience literature (notable exceptions include Eriksson et al., 2014; Falkenmark, 2016; Rockström et al., 2014; Rodina 2018b), but that does not preclude that research on resilience thinking concerning different

elements of water resources, ranging from flood management to water governance issues, has been on the increase in the last decade (Rodina, 2018a).

The earliest conceptions of resilience in water systems centered around the engineering concept of resilience, which is a measure of reliability and continuity of the services and supply of urban water systems (Hashimoto, Stedinger, & Loucks, 1982; Rodina, 2018a). However, more recent scholarly works on water resilience are more focused on ecological water resilience (Rodina, 2018a). The first Intergovernmental Panel on Climate Change (IPCC) Working Group Technical Report on climate change and freshwater resources highlighted the concept of resilience in water resources by discussing resilient strategies for managing freshwater flooding issues (Bates, Kundzewicz, & Wu, 2008). This is probably one of the reasons why there has been an increase in policies and strategic frameworks that utilize the resilience concept in different aspects of water management and governance (e.g., United Nations, 2015).

Water resilience is thus the utilization of the social-ecological resilience concept in the management and governance of water systems (Rodina 2018b; Shin et al., 2018). In recent studies, water resilience has been defined as the capacity of water systems to adapt or transform when there are disturbances, crises and changes in ways that continue to support human wellbeing (Eriksson et al., 2014; Folk et al., 2016; Rockström et al., 2014). It has also been described as the ability of water systems to withstand different water-related disturbances (e.g., floods, droughts, changes in water quality), as well as to adapt and transform while retaining their ability to provide essential ecosystem services (Folke, 2016), with society also able to anticipate, adjust, and respond to these water related disturbances.

Though water resilience is now being proposed as a viable solution to current water governance and management issues, its ability to adequately do this is faced with various challenges like lack of understanding, complexity of implementation, institutional barriers and cost implications (Allen & Gunderson, 2011). However, its appeal lies in its potential to implement a more system view approach to water management especially in the Anthropocene. Thus, at present, the “water resilience” perspective is still evolving, with little proof of its practical application and success (Eriksson et al., 2014; Rodina 2018b).

2.5 The Individual Agency

As the concept of social-ecological resilience has grown, so also has the recognition of human responsibility and involvement in producing social and environmental change and transformation (Harvey, 2002; Morosanu, 2016). The involvement, support, agreement and action of individuals in society as active actors and partners in the water governance process, is therefore highly necessary (Fischer et al. 2012).

In response to current environmental challenges in general, and water governance challenges in particular, agency and collaboration have been recommended as effective ways of integrating diverse and competing interests, whereby different actors (such as individuals in society, businesses, agencies, and NGOs) are able to be involved in policy making and governance (Betsill et al., 2020). This is the concept of agency. Agency is the capacity, or power to be the originator of action and to act purposely to achieve a change or transformation. Although agency may be exercised at several levels (individual, group or political) (Alkire, 2005), this research

focuses on individual agency. Individual agency is therefore the capacity of individuals to plan and initiate action, and to act purposely to achieve transformational change that would not have occurred otherwise (Bhaskar, 1994; Cleaver, 2007; Harvey, 2002). It is an ‘a priori’ condition to action, an individual’s ability to take important and meaningful action (Dale, 2013; Mc Nay, 2004; O’Brien, 2011; Osterblom & Folke, 2013). Individuals have the power to be influential agents for change, and their influence, perception and support can affect related policies, plans, and actions at all levels of society (Bandura, 2000; Cleaver, 2007; Lubell, 2017; Mc Nay, 2004; Neil Adger et al., 2005; Schelfaut et al., 2011). Individuals constitute interest groups, such as water user associations, and by their collective individual power, are able to act as intervening bodies between the aspirations and framings of their individual members and the critical outcomes of policy processes to influence change (Cleaver, 2007; O’Riordan & Jordan, 1999).

Research demonstrates that policy communications are developed not just by a rational, logical and structural approach to policy formation and creation, but ultimately are determined and influenced by the social interactions, concerns and interests of individuals in the society (Hajer, 1995; Howarth, 2005). Hence, knowing and understanding the perceptions of individual resource users in a particular setting, and the extent to which they are willing to endorse or support certain governance policies and plans, can be valuable to policy planners in formulating policies and developing messaging that align with the views, values and beliefs of individual actors in that context (e.g. Redlawsk et al., 2010). There is now a myriad of evidence of individual agency, especially through a number of climate change initiatives, including grassroots associations like the Youth Climate Movement, the Women’s Earth and Climate Action Network, and other organizations of individuals who are insisting on more sustainable structures and processes (O’Riordan & Jordan, 1999).

Nonetheless, some scholars have raised concerns about the structural constraints to individual agency and have questioned the effectiveness of individuals to influence valid transformations. Historically, the concern is that individual actions do not adequately deal with structural factors like governance structures, regulations, power issues, capacity building, policies, and institutions that impact actions that are critical for social transformations (Johannessen & Wamsler, 2017; Hitlin & Elder, 2006; O’Brien, 2015). Responses to critiques of individual agency argue that a broader perception of political agency acknowledges that the seemingly insignificant individual actions can have extensive global impacts and that sudden large-scale transformations can and usually do happen as a result of the individual agency (Khoury, 2015; O’Brien, 2015). Individual agency can influence not only the emergence and design of governance structures, but also decisions about policy choices and the way policy outcomes are assessed within those structures (Morrison et al., 2019).

With the advent of the Anthropocene and the challenges faced by local and global freshwater systems, it is imperative for government agencies and decision makers to find ways to limit human impacts on the environment by changing political, economic, social, and legal systems at multiple scales. There is now a global realization that effectively making and implementing these changes would require the support and involvement of a broad range of actors. (Betsill et al., 2020). Therefore, determining and understanding individual agency and how it influences mindset and positive action towards environmental sustainability can be a valuable instrument to effect the much needed transformation shift to a water resilience-based governance approach. In

addition, individuals' mindsets must be aligned with resilience thinking as the influence of individual agency usually begins in the mindset and attitudes of individuals, which is one of the most effective 'leverage points' for transformation (Meadows, 1999).

2.6 Leverage Points and Mindset Change

An important question with regards to effecting system transformation is, 'Where in a system should intervention be made to change the long-term overall behavior of the system?' (Abson et al., 2017). Research indicates that leverage points have the potential to effect system transformations (Abson et al., 2017; Meadows, 1999). Leverage points, also referred to as 'points of power', are places or areas within complex systems where a slight shift may lead to a fundamental change in the entire system (Meadows, 1999). Proposing a hierarchy of twelve intervention points for leveraging change, Meadows (1999) argues that the transformational ability of an intervention to cause a change in behavior depends on a large part on what aspects of the system the intervention acts upon, as this determines its potency.

Meadows (1999) identified twelve leverage points that can influence the behavior of a system, ranging from 'shallow' leverage points, which can be executed easily but with non-significant changes to the entire system behavior, to 'deep' leverage points, which are more challenging to implement but with more potential for transformational change. The two deepest leverage points include the power to transcend system paradigms and the power to transform the mindset out of which the system arises. Both of these leverage points are focused on the intent of the system and directed towards the underlying goals, values, and views of actors that shape the emerging direction of a system. This study focuses on the leverage point of people's mindsets, which is classified as the 'deepest' leverage point, with the greatest potential that could effect systemic environmental transformational change (Meadows, 1999). Though changing societal paradigms could be a difficult task, it can happen in a millisecond in individuals. 'All it takes is a click in the mind, a falling of scales from eyes, a new way of seeing' (Meadows, 1999, pp. 17). Hence, transformation starts with a change in the individual mindset (Pourdehnad & Bharathy, 2004), and an individual's viewpoint must be considered in order to open the mind to greater possibilities (Rorty, 1991).

Hence, individuals' mindset and endorsement are important in implementing resilience-based water governance and management approaches. This study explores individual mindset towards the resilience principles with a view to understanding how to influence them to achieve transformational change in the management of water resources.

2.7 Sense of Place: Local and Non-Local Perspectives to Endorsement

There has been growing interest over the last two decades on the relationship between people and place, that is, the relationship and attachment that people have with their meaningful environment (Lewicka, 2010; Schultz, 2000). Place in this regard refers to a spatial location that is ascribed meaning and value by individuals and society (Halpenny, 2010). This people-place relationship has been developed and discussed under different concepts, such as a sense of place, place attachment, place rootedness, place dependence, place identity, connectedness to nature and place satisfaction (Lewicka, 2010). However, the use of the term 'sense of place' or 'place attachment' for the rest of this thesis refers to a general conception of the people-place relationship.

A sense of place or place attachment is an emotional bond with a place (especially for public places like rivers, parks, or consecrated spaces), that has no intent to control (Schultz, 2000). It has also been described as a positive bond (usually social or physical), between an individual and a place, usually displayed through affective and cognitive behaviours (Scannel & Gifford, 2010). It has also been described as an emotional bond with a meaningful environment (Lewicka, 2010) and a desire, feeling of pride or longing for a place (Halpenny, 2010). In summary, the beliefs, memories, meaning, and knowledge that people associate with a particular place creates a deep personal bonding with such places (Scannel & Gifford, 2010).

Sense of place has been categorized in two ways. First, it has been categorized as occurring on two levels, an individual level and a group level (Scannel & Gifford, 2010). At the individual level, it involves a person's personal connection to a place, for example places that evoke personal memories or places where important events or milestones have occurred (Manzo, 2005). At the group level, a sense of place is comprised of shared symbolic meanings that people have with a place such as symbols of culture and historic experiences (Low, 1992). Sense of place has also been categorized into two types: social and physical place attachment (Hidalgo & Hernandez, 2001). Social place attachment involves having social ties and a feeling of belonging to a community, as well as an emotional connection with other residents in neighborhood. Physical place attachment involves a sense of rootedness in a place, usually indicated by owning property, number of years of residence, intention to stay in a place, a bonding with a particular physical place, such as neighborhoods, coffee shops, nature spots or other spaces that support social interaction (Stedman, 2003). Physical place attachment can also depend on the physical elements or characteristics of a place, especially if it has amenities or resources that support people's goals and meet some physical needs (Manzo, 2005; Stokols & Shumaker, 1981). These needs include survival and security (places that provide necessary provisions like shelter, water and food), goal support (places that provide the resources required for people to reach their goals), and temporal or personal continuity (places that give a stable sense of self) (Halpenny, 2010). This study's focus is on physical sense of place attachment.

Many variables affect environmentally responsible behavior and studies have shown that a sense of place has the ability to affect place-specific and general pro-environment behavioural intentions. Pro-environment behavior are actions by individuals or groups that promote the sustainable use of natural resources (Halpenny, 2010). Positive attachments to a place may be linked to the readiness of individuals to protect the place, and to have a high level of concern and care for it (Schultz, 2000). Studies also show that a positive attachment to a place, particularly a nature-based location like a park or a river, may be strongly linked to the level of behaviours that can positively benefit the general wellbeing of that place (Stokols & Shumaker, 1981).

Research also theorize that attachment to a place can encourage commitment and responsibility and increase the probability of people showing behaviours and actions that can protect those places (Giuliani, 2003; Halpenny, 2010). In addition, individuals show a willingness to support and engage in conservation initiatives designed to protect places for which they have an attachment (Kaltenborn, 1998; Schultz, 2000). For example, Kaltenborn's (1998) study illustrates that place attachment played a role in residents' responses to environmental impacts, as due to a strong sense of place, residents refused to support increased tourism due to its likely negative impact on their environment. On the contrary, a disconnect from a place (which may be

physical or social disconnect) could be a cause for indifference and pro-environmental inaction, as people usually would not show concern for a place for which they have no bond or attachment (e.g. Liberman, Trope, & Stephan, 2007; Reser, 1995; Roszak, 1992).

2.8 Evaluating and Enhancing Resilience

With the growing opportunities for resilience in social-ecological systems, careful consideration should be paid to what a successful and practical social-ecological resilience management structure would look like and what it would require in terms of resource investment and institutional arrangement (Benson & Garmestani, 2011). This will require translating the resilience concept into real life practical use and application (Biggs et al., 2012; Plummer et al., 2014; Walker & Salt, 2012).

However, while the resilience concept thinking is very promising, translating it into practice has proven a challenge. Making the transition from resilience thinking to resilience practice, including measuring resilience, evaluating its public acceptance, incorporating it in governance and institutional frameworks, documenting how it is applied in real life, and integrating the resilience theory into natural resource management, is an identified challenge (Benson & Garmestani, 2011; Miller et al., 2010; Walker & Salt, 2012). Without a clearer explanation of how resilience thinking addresses the limitations of past water governance approaches, and how it can be implemented as a management objective, it may fail to effectively transform management and governance practices (Benson 2009; Benson & Garmestani 2011; Ruhl & Fischman, 2010).

To address this challenge, several studies propose general guidelines for building, capturing and practicalizing resilience (e.g. Anderies et al., 2013; Baird et al., 2016; Biggs et al., 2012; Plummer et al., 2014; Tyler & Moench, 2012; Walker & Salt, 2012). Notable examples include the four factors for building resilience in SES (Folke et al., 2003), eight governance attributes and five ecological attributes which are critical when governing aquatic ecosystems for resilience (Plummer et al., 2014). In addition, Walker & Salt (2012) propose a three-step guideline for successful resilience practice. The Resilience Alliance also provides an online free workbook to assist practitioners and researchers to perform resilience assessments (Resilience Alliance, 2010). These varied guides however, have led to a rather fragmented understanding of what is actually important for building, accessing and applying resilience in practice (Biggs et al., 2015; Simonsen et al., 2014). This is likely due to the absence of adequately defined, detailed and explicit guidance on how to actually carry out actions that build resilience in managing natural resources (e.g., who are the actors to involve; at what stages do they become involved; what are the available management choices, etc.) (Miller et al., 2010). At the other extreme, there is the danger of having too detailed instruction manuals that may not be suitable for governing all types of complex social ecological systems (Miller et al., 2010). Clearly, it is necessary to strike a balance between definite guidelines that can answer particular questions, and flexible guidelines that recognize and incorporate the range of possible variations that can occur in social ecological systems.

2.9 The Resilience Principles

The fuzziness of the resilience concept contributes to the difficulty in trying to translate it from an ecological concept to become a policy concept in practice (Olsson et al., 2015; Welsh, 2013;

White & O'Hare, 2014). Hence, this study utilizes the underlying principles of resilience rather than the actual term itself in order to alleviate this challenge.

This study utilizes seven principles identified by Biggs et al. (2012), which are believed to be crucial for increasing the resilience of social-ecological systems. These principles, which were developed using a combination of an evaluation of the resilience literature, a modified Delphi survey of leading resilience experts, and a mock court workshop, provides some criteria or standard by which to capture or assess resilience, including detailed guidelines and strategies to apply them (Biggs et al., 2012, 2015). Biggs et al. (2012) propose that the presence of these principles in a SES reflects their level of resilience, and although the water resilience concept is conceptually evolving, by viewing freshwater resources through the lens of these seven principles, water managers and policy managers can identify and focus on the components of the system that can better influence resilience (Biggs et al., 2012; Folke, 2016).

The seven resilience principles are utilized for this research as they represent current knowledge with regards to requirements to build up resilience in SES. It is also important to note that the seven principles are interconnected and mutually dependent in practice and may not be implemented successfully as singular elements (Biggs et al., 2012).

2.9.1 Principle 1: Maintain Diversity and Redundancy

Diversity is “the variety and variability among living organisms and the ecological complexes in which they occur” (OTA 1987, pp. 3). It is also described as the ability of an ecosystem to have different components (e.g., having different species like predators, herbivores, pollinators, nutrient transporters), knowledge systems, actors, landscapes (e.g., lakes, deserts, grasslands, woodlands, streams, etc.) and communities, who have different overlapping response techniques to disturbances (Elmqvist et al., 2003). Redundancy is closely connected to diversity and is described as the ability of different components in a system to completely or partially compensate for any changes or failures in other components in the system, thus ensuring a continual balance in the system (Folke et al., 1996; Rosenfeld, 2002).

In SES context, ecosystem elements that may demonstrate diversity include species, landscape patches and genes, while social elements that may display diversity include government structures, governance approaches, cultural groups, stakeholder responses and livelihood options. An example of diversity in an ecosystem is the planting of different food crops in a farm, with the intention that a failure of any one crop would not have disastrous impacts on the total yield of the farm. An example of diversity in a social system is the existence of a varied group of stakeholders, such as government officials, researchers, NGOs, industry leaders, and community members with local knowledge, all sharing overlapping responsibilities for managing and making decisions (Biggs et al., 2012).

Diversity and redundancy tend to be positively correlated, with one increasing as the other increases (Hector & Bagchi, 2007). However, there are instances of systems when this does not occur (Janssen, Anderies, & Ostrom, 2007; Mills & Doak, 1993). Further, there are concerns that extremely high levels of redundancy and diversity can also weaken the resilience of SES in the long term by decreasing system effectiveness and enhancing the likelihood that the system may stagnate (Ulanowicz, Goerner, Lietaer, & Gomez, 2009). A very good example can be seen when

there is high redundancy in organizations, which increases management and administrative costs, and causes power tussles among departments, all of which have the capacity to reduce resilience, and render the system incapable of effectively adapting in the face of change and disturbance (Jentoft et al., 2009).

Biggs et al. (2012) propose that great effort should be put towards maintaining ecological diversity, especially as a reservoir for preserving essential ecosystem services such as pollination, nutrient cycling, and pest control. Diversity and redundancy also need to be deliberately built into governance systems and approaches (Biggs et al., 2012). One of the most effective ways to do this is for resource managers to consciously recognize and incorporate diverse perspectives and sources of knowledge in their decision-making processes. Other ways to do this include encouraging policies that can better cope with environmental and other disturbances, though they may come at a higher cost (Biggs et al., 2012), and dedicating resources to practices that facilitate collective learning and the creation of distributed learning networks like the Intergovernmental Panel on Climate Change (Norgaard & Baer, 2005a). Maintaining resilience in SES requires a delicate balancing of diversity and redundancy to take advantage of all their benefits while reducing the possibilities of their limitations (Biggs et al. 2012).

2.9.2 Principle 2: Manage Connectivity

Connectivity refers to the nature and strength with which actors, species or resources in a system migrate, link, spread or interact across habitats, patches, or social domains in a social-ecological system (Bodin & Prell, 2011). A good example would be patches of forests that are connected to form a landscape: the strength of the linkages of the forest patches determines the ease or difficulty that an organism would experience in moving from one patch to another. From a social perspective, connectivity is the composition, depth and strength of the networks that connect individual actors within a system (Bodin & Prell, 2011).

Connectivity in SES enhances resilience in several ways. It promotes the possession and dissemination of important information and material needed for the effective functioning of ecological and social processes. In addition, it influences the speed and way disturbances spread and in which recovery is achieved after a disturbance (Bodin & Crona, 2009; Elmqvist et al., 2003). For example, it has been found that coral reef recovery after a disturbance is directly correlated with the degree of connectivity between remnant patches (Mumby & Hastings, 2007). In social systems, connectivity improves commitment and collaboration in the governance process by facilitating information sharing that in turn, increases the trust and cooperation that are necessary for collective action (Bodin & Crona, 2009; Brondizio, Ostrom & Young, 2009).

A number of studies support the general hypothesis that the more the existence of connections between individuals or actors (network density), the more the potential for collaborative actions, better information sharing, increased mutual trust, exposure to new insights and the development of common resource governance regulations (e.g. Bodin & Crona, 2009; Janssen et al., 2007; Pretty & Ward, 2001). An empirical study by Sandstrom, 2008 demonstrates the impact of network density on collective action of resource managers in northern Sweden, highlighting the importance of social ties between different kinds of actors in a network (e.g. between governmental officials and local fishermen).

In ecological systems, connectivity enhances the resilience of population species. Many organisms move between habitats for a variety of reasons ranging from seasonal breeding migrations, to a desire for more favourable environmental conditions (Mumby & Hastings, 2008). Other reasons include the search for different food sources as the organism grows, as well as the search for habitats that offer the highest survival of offspring during reproduction (de la Moriniere et al., 2003). The features and layout of physical landscapes and habitats are important in this regards, as they can either assist or restrain the movement of organisms between habitats (Tischendorf & Fahrig 2000; Thrush et al., 2006), hence the presence of well-connected corridors between landscapes is an important factor for species population viability (e.g., Beier & Noss, 1998; Gilpin & Soule, 1986; Meffe & Carroll, 1997).

Research indicates that putting connectivity into operation in real life is challenging; however, Biggs et al. (2012) propose some guidelines for operationalizing connectivity in ecosystem management. The most important step is to have a connectivity chart that identifies the important parts of the system, as well as the structure, scale and strength of their interactions and connections. It is also important to establish the central nodes in the network or the remote patches in the landscape, in order to improve, restore or change the connectivity patterns of the system. Biggs et al. (2012), however, identifies the challenge of identifying and measuring connectivity, due to the variety of measuring indices, difficulty in identifying network boundaries, and the irregular and changing nature of connectivity (Bodin & Crona, 2009). Knowing how networks change over time however, can provide important insights on how to take advantage of emerging and changing network ties.

2.9.3 Principle 3: Manage Slow Variables and Feedbacks

Social-ecological systems are configured at multiple dynamic space and timescales, with system variables connecting and interacting with one another on different levels on a range of timescales (Gunderson & Holling, 2002). Events happening at one scale are able to affect or influence events at other scales (Resilience Alliance, 2010), and over time, these events or variables cause fast and/or unanticipated changes as well as slow and/or predictable changes. In many instances, the slow variables create conditions that the fast variables respond to (Gunderson & Holling, 2002; Resilience Alliance, 2010).

In the social realm, traditions, values, culture and legal systems can also be important slow variables that can affect ecosystem services over time (Abel, Cumming, & Anderies, 2006). Abel et al. (2006)'s study in Zimbabwe show how resilience was enhanced by changes in wildlife legislation and related policies, during a period of severe drought. Changes that occur in ecosystems (social or ecological) are also influenced by the level of spatial and temporal scale, with larger systems generally likely to change more slowly and less frequently (e.g., the water color of an ocean with coral reefs or the culture of a community), than smaller systems (e.g., individual corals or small patches) which are likely to change more rapidly and frequently relative to the larger ecosystem (Resilience Alliance, 2010).

SES are complex adaptive self-organizing systems that are capable of adjusting and reorganizing in response to disturbances and change, and in order to adjust successfully, SES respond to the feedback that they receive from the environment (Biggs et al., 2012). When a system responds appropriate and timely, this can prevent it from crossing critical thresholds or making unwanted

regime shifts (Scheffer et al., 2009; Young, 2010). Feedbacks are the way the system responds to stimuli that can either strengthen (positive feedback) or dampen (negative feedback) subsequent similar changes or stimuli (Biggs et al., 2012). They affect how swiftly and strongly the impacts of change in one part of the system will impact the other parts (Beilin et al., 2013). When there are changes in slow variables in a system, and the corresponding feedback are not responded to, such changes could exceed certain thresholds which could lead to considerable, persistent and often sudden regime shifts, with significant impacts on the ES produced by the SES, and a weakening of the resilience of the system (Scheffer, 2009).

Hence, feedbacks that result in beneficial system relationships should be strengthened and slow variables should be regularly checked for their nearness to critical thresholds (Scheffer et al., 2009; Young, 2010). Feedbacks in governance system can also be reinforced to build up resilience by developing structures and interventions that are capable of actions that encourage and even provide incentives for valuable feedback (Steneck et al., 2009), and that can effectively respond to the data received from monitoring slow variables. A combination of these actions would enhance resilience (Biggs et al., 2012).

Despite the importance and significance of managing slow variables and feedbacks for the resilience of SES, it is quite challenging to implement them in practice. Managers often hardly focus on monitoring slow variables, which are often difficult to detect and predict, preferring instead to focus on fast variables that are easier to observe. Also, there is the challenge of identifying the critical threshold limit points that if crossed, could lead to a new regime or a reconfiguration of the system (Biggs et al., 2012). Once these challenges have been tackled, the task of managing slow variables and feedbacks becomes easier.

Biggs et al. (2012) recommend certain guidelines that can be applied in managing slow variables and feedbacks. They suggest that when feedbacks have been identified, it is important to avoid activities that can mask or interfere with them and to continually monitor them (Biggs et al., 2012). In addition, establishing management and governing structures that understand the role of slow variables and that can collect and respond to monitoring information is equally critical (Biggs & Rogers, 2003).

2.9.4 Principle 4: Foster an Understanding of Social-Ecological Systems (SES) as Complex Adaptive Systems (CAS).

The understanding of complex adaptive systems (CAS) is the view that systems like SES, and the interactions within them, are generally unpredictable, uncontrollable, complex, uncertain and nonlinear (Levin et al., 2012). Hence, rather than viewing ecological and social systems separately, CAS thinking not only acknowledges that the two systems are interconnected, but also considers them as a coupled social-ecological system (SES). In SES, the ecological and social domains are so intimately linked that occurrences in one domain impacts, and are impacted by, occurrences in the other domain (Folke et al., 2005). This interconnectedness of the two domains renders any demarcation between them arbitrary but instead, sees them as one co-evolving system (Berkes & Folke, 1998; Folke et al., 2005; Levin et al., 2012).

Hence, social-ecological systems are regarded as complex adaptive systems (CAS) that have a multitude of perspectives, are highly unpredictable, with high levels of uncertainty in the

interactions of the different components of, and actors in the system (Levin, 1998). Much of this uncertainty is due to the fact that in responding to situations across different scales and organization levels, humans are generally uncertain of what might happen next, as well as the consequences of their responses. Surprise therefore seems to be the norm in such systems and the responses are mostly experimental (Behensky & Lynam, 2005).

Hence, managing such systems cannot be effective with a one size fits all mindset, governance structure or approach. Instead, such systems require an understanding of how different actors within the system think, and how their way of thinking affects or influences their decisions and actions (Stockholm Resilience, 2015). It involves a deep understanding and insight into how different stakeholders perceive the system, how they understand the system, how the system is managed and governed, and how they react to disturbances and changes within the system (Stockholm Resilience, 2015).

Biggs et al (2012) outlined some guidelines for cultivating and applying CAS thinking in the management of ecosystems. The first and most important step is to adopt and implement systems thinking that focuses on understanding the interactions, inter-dependencies and relationships between humans and the environment. The next step is to anticipate likely changes that could occur in the system, probably using scenario planning, and then based on the scenarios developed, to evaluate the intentional and unintentional outcomes of different decisions that could be taken in the different situations, as well as likely trade-offs that may have to be made (Biggs et al., 2012, Stockholm Resilience, 2015). Employing a participatory method in this process, by involving different key stakeholders and interest groups, will produce optimal results.

In order to foster CAS thinking, some restructuring of responsibilities may be necessary to allow the development of the right proficiencies and expertise that would enable a shift from the traditional resource management mindset to a more integrated CAS management mindset (Biggs et al., 2012). This restructuring would also combat the expected resistance and barriers to change, especially from those who fear that a CAS thinking and a more integrated system might compromise their position and interests (Biggs et al., 2012, Stockholm Resilience, 2015). Developing knowledge and understanding of SES dynamics enhances the ability to monitor, detect, translate and respond to environmental feedback in a way that enhances resilience (Folke et al., 2005).

2.9.5 Principle 5: Encourage Learning and Experimentation

Social-ecological systems are complex and dynamic, always developing and changing, and building resilience involves dealing with, adapting to, and transforming in the face of these surprises and changes. Hence, there is a constant need to stay abreast not only about current and ongoing events, but also about likely future events as well (Biggs et al., 2012). This is usually accomplished through processes that generate knowledge, experience and meaning that can be practical in responding to environmental disturbances and change (Folke et al., 2005).

Learning and experimentation in SES seeks to overcome the limitations of the conventional command-and-control management approach by endeavoring to record and learn from both expected occurrences and unexpected environmental surprises (Fernandez-Gimenez et al.,

2008). In the resilience literature, learning involves continuously updating existing knowledge and experimenting with new knowledge, information, skills and values in order to adapt to deal more effectively with changes and disturbances (Gunderson & Holling, 2002; Olsson, Folke, & Berkes, 2004; Walker & Salt, 2012). In order to build and enhance the resilience of SES, discovering, testing and appraising alternative theories of how the system works, alternative management approaches, and alternative solutions to problems, are critical tasks. It is also crucial to share knowledge across scales and amongst different actors in the system, from community members to policy makers. This process of sharing knowledge and reflecting on experiences actually leads to increased trust, better governance processes, greater collective action, enhanced cooperation, development of valuable social norms and ultimately enhanced resilience (Armitage et al., 2007; Biggs et al., 2012; Olsson et al., 2004; Stockholm Resilience, 2015).

Experimentation in SES is a risky process, and to be effective, requires ample resources, strong leadership, and trust because experimentation implemented without these core requirements could lead to ill-fitting solutions and decisions (Olsson et al., 2004) that would undermine resilience. Experimentation involves research, investigation, testing and monitoring, all of which are broadly used techniques that facilitate learning in natural resource management. In monitoring, information about ongoing changes is obtained and in research, testing, investigation and active manipulation of particular SES processes and structures are performed in order to observe and compare end results (Walters & Holling, 1990).

It is important to stress that learning and experimentation should not be limited to scientists, researchers or specialist groups in the society. There is a growing recognition of the significance of including a more collaborative, wide ranging, and broader participation, combining different knowledge processes and learning environments. This involves including different groups in society in the learning and experimentation process to enhance the capacity for dealing with complexities and uncertainties (Armitage et al., 2007; Biggs et al., 2012; Danielsen, Burgess, & Balmford, 2005; Ludwig, Mandel & Haddad, 2001). For example, by combining the scientific knowledge about the dynamic interactions between freshwater and forest ecosystems with their traditional knowledge system, a community in Ecuador were able to change their unsustainable forest management practices and improve the resilience of their moist forest commons (Becker & Ghimire, 2003).

Biggs et al. (2012) propose certain guidelines for fostering learning and experimentation in SES. A major key is to design a learning process and provide opportunities and context for different stakeholders to interact and engage in order to share knowledge. This might even involve creating communities of practice and ensure that there are adequate resources to enable an effective learning process. Resource managers should be mindful of power dynamics in the learning process, which is capable of stalling or disrupting the learning process. Greater attention to local and traditional knowledges will be beneficial for learning, experimentation and thereby resilience (Myers et al., 1997).

Social learning and experimentation are important elements that enhance the adaptability and responsiveness of social–ecological systems, enabling them to better deal with and adapt to disturbances, stress and surprises, without changing their fundamental structure, thus leading to more resilient social–ecological systems (Berkes & Folke, 1998).

2.9.6 Principle 6: Broaden Participation

In recent years, there has been a global trend towards increasing public involvement and engagement in the management, policy formulation and decision-making activities of governments, organizations and institutions - a concept commonly referred to as public participation (Folke et al., 2005). Participation is the process of actively involving and engaging relevant stakeholders in the different stages of managing and governing SES (Biggs et al., 2012; Rowe & Frewer, 2005). This kind of stakeholder involvement is important for the collective action required to assemble the information and perspectives required to manage SES in order to appropriately respond to the disturbances and complexities involved (Colfer, 2010; Lebel et al., 2004). Several researchers propose that the participation of different stakeholders in the various stages of SES management promotes understanding and cooperation, improves legitimacy, uncovers various perspectives, facilitates knowledge sharing, aids collective action and improves the capacity to detect and resolve disturbances, all of which contribute to resilience (Biggs et al., 2012; Folke et al., 2005; Ostrom, 1990).

Participation may occur in certain, or all, stages of the management and decision-making process. It may also occur at various levels, ranging from simply informing stakeholders of decisions already taken, to soliciting stakeholder opinion through questionnaires, to involving them in an advisory committee, and to a complete delegation of power to them (Rowe & Frewer, 2005). The potential of a broadened participation of local and scientific knowledge to build trust that results in better shared understanding and collective action is aptly exemplified in the case of the Great Barrier Reef in Australia (Olsson et al., 2008), where the initiation of extensive public participation helped raise awareness and public support which eventually aided a resolution to the environmental threats to the Great Barrier Reef (Olsson et al., 2008).

Rowe and Frewer (2005) propose three labels to describe different forms of public participation, following the flow of information between stakeholders and sponsors. The three labels are public communication, public consultation, and public participation, which are all generally referred to as public engagement.

In public communication, information moves in one direction from the authorities (usually, but not always, a governmental or regulatory organization) to the public or to the public representatives, and public feedback is neither required nor explicitly sought (Rowe & Frewer, 2005). Some mechanisms used for public communication include television, drop in centers, information broadcasts, internet information and hotlines (Rowe & Frewer, 2005). In public consultation, however, the authorities initiate an informal process to elicit and receive information, opinions and viewpoints from members of the public, hence there is some flow of information from the public to the authorities and there are mechanisms to deal with the information received. Some mechanisms for public consultation include opinion polls, surveys, and community meetings (Rowe & Frewer, 2005). In public participation, there is usually a dialogue and exchange of information between members of the public and the authorities, usually in a group setting, involving representatives of both parties in different proportions (depending on the type and objective of the engagement). Hence, there is an active two-way flow of information in public participation. Some mechanisms for public participation include community meetings with voting, focus groups, and citizen panels.

To develop and implement a successful participation process, it is important to clarify the goals, objectives and expectations of the participation process, as a clear knowledge of the goals and expectations will ensure that the participation process achieves its objectives. It is also important to get adequate resources, the right people involved in the process, and have set processes to deal with power issues and potential conflicts that may arise (Biggs et al., 2012).

2.9.7 Principle 7: Promote Polycentric Governance Systems

Practical and research experience indicate that the acknowledgement and successful utilization of cross-scale opportunities have been very instrumental in improving human and organizational well-being (e.g. Folke et al., 2002; Gunderson & Holling, 2002; Lansing, 2009; Ostrom et al. 2002). In this view, environmental issues need to be simultaneously dealt with at several levels, with authority and decision-making power redistributed to all the levels (Cash et al., 2006). Management, governance authority and decision-making responsibility should therefore be shared across a hierarchy of governance organizations and institutions, to match the complex nature of the environmental issues (Folke et al., 2007).

In response to ongoing challenges in managing natural resources, and to incorporate cross-scale into the response to environmental issues, Andersson and Ostrom (2008) propose a polycentric view that considers the relationships among several governance units with overlapping areas of responsibilities and authorities. Each unit has the independence to establish, alter and enforce rules in a prescribed domain of authority within a specified geographical location, and may link with other units, locations or domains, depending on the scale of the problem (Folke et al., 2007; Ostrom, 2005). Polycentricity is an adaptive governance system without a single central authority dominating the lower authorities with regard to all policy arenas. Instead, the polycentric governance system usually has a range of governing bodies interacting at differing levels in order to develop and implement policies, rules and regulations within the system (Andersson & Ostrom, 2008; Ostrom, 2005).

In polycentric governance structures, decision making power and responsibility are shared among different government agencies, communities, user groups, and non-governmental organizations, drawing on various sources of knowledge and information, guided by a shared vision (Olson et al., 2004; Shannon & Antypas, 1997). Polycentric, or cross-level or cross-scale interactions occur when there is vertical interaction between or among different level regimes on the jurisdictional scale or management systems at adjacent levels or even between local level traditional practices and global regimes (Young, 2006). In recent years, the concept of polycentricity has gained traction as a theoretical construct utilizing multi-scale and multi-stakeholder as a viable water resource governance system (e.g. Molle et al., 2007; O'Toole et al., 2009).

This ability of polycentric governance structures to match governance levels to the scale of the problem is what makes it unique (Folke et al., 2007). Additionally, higher levels of governance can intervene when lower levels collapse or fail, and vice versa when higher level efforts prove ineffective (Biggs et al., 2012; Nagle & Ruhl, 2002; Rohlf, 1991). Polycentric systems also provide opportunities for broader participation, testing different policies and enhanced learning and experimentation (Biggs et al., 2012; Brondizio et al., 2009).

Several studies have highlighted various advantages of the polycentric governance structure including improved access to local knowledge, better capacity to review and capture performance feedback on decisions in a disaggregated way, establishment of new opportunities for multiple actors at different scales and levels to be accountable and responsible, and increased redundancy in governance (e.g. Anderson & Ostrom, 2008; Carlisle & Gruby, 2017; Jordan et al., 2015; Low et al., 2003; Marshall, 2005, 2008; Nagle & Ruhl, 2002; Neef, 2009; Nelson et al., 2008; Olsson et al., 2004; Ostrom, 1996, 2005, 2010). Implementing polycentric structures, while guaranteeing more sustainable use of water resources, continue to remain a challenge (Andersson & Ostrom, 2008; Neef, 2009, O'Toole et al, 2009; Shering, 2009).

Polycentric structures can be weakened in the face of tensions between actors and negative institutional interactions during decision-making, the costs of having multiple governance bodies and interests, handling trade-offs between various stakeholders, and dealing with political conflict caused by bias and competing interests of different stakeholder groups (Adger et al. 2005; Lebel et al. 2005; Neef, 2009, O'Toole et al, 2009; Ostrom, 2005; Shering, 2009). Despite these challenges, polycentricity still holds the potential for experimentation with new governance guidelines and provides opportunities to combine expert and traditional knowledge in governing and managing natural resource, which creates opportunities for more non-state actors to maneuver and participate (Blomquist & Schlager, 2005; Molle et al., 2007; Ostrom, 2005; Rhodes, 1997). As these are congruent with the other resilience principles, polycentric governance may actually be an essential ingredient for enhancing the resilience of SES.

2.9.8 Summary of the Resilience Principles

A review of the seven resilience principles shows a high level of interdependence among them, because the application of any principle independently of the others will rarely build or enhance resilience. For instance, effective participation is required for learning and polycentric governance to be effective, while effective learning, polycentric governance, diversity and redundancy, all rely on the relationship and trust developed through participation (Biggs et al., 2012). Some caveats and challenges need to be emphasized with respect to the seven principles outlined above, as well as to other resilience principles that have been proposed by other researchers for assessing or developing resilience (e.g. Biggs et al., 2015, Clarvis et al., 2015; Ostrom 2007, Pahl-Wostl et al., 2010; Walker et al., 2004).

These principles should not be viewed as a destination or an end, or as predictive models that provide universal solutions to implement and enhance resilience. Rather, they should be used as tools and techniques for generating or assessing conditions that allow for resilience building in complex social-ecological systems (Biggs et al., 2012; Folke, 2016; Walker et al., 2004). Beyond this, it is necessary to acknowledge the challenge of measuring or assessing certain principles like 'learning and experimentation' (Muro & Jeffrey, 2008; Rodina 2018a), as well as the concern of entrenching or exacerbating existing inequalities when applying or assessing these principles (Biggs et al., 2015).

2.10 References

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3 Chapter Three: Method Development for Measuring Individual Endorsement for Water Resilience Principles

The purpose of this chapter is threefold. First is a brief description of the current water related challenges facing the world and the potential of a water resilience approach as a possible solution to these challenges. In this regard, the importance of individual endorsement of the water resilience approach is discussed. Second is to describe the process of developing a methodology and a data collection instrument for determining and measuring individual endorsement of the principles of water resilience. Third is a discussion of the pilot process to test the data collection instrument and methodology developed to measure individual endorsement of the resilience principles.

3.0 Introduction

There is an ongoing world-wide water crisis, evidenced by many challenges being experienced by freshwater resources globally (IPCC, 2018; Steffen et. al, 2011; Vörösmarty et. al, 2013). Several studies clearly indicate that freshwater resources may be unable to meet the increasing water demands and the continued production of critical ecosystem services that all humanity depends on (Baker, 2009; Rockstrom et al., 2014; Vörösmarty et. al, 2013). There have been indications that the core of this global water crisis is largely related to the limitations of the conservative command-and-control water governing approach being used to govern water resources (United Nations World Water Assessment Programme, 2003). This approach utilizes an inflexible bureaucratic governance style, which does not address potential water challenging issues until they become critical (Cox, 2006; Holling & Meffe, 1996; Resilience Alliance, 2010).

In contrast, utilizing a social ecological governance approach that recognizes the constantly changing interactions between the ecological and social domains of freshwater systems would produce better results. This governance approach recognizes the possibility of uncertainty and changes, and thus, is flexible enough to adequately address these challenges when they arise (Resilience Alliance, 2010; Rockstrom et al., 2014). This consideration of the interactions of the social and ecological aspects of water governance increases the awareness of potential changes and the readiness to adapt successfully to changes. Hence, applying a social ecological concept to the management and governance of water resources will more adequately address water challenges better than a command and control governance method (Rodina 2018b; Shin et al., 2018).

Individual agency is an important consideration for successfully implementing a social-ecological resilience-based approach to managing freshwater resources because of the power of individuals in society to affect the outcome of policy implementation. Individuals have the power to affect the successful implementation of government policies through their support and approval of policies and initiatives (Lubell, 2017; Khoury, 2015; Osterblom & Folke, 2013). It is also expected that individuals who endorse water resilience can be reasonably expected to accept and support policies based on water resilience principles and, in some cases, advocate for them. Hence, the knowledge and understanding of the extent to which individuals in society are willing to endorse or support resilience-based governance policies can be valuable to policy planners in formulating policies and developing messaging that align with the perspectives of individuals in

society, and which they will support and promote (Dale, 2013; Johannessen & Wamsler, 2017; Lubell, 2017; Khoury, 2015; Osterblom & Folke, 2013).

Nevertheless, though water resilience research has paid considerable attention to water systems analyses in large communities, watersheds, provinces, regions, countries, continents, and the planet (e.g. Baird et al., 2016a; Schuetze & Chelleri, 2013), an equivalent amount of attention has not been given to the role of individual actors with respect to water resilience and its principles.

It is therefore important to consider the level of individual endorsement for the principles that underly a water resilience governance approach, as this is likely to affect its successful implementation in society (Bennett, 2016; Curado et al., 2013). Ultimately, being able to understand how individuals in society endorse (i.e., agree with and support) water resilience and its principles can offer valuable insights to policy makers and government agencies on how to formulate policies that align with societal perceptions, build public support and thus enhance the successful implementation the policies and governance approach (Cleaver, 2007). However, the empirical determination of individual endorsement of water resilience has not received much attention in the literature.

3.1 The Challenge of Measuring Resilience

It is challenging to measure, predict or translate resilience into practical natural resource management (Baird et al., 2016b; Olsson et al., 2015; Welsh, 2013; White & O'Hare, 2014), and this trend has led to growing calls for empirical studies that translate the resilience concept into definite measurable and practical uses in policy and practice (Kythreotis & Bristow, 2016; Welsh, 2014). It is also difficult to determine and measure the level of support of individuals in society for the resilience concept (Benson & Garmestani, 2011; Karssenberg et al., 2017; Miller et al., 2010; Walker & Salt, 2012). Without a clear explanation of how resilience impacts water governance and the level of acceptance it has, especially in society, it would be challenging to implement resilience as a management objective able to transform water management and governance practices (Benson 2009; Benson & Garmestani 2011; Ruhl & Fischman, 2010).

Several studies have proposed general guidelines to address the challenge of successfully measuring and implementing resilience (e.g., Anderies et al., 2013; Baird et al., 2016b; Biggs et al., 2012; Folke et al., 2003; Plummer et al., 2014; Tyler & Moench, 2012; Walker & Salt, 2012). Biggs et al. (2012), proposed seven principles, whose presence in a social ecological system reflects the level of resilience of that system. The seven resilience principles include three principles focused mainly on generic SES ecological and social properties (P1: Maintain Diversity and Redundancy, P2: Manage Connectivity, P3: Manage Slow Variables and Feedbacks), and four principles related to key properties of social-ecological systems governance (P4: Foster an Understanding of Social-Ecological Systems as Complex Adaptive Systems, P5: Encourage Learning and Experimentation, P6: Broaden Participation, and P7: Promote Polycentric Governance Systems).

As these principles indicate resilience in SES, a considerable endorsement for them would indicate a considerable support for a water resilience governance approach. Hence, an understanding of how individuals in society endorse these principles would enable water

managers and policy planners identify and be able to focus on components of the governance approach and of the system that can better enhance resilience (Biggs et al., 2012; Folke, 2016). It is therefore necessary to develop an appropriate methodology to determine the level of endorsement that individuals in society have for the resilience principles.

The purpose of this study was to develop a data collection instrument and a methodology to determine and measure individual endorsement levels for resilience principles, with a focus on water resources. Due to the complex nature of the resilience concept, an appropriate instrument and methodology that can capture this complexity in a simplified relatable form within specific contexts, is necessary. In this regard, some potential methodologies including the adaptive staircase method (Cornsweet, 1962; Mangham et al., 2008), the conjoint analysis approach (Moore, 2004; Smith & Fennessy, 2011) and a traditional multiple-choice questionnaire method used in a related earlier study (Baird et al., in press) were considered and reviewed. However, a vignette survey was the best suited of the options reviewed because it was the method that was able to conceptualize the principles in the most simplified way within a context. It is important to note that an exhaustive review of the different approaches was not done; rather the focus was on finding a suitable approach for this study.

3.2 The Suitability of the Vignette Approach to Measure Individual Resilience Endorsement

Vignettes are short scenarios, illustrations or brief stories that describe hypothetical or real situations of concepts in specified contexts. They may be written, spoken, in visual images, video or audio, and are presented to participants within surveys to elicit their response, reasoning and judgments as it relates to the research interest portrayed in the specific contexts (Encyclopedia of survey research methods, 2008; Finch, 1987; Hughes & Huby, 2004; Martin, 2006). Respondents are usually asked to project themselves into the vignette situation, and/or to perform certain tasks like choosing, ranking, rating, or sorting options, expressing feelings or judgements, and making recommendations (Finch, 1987; West, 1982). Vignettes have a long history in quantitative and qualitative social science research and have been used in research on social judgments (Piaget, 1966), in cross-cultural research (Christopherson, 1998; Soydan, 1995), in service users research (Sim et al., 1998) and in comparative research between professional groups (Wilson & While, 1998).

A quantitative vignette study has two main components: the vignette description, and a traditional questionnaire survey that elicits participants' responses (Atzmuller & Steiner, 2010). The combination of the vignette technique with a traditional survey in quantitative research is a very promising research technique for investigating respondents' beliefs, attitudes, or judgments about a research subject, and its specificity allows for the examination of contextual influences on judgments (Atzmuller & Steiner, 2010; Finch, 1987). Unlike the traditional questionnaire survey or attitude statements that are usually direct, abstract, uninteresting and vague, and seeks responses in a vacuum, vignettes seek responses in a non-directive form, and on a detailed contextualized basis that allows respondents to define and interpret the situations for themselves (Alexander & Becker, 1978; Finch, 1987; West 1982). The direct questioning techniques usually could elicit biased and unreliable self-reports because respondents are required to make judgments that are usually too abstract (Alexander & Becker, 1978). On the other hand, vignettes

explore participants beliefs, judgments, reasoning and preferences with regard to specified contexts, which may be hypothetical or real-life, rather than in a vacuum (Finch, 1987).

Although vignettes have been used for studies related to individual beliefs in the justice system (Alves & Rossi, 1978), individual exploration of public support for welfare (Cook, 1979), and individual beliefs about marriage and divorce (Clark & Samphier, 1984), they have not been used in resilience related research. However, it is possible to utilize vignettes to compute quantitative metrics for determining individual endorsement levels for water resilience principles.

3.3 The Development of the Vignettes

In developing the vignettes for this study, the objective was to present respondents with real water situations in two contexts: (1) challenging water situations in their locality that they might encounter or have encountered or at least have heard about and (2) challenging water situations in another country that they may or may not have heard about. The study aimed to measure how individuals endorse the resilience principles with regards to water resources. The study also aimed to discover whether levels of endorsement differed based on local and non-local water challenging situations.

The data collection instrument was developed as a questionnaire with two sections. The first section of the questionnaire aimed to gather demographic information including age, sex, religious attendance (how often people attended religious services), political ideology (where people stood in terms of their political beliefs), income, the meaning of local water bodies to them, education and length of residency in the community. These demographic variables are similar to those used in an earlier related study (Baird et al., in press) and they were chosen because they have been shown to have the potential to influence pro-environmental behavior in other studies (e.g., Curado et al., 2014; Petrosillo et al., 2007; Tarannum et al., 2018). The second section of the questionnaire comprised of a series of six vignettes, three of which were focused on local water related challenges and the other three were focused on non-local water related challenges. The vignettes were based on real life case studies and were written in a detailed paragraph in a style that was intended to be interesting and relatable.

Each vignette was followed by a series of ten multiple-choice questions based on the seven resilience principles. Six questions were based on resilience Principles One to Three (one ecological and one social question for each principle), and the remaining four questions were based on Principles Four to Seven each. Having six vignettes that describe different freshwater related challenges, resulting in three responses per principle for each vignette category (local and non-local) produced a robust set of data with better accuracy, which is important for such an exploratory study. Ensuring that the variety of vignettes cover a range of freshwater related challenges that would resonate with different demographics in the community ensured that the resulting endorsement scores could be applied to different water related situations and also could be generalized to the case community.

The ten multiple choice questions and options were designed to practically describe and illustrate the resilience principles in relation to the particular vignette situations. This way, respondents can interpret the questions in the context given rather than simply answering a direct abstract

question. In this study, participants were encouraged to respond from their own personal viewpoints, although vignettes may also require that participants respond from the point of view of their peers, the vignette characters, or people in general (Constant et al., 1995; Hughes & Huby, 2004). The ten multiple choice questions were followed by four action statements that represented four levels of endorsement intensity for each resilience principle. Participants were asked to select all the action statements they agreed with, and thereafter participants ranked their selections in the order of preference, with their most preferred action ranked first.

To ensure consistency with the data collected, the four levels were rated on a scale of 1 to 4 as follows: 1) No endorsement of the principle; 2) endorsement of a 'low level' of the principle; 3) endorsement of a 'medium level' of the principle; and 4) endorsement of a 'high level'. The most preferred action statement option selected by participants for each principle was used to determine their endorsement score for each principle. For example, if a respondent ranks action statement 4 as their most preferred option for a principle, then their endorsement score for that principle would be determined to be at a level 4 (high endorsement). To avoid bias and easy identification of patterns by respondents, the four options were randomized for each question in the questionnaire. In addition, care was also taken to use neutral, easily understood vocabulary in order not to influence respondents' answers and to ensure understanding.

The determination of the ranking categories representing appropriate expressions of the resilience principles in different levels of intensities was guided by a review of empirical and theoretical frameworks from the resilience literature. Some criteria were established to guide the determination of the endorsement levels (Appendix A.3.1) and was directed at challenges related to 'water on the landscape' that is, water issues caused by weather events, source supply problems, erosion problems, lack of availability for use and environmental flows. Water issues that were mainly infrastructure based as well as municipal drinking water supply structural issues were excluded.

In designing and developing vignettes, it is important to consider their relevance to the research topic (Gould, 1996; Hughes & Huby, 2004). Hence, the researcher should consider existing literature or suitable case study materials to develop the scenarios. For this study, the vignettes, accompanying questions and ranking options were validated by three independent resilience scholars who are knowledgeable about the resilience concept and the principles. They provided feedback which was incorporated in the design of the questionnaire, and they confirmed that the ranking options reflected a progression of intensity for the seven resilience principles as described.

3.4 The Pilot Testing Process

The pilot testing involved four stages: (1) online pilot testing of the questionnaire (2) adjustments of the questionnaire based on the outcome of the pilot study (3) a second pilot test of the questionnaire including a semi structured 15-minutes interview with five respondents from the Town of Lincoln, Ontario (4) further adjustments of the questionnaire based on the outcome of the second pilot study.

In preparation for the pilot tests, the six vignettes were paired in various combinations (one local and one non-local vignette), and this resulted in nine pairs of vignettes (Appendix A.3.2). An

online pilot test was conducted with a convenience sample of eleven pilot participants who were recruited from within the network of the researcher. Each participant was presented with a different pair of vignettes (one local and one non-local) and asked to complete the questionnaire. The aim of the pilot test was to assess of the length and language of the questionnaire as well as the ease of understanding the vignettes and selecting/ranking the options. Open ended questions soliciting additional comments from the participants were also included. Participants completed a consent form before being allowed to participate in the study (Appendix A.3.3) and no compensation was offered to participants.

The pilot test identified some issues. First, respondents specified that fifteen minutes, which was the time determined to complete the questionnaire and provide additional comments, was not adequate. Second, respondents asked for clarification and simplification of some terms used. Third, they highlighted the importance of including a back button to allow respondents go back to previous questions if they wanted. Fourth, respondents wanted more clarity in the instructions and requirements for completing the questionnaire. Fifth, and on a more positive note, respondents found the vignettes interesting and relatable and found the language easy to understand. Generally, vignettes are usually more effective and cause less fatigue when they occupy participants' interest, are relatable and relevant (Hughes & Huby, 2004).

The Lincoln pilot test was conducted in person with five randomly selected participants across a range of demographics in the town. The participants included residents in the town, as well as people who were familiar with the town's water policies and programs to ensure that the vignettes and questions were realistic and relatable. Participants completed the online questionnaire and were invited to participate in a short fifteen minute recorded semi structured interview that discussed their experiences in completing the questionnaire. A semi structured interview guide (Appendix A.3.4) was ideal as it typically yields very detailed information and allows the researcher to deeply probe in order to get more clarified responses and additional insights (Gillham, 2010). Participants also completed a consent form before being allowed to participate in the study (Appendix A.3.5) and were compensated with a \$20 Tim Hortons gift card.

The interview questions probed for a deeper understanding of participants' experience in completing the questionnaire, their understanding of the options provided and any difference in perspectives between the Lincoln and non-Lincoln vignettes. Such probing techniques have been very useful to critically evaluate question meaning during pilot tests for surveys (e.g. Belson, 1981; Cantril & Fried, 1994; DeMaio & Rothgeb, 1996; Oksenberg et al., 1991). Research shows that making important revisions to survey questions in order to correct problems revealed by pretesting is very effective in reducing misreporting (Fowler, 1992). However, it is important to ensure that such interviews are short, so respondents do not become fatigued by continuous probing questions to which the answers almost always become mechanical. The pre-testing yielded information and feedback for revisions to improve the questionnaire, and the semi structured interviews proved useful in understanding respondents' reasoning and interpretation of the vignettes.

Table 3.1 presents six themes that emerged from the interviews and how participants described their experience in completing the questionnaire.

Table 3.1 Common observations as described by interviewed pilot participants (n=5).

Themes	Common Observations
Interest and how vignettes and options reflect reality	Thought provoking Interesting Showed different options for water challenges Closely related and applicable to reality in Lincoln
Length of questionnaire	Not too long, not too short Attention grabbing; Engaging
Language and instructions	Easy to understand Technical knowledge not required Clear instructions
Experience of choosing options and ranking	Almost similar options that require some thought A good exercise – prompted deep thought Different perspectives; depends on experience
Difference in perception for local and non-local vignettes	Same perception, similar water issues Most appropriate options selected despite local or non-local Easier to answer the non-local questions as it was impersonal
How the vignette approach influenced answers	More in-depth answers rather than ‘Yes’ or ‘No’ A different questionnaire experience with context

With regards to the interest of the vignettes and how the options reflected reality in Lincoln, participants felt the options were closely related to what would actually happen in the town in the context of the vignettes.

One participant commented:

You have obviously done a lot of research. These options clearly reflect the actions that would happen in the town for this issue.

Another participant also commented:

It was very thought provoking, and it was nice to see some of the different options, because there were some options that I never even thought of when reading the questions.

With respect to the experience of choosing and ranking options, respondents liked the idea of being able to pick multiple actions and then choose the one they preferred the most.

A participant noted:

I would like to pick all options, but being able to rank it indicates that although I would like the best action, if that would not be possible due to money or commitment or resources, then I would like to see the next level action, etc. It gives an opportunity to see different people's perspectives.

Another participant noted:

I like the ranking, because there's different ways to approach things and all the options can be considered, its just how you rank them. Its not a black or white situation. It makes people think of it more and consider the different options.

With respect to how their perceptions differed for the local and non-local vignettes, respondents think they had similar perceptions regarding both local and non-local, though they admitted to a better understanding of how implementation could happen in Lincoln because they lived and/or worked there.

A participant commented:

My perceptions of the local and non-local issues were not very different. However, because I work in the Town of Lincoln, I can more clearly understand the issues, and in selecting the options, I can more clearly visualize what that would look like in practice as opposed to my priorities. If I think strong action should be taken in Lincoln, I also think strong actions should be taken in India.

Another participant said:

In answering the non-Lincoln questions, it was more theoretical, so it was easier for me to answer. For the Lincoln area, because I am so familiar with it, I was thinking more deeply about the options, so it was a little harder because my mind had more facts..... that was the difference.

With respect to how their answers were influenced by the vignette approach, participants felt that the vignette questionnaire was different and helped them to conceptualize the events and their responses.

One respondent commented:

Different people have different perceptions of what 'more' means. If you had the question more directly not related to a particular event, people would be able to give their answers more easily. But that would also depend on the details in the questions being asked. But I liked the ranking because I could rank the actions that I want to see. I think this is a really good way to contextualize problem solving and decision making.

Based on the feedback from the second pilot study, the questionnaire was further revised and then finalized (Appendix A.3.6). Overall, the results of the pilot study indicated considerable endorsement of the resilience principles.

3.5 Exploratory Factor Analysis (Principal Component Analysis)

The finalized questionnaire was utilized in a research study in the Town of Lincoln, Ontario to measure how individuals endorse the water resilience principles, with a sample size of 215 (See Chapter Four of this thesis for details of the study). A reliability analysis was carried out on a 7-item resilience endorsement scale for the seven resilience principles. The Cronbach's alpha showed the questionnaire to reach acceptable reliability, $\alpha = .795$. All items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted.

The overall endorsement scores of the resilience principles from the Lincoln research study were subjected to an exploratory factor analysis (PCA) with Kaiser normalization and Varimax rotation to estimate factor loadings. It is assumed that the resilience principles have set of *underlying* factors that can explain the interrelationships among the principles. Biggs et al (2012) have categorized the resilience principles into two categories (P1 to P3 as focused on the ecological and social components of SES, while P5 to P7 are focused on the governance aspects of SES) The factor analysis seeks to determine if the practical categorization of the resilience principles would align with Biggs et al. (2012)'s categorization.

Two distinct factors emerged from the exploratory factor analysis, and the Bartlett's test of sphericity reached statistical significance. The PCA revealed the presence of two factors explaining 62.09% of the total variance, with eigenvalues greater than 1.0. Factor 1 explained 46.64% of the total variance, compared to 15.45% for the second factor extracted. Four principles loaded on the first factor (P1 to P4) and three principles loaded on the second factor (P5 to P7). Cronbach's alpha for Factors 1 and 2 were 0.794 and 0.661 respectively (Table 3.2).

Table 3.2: Factor loadings for the exploratory factor analyses

Aggregated Resilience Principles		
Principle	Factor 1	Factor 2
Maintain Diversity & Redundancy (P1)	.802	
Manage Connectivity (P2)	.818	
Manage Slow Var & Feedbacks (P3)	.851	
Foster Complex Adapt. Systems Thinking (P4)	.572	
Encourage Learning (P5)		.721
Broaden Participation (P6)		.769
Promote Polycentric Governance (P7)		.740

The two factors represent two components of the resilience principles – Factor 1 reflected principles pertaining to the ecological properties and system dynamics of social-ecological systems (P1 to P4) and factor 2 reflected principles pertaining to the governance and social components of social-ecological systems (P5 to P7). A two-level categorization of the resilience

principles agrees with Biggs et al. (2012)'s grouping of the resilience principles. However, though this study differs from Biggs et al (2012)'s in its classification of Principle 4: Foster CAS Thinking, as an ecological/system dynamics principle, it is in agreement with the categorization made by Jentoft et al (2009) of the 'system-to-be-governed' and the 'governance system'. The former refers to everything relating to the dynamic processes and properties of SES, while the later refers to anything relating to the social and political processes of SES (Pahl-Wostl, 2009).

Bigg's et al (2015)'s exposition of P4: Foster CAS Thinking, indicates that the fundamental elemental focus of this principle is the dynamic varied interactions occurring in SES ('the system to be governed') and not primarily the governance of SES. It is the understanding of the 'system dynamics' that fosters a CAS thinking (Levin et al., 2012; Walker et al., 2002). Hence, this feature of P4 that directly focuses on the SES dynamics, an understanding of how 'the system works', qualifies it to be classified in the same group with P1 to P3. In addition, similar to P1 - P3, P4 (unlike P5 to P7) could be viewed as a dual principle, having both an ecological/social perspective (system dynamics) and a governance perspective (applying CAS knowledge to the management of SES). In summary, the similar features of P4 with P1 to P3 (which they do not share with P5 to P7), qualifies P4 to be grouped together with P1 to P3.

Biggs et al (2012)'s initial evaluation of the resilience principles affirmed that their categorization of the principles was not set in stone, as an appropriate combination of the principles may depend on the particular context being considered as well as on how the principles are applied. They also acknowledge that other categorizations of the principles may emerge from further research. However, further research is necessary as these results could be sample specific.

3.6 Discussion and Reflections

3.6.1 Reflections, Challenges and Limitations of the Vignette Methodology

The vignette approach for determining individual resilience endorsement was exploratory and intended to inform its potential as a methodological framework for determining endorsement levels for the resilience principles.

Developing the vignettes involved working across different bodies of scholarship and definitions of concepts especially resilience. It also involved working at the nexus of the social and natural science domains, that is, highlighting both ecological and social water issues and connecting both. This was a challenging but necessary aspect of developing the vignettes and questions, as well as in determining the ranking of the options.

Some challenges were encountered in developing the vignettes, the questions and answer options. First, it was challenging to describe the resilience principles in a particular context with interesting, relatable practical terms using neutral everyday vocabulary, hence there was a lot of iterations to revise language and key terms to avoid bias and make it understandable to individuals without specialized knowledge. Second, some difficulty was experienced in developing robust but short vignettes and question options that address all seven resilience principles using a single vignette in a style that would prevent fatigue and boredom.

The vignettes for the current research study was a continuous narrative vignette and was economical in terms of time as fresh contextual material was not developed for each resilience principle (Hughes, 1998). Though it may have been easier to make the vignettes longer to incorporate more information, it was more practical to have the shorter but more direct continuous narrative vignettes as longer vignettes may cause participants to lose interest over time (Lawrie et al., 1998; Nosanchuk, 1972). Another approach may have been presenting very short vignettes (a couple of sentences) that separately address each of the seven resilience principles. However, with this, respondents may lose attention as they get tired of responding to the short vignettes with changing contexts (Nosanchuk, 1972; Sniderman & Grob, 1996).

In addition, it was difficult to apply the resilience principles to every type of water issue, especially infrastructure-based issues and/or medium to long term construction solutions. The lack of attention to infrastructure is a recognized critique of social ecological resilience scholarship (Hayes et al., 2019; Olsson et al., 2015). In addition, a few principles did not apply in a direct way to some of the vignettes, hence their applications were slightly indirect. For example, in the Lincoln 3 vignette, representing the connectivity principle (P2/Ecological) through irrigation water flows/availability was characterized as more of an infrastructural connectivity, rather than strictly ecological. This challenge would have to be addressed in future research.

Another arduous task was determining the amount of information to include in a vignette and the optimal number of vignettes to present to each respondent to get accurate results (e.g. de Macedo et al., 2015). Though presenting respondents with all the vignettes would have been preferable, however, due to the length of the survey, it was clearly unrealistic as one vignette had ten questions with four options each. In the end, each respondent was presented with two vignettes each, a total of 20 questions with 80 options. West (1982) estimates that respondents can cope with four vignettes before they start to lose interest. However, this also depends on the length of the vignettes, the number of questions and the variables being tested.

The result of this pilot study sets the stage for future studies. As the pilot study indicated that participants had higher endorsement for the principles with regards to the non-local than the local vignettes, it would be necessary to replicate this study in other communities in Canada and around the world to show how the results differ according to the community or country being researched.

3.6.2 Advantages, Disadvantages and Criticisms of Vignettes as a Survey Instrument

The use of a vignette methodology for designing survey questionnaires has some advantages and disadvantages. Some criticisms have also been made concerning the vignette methodology. These will be discussed in this section.

Insights from the pilot study indicated that respondents found the vignettes interesting, relatable and just the right length. Most respondents indicated that the vignettes made them think and reflect more deeply on the water issues, the questions and the options before choosing and ranking their selections. Studies have shown that vignettes responses reveal deeper perspectives and interpretations that respondents may be unaware of, or that they may not explore with a typical survey questionnaire (Kirby & Jacobson 2014; Martin, 2006).

However, some respondents indicated the need for pictures or visual illustrations for some of the vignettes to aid understanding, especially for the non-local vignettes. Respondents were able to more easily visualize the local water issues than the non-local ones. This is a notable observation as vignettes are flexible and can be presented in different forms, including pictures, audio, or video depending on the research interest and purpose (Atzmüller & Steiner, 2010).

A likely criticism would be the need for much more information in the vignettes to fully capture the context of the particular water challenges. However, the vignettes in this pilot were explicit regarding the research topic of interest. Studies however indicate that vignettes cannot include all the information that participants may wish to see in the vignette events because, ultimately, the vignettes are usually context specific (Hughes, 1998; Soydan, 1995; Wilson & While, 1998). In some instances, the vignette may be explicit regarding particular perspectives, and in other instances, participants may have the freedom to adopt their own perspectives, and many research studies have integrated these two approaches (Hughes & Huby, 2004).

3.7 Conclusion and Future Research Directions

A viable way to deal with and manage the complexities and constant changes of freshwater resources is through a water resilience governance approach. Getting the support and buy in of individuals in society as active actors and partners in a water resilience governance process is a very important element for the success of this governance approach as people will obey policies that they support (Lubell, 2017; Khoury, 2015). Hence, having clear insights and understanding of the viewpoints and endorsement of individuals for this approach would be a valuable tool for policy makers and government agencies to be able to more accurately formulate policies and education programs that align with societal perceptions. Such policies will be better supported, better implemented and thus be more effective in achieving its objectives (Cleaver, 2007)

Water resilience is an emerging and quickly developing area of scholarship (Rodina, 2018b). The ability to produce robust and evidenced-based strategies that will address the several water challenges in the world, is necessary. The uncertainty and immensity of local and global water related challenges calls for novelty, the creation new frameworks, and the redesigning of current frameworks that would elicit more meaningful data in research studies. Using a vignette methodology to assess water resilience endorsement shows potential in this area. Gaining insights into how individuals in society endorse water resilience and its principles provides policy makers and water managers with robust valuable data in making decisions and formulating policies.

Choosing the right data collection instrument and research technique usually determines the success of a research study and the accuracy of the data collected. This study designed and pilot tested a methodology using vignettes to determine quantitative measures of individual endorsement for water resilience principles. Due to the abstractness of the resilience concept, a data collection instrument that can translate and conceptualize the resilience principles in a simplified manner within particular contexts was required, and vignettes are well suited for this. Vignettes have the potential to explore interpretations and meanings in standardized situational contexts that is not easily accessible through other methods that ask questions directly. They also motivate the respondents to think deeply about the questions before responding, encouraging more insightful responses that reveal respondents' perceptions about a research interest.

Academically, the results of this research contribute to resilience research by proposing a data collection technique that facilitates the measurement of individual endorsement of the water resilience principles.

The result of this research also has practical implications for water related policy formulation. Policy planners are usually required to formulate and adjust policies as well as to develop adequate planning programs on a regular basis. In order to do this effectively, they require accurate data and information on the best areas (in policy and society) that require attention. Vignette surveys hold potential in this area as a research technique that allows for the collection of practical and insightful data. Data on how different demographics of individuals in a community endorse the resilience principles provides valuable insights to inform accurate policy formulation that are rational, objective, applicable and useful for the community. Such policies and programs will be better supported by the community. Thus, the use of vignettes for exploring attitudes in water challenging situations and as a statistical technique for measuring endorsement makes a valuable practical contribution in this regard.

Two factors emerged from this study, classifying the resilience principles into two distinct categories: principles relating to the ecological properties and system dynamics of social-ecological systems (P1 to P4) and principles pertaining to the governance components of social-ecological systems (P5 to P7). Biggs et al (2012) acknowledged that different categorizations of the principles may emerge from further research depending on the context in which they are applied. However, further research is necessary as to examine factor loadings for the principles in different contexts.

The results of this study indicate the viability and practicability of using vignettes as a methodology in water resilience research. However, viable prospects for future research remain. In moving forward, the vignette methodology framework presented here offers a foundation and opportunity to continue assessing water resilience endorsement at the individual level in varying contexts. It is hoped that by highlighting the successful use of vignettes as a methodology for determining individual endorsement for the resilience principles, they would be utilized more in further broader scale studies. Additional research is also warranted to compare individual endorsement using a combination of vignettes and other data collection methodologies, as well as comparing individual endorsement across a range of different methods.

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4 Chapter Four: Determining and Measuring Individual Endorsement for Water Resilience: A Case Study of the Town of Lincoln, Ontario

4.0 Introduction

The earth's freshwater resources are facing increasing challenges at an unprecedented rate (IPCC, 2018; Steffen et. al, 2011; World Economic Forum, 2020; Vörösmarty et. al, 2013). The intensity of these challenges has led to increased research studies and global policy discourses, which have identified that these challenges are actually due to weaknesses of the traditional command-and-control approach to governing water resources (Bucknall, 2006; United Nations World Water Assessment Programme, 2003).

The command-and-control approach to managing fresh water systems uses an inflexible centralized model that focuses on rigid rules rather than on managing changes as they come (De Loë, Kreutzwiser & Moraru, 2001; Resilience Alliance, 2010; Rogers & Hall, 2002). It also emphasizes technical solutions to clearly defined problems, and views water systems as controllable elements (Pahl-Wostl et al., 2010). In addition, it largely excludes individuals in society as influencers in the governance process, hence disregarding a critical element for water governance. The command-and-control governance method may have worked in the past but is inadequate for dealing with the current kinds of non-linear changes and unexpected system behavior of freshwater ecosystems (Berkes & Folke 1998; Carpenter et al., 2009; Pahl-Wostl et al., 2010; Schoeman et al., 2014). Hence, there have been calls for a shift to a 'new water paradigm' (Pahl-Wostl et al., 2010; Schoeman, Allan & Finlayson, 2014).

The 'new water paradigm' represents a critical shift in the approach to water management, emphasizing system thinking, more awareness and acceptance of complexity in water systems and wider involvement of more actors in society (Pahl-Wostl 2007; Schoeman et al., 2014). This new water paradigm, a social ecological resilience approach to water resources (also referred to as water resilience), embraces complexity and surprises, and recognizes that people and ecosystems are connected, difficult to predict, uncontrollable, innately complex, and thus encourages systems thinking in managing them (Schoeman et al., 2014; Walker & Salt, 2012).

Resilience scholarship has roots in several fields, including psychology and ecology, and water resilience scholarship has evolved from its ecological roots (Folke, 2003). Though the earliest conception of resilience in the 1960s and 70s centered around the notion of persistence (Holling, 1973), it has since developed in several different directions, with a notable focus on social-ecological resilience. Social ecological resilience explicitly recognizes that social and ecological systems are intertwined, and that complexity and uncertainty are inherent system characteristics (Folke, 2016). Water resilience has developed from this conception. Recent scholarly work has extended water resilience beyond a water engineering perspective towards a focus on social-ecological water resilience (Hashimoto et al., 1982; Rodina, 2018). In recent studies, water resilience has been defined as the ability of water systems to persist, adapt or change when they encounter disturbances, crisis and unexpected changes, and still being able to provide the ecosystem services that humanity depends on (Eriksson et al., 2014). Hence a water resilience approach shows potential to handle current and future water challenges.

The first IPCC Working Group Technical Report on the effects of climate change on freshwater resources drew attention and interest to the concept of resilience in water resources by highlighting resilient ways to manage water challenges (Bakker & Cameron, 2005). This has had an impact on the obvious growth in the application and use of the resilience concept in water policies and governance strategies (United Nations Water, 2015). However, this emerging “water resilience” perspective is still in the conceptual phase, as evidence to show how it is actually applied in practice is still being growing (Eriksson et al., 2014).

The Resilience Principles

The resilience approach has attracted growing attention in the past two decades, leading to increased research into system features that may influence the resilience of social ecological systems (Berkes et al, 2008; Gunderson & Holling, 2002; Walker & Salt 2006). However, as a result of the diverse nature of resilience in different disciplines, the variety of factors proposed has led to a somewhat dispersed and fragmented understanding of the factors that are likely to practically influence resilience in particular social–ecological settings, as they are mostly not backed up by extensive empirical research and lack a synthetic definition of where and when they apply (Biggs et al., 2012; Walker & Salt, 2006). Also, resilience has become a buzzword among natural resource managers, with so many ‘fuzzy’ meanings that has left it open to numerous interpretations even in policy contexts (e.g., Benson & Garmestani, 2011; White & O’Hare, 2014). This is largely because resilience is difficult to grasp, especially in practical terms, and without a clearer explanation of how resilience can be implemented as a management objective, the concept may remain loosely understood, and unable to successfully transform water management and governance practices (Benson 2009; Benson & Garmestani 2011; Ruhl & Fischman, 2010). Hence, it became necessary to evaluate the various proposed factors and system attributes to identify key underlying principles for practically building resilience in social ecological systems.

Biggs et al. (2012) identified and proposed seven principles believed to be crucial for developing the resilience of social-ecological systems. These principles provide some criteria or standard by which to capture or assess resilience, including step by step procedures of how they are implemented in reality. They also inform the practical governance and management of SES at local, regional and global scales (Biggs et al., 2015). The resilience principles include three principles focused mainly on generic ecological and social properties: P1: Maintain Diversity and Redundancy, P2: Manage Connectivity, P3: Manage Slow Variables and Feedbacks, and four principles related to key properties of social-ecological systems governance: P4: Foster an Understanding of Social-Ecological Systems as Complex Adaptive Systems, P5: Encourage Learning and Experimentation, P6: Broaden Participation, and P7: Promote Polycentric Governance Systems. It is important to note that in reality and practice, the principles are interconnected and mutually dependent and may not be implemented successfully as singular elements in their own merits (Biggs et al., 2012).

By viewing resilience through the lens of the seven principles, which practically demonstrate how resilience is implemented in practice to enhance ecosystem services, scholars, water managers and policy makers can identify and focus on the components of the system that can better influence resilience (Biggs et al., 2012). Also, the seven principles make it easier and more practical to apply resilience to water challenges in different contexts.

People-place relationships can affect the level to which people support a water resilience-based governance approach. This is because positive attachments to place has been linked to the willingness of people to be concerned about and protect a place for which they have an emotional bond to (Schultz, 2000). Hence, a positive attachment to a place, particularly natural settings like water bodies, may be strongly linked to an individual's level of endorsement for a water governance approach that would positively impact such places (Stokols & Shumaker, 1981).

Individual Agency and Changing Mindsets

Individual agency, which is the capacity, or power of individuals to be the originator of action and to act purposely (Cleaver, 2007), has been recognized to have both potential and potency to effect transformational change (McNay, 2013; O'Brien, 2015). This agency, also referred to as an 'a priori' condition to action, is hugely effective when individuals see themselves as resourceful and imaginative agents with a voice in how resources are administered and managed, rather than viewing resources as an inventory to be managed by politicians and bureaucratic experts (Dale, 2013; Ziervogel et al., 2016). It is thus a very important element for enhancing resilience and successfully dealing with the complexities of fresh water resources (Dale, 2013; Lubell, 2017; Khoury, 2015; Osterblom & Folke, 2013).

However, individual agency is often constrained by governance structures, capacity building, accountability, issues of power and the potential for science-policy integration, among others (Johannessen & Wamsler, 2017). But despite these constraints, knowing and understanding the perceptions of individual resource users in a particular setting, and the extent to which they are willing to endorse, support and take action on certain governance policies and plans, can be valuable to policy planners in formulating policies and developing messaging that align with the views, values, and beliefs of individual actors in that context. Policy makers can identify and focus on water challenges and demographic groups that need improving and will thus be better prepared to alter and align initiatives in those directions.

Individual agency alone is not sufficient to effect a resilience governance transformation. Individuals' mindsets must be aligned with resilience thinking, and the concept of leverage points shows great potential as a boundary concept for which diverse perspectives can come together for genuine environmental sustainability transformation (Abson et al., 2016). Leverage points, also referred to as 'points of power', are places or areas within complex systems where a slight shift may lead to a fundamental change in the entire system (Meadows, 1999). Proposing a hierarchy of twelve intervention points for leveraging change, Meadows (1999) argues that the transformational ability of an intervention to cause a change in system behaviour depends on a large part on what aspects of the system the intervention acts upon, as this determines its potency.

Leverage points range from 'shallow' leverage points, which are easier to apply but usually would result in only slight modification in system behavior, to 'deep' leverage points, which may more challenging to apply but usually brings about transformational change (Abson et al., 2016). The deepest leverage points include the power to transcend paradigms and to transform the mindset/paradigm out of which the system arises. These leverage points are focused on the intent of the system and directed towards the underlying goals, values, and views of actors that shape

the emerging direction of a system, and not simply focused on techno-fixes (e.g. Campeanu & Fazey, 2014; O'Brien, 2018) that have limited potential to produce transformational change (Abson et al., 2016; Meadows, 1999). This is consistent with the personal sphere of transformation as described by O'Brien, 2018, which represents the individual views, values, and perceptions that affect how they perceive and understand how agency works and how it impacts how systems are structured. It also affects people's perceptions and behavior towards natural resources. Hence the ability to influence the individual beliefs, viewpoints and perceptions as agents of change is a promising key driver for effecting transformational system change.

Based on the rapidly worsening state of water resources, there is the urgent need for society to endorse water resilience-based governance in order for the resilience principles to be reflected in related policies, plans, and actions at all levels of society. Gaining public endorsement (i.e., agreement and belief in importance) for water resilience and its underlying principles (Biggs et al., 2012) is critical for facilitating strategies and policies to enable the substantive transformational shift to water resilience-based governance systems (Eriksson et al., 2014). This transformational shift would require that individuals in society move to a new mindset of water resilience through a three-phase framework of sense making, envisioning, and gathering momentum (Moore et al., 2014).

Using this framework, the first step towards transformation would involve an in-depth understanding of the problems and weaknesses of the command and control governance system and the need for a change in water management and governance to address the issue (Olsson et al., 2004; Weick & Sutcliffe, 2007). The next step is to envision alternative pathways towards a water governance transformation, with the use of scenario planning that considers alternative action steps in making the governance shift (Moore et al., 2014). Individuals would then need to actively make decisions, choices and actions to make the substantive shift to a new mindset regarding the management and governance of water resources. This transformational process would involve a change in perceptions and viewpoints, including developing networks that help to build a shared identity in making the desired transformational changes (Moore & Westley, 2011), and individual agency and mindset are critical catalyst in achieving this transformational shift (Meadows, 1999; Plummer et al., 2014).

Water resilience research has paid considerable attention to the predominant water related issues especially in large communities, watersheds, provinces, regions, countries, continents, and the planet (e.g. Baird et al., 2016; Schuetze & Chelleri, 2013), but an equivalent amount of attention has not been given to the role of individual actors, individual mindsets and perceptions with respect to this concept (e.g. Baird et al., in press). It is currently unknown to what extent individuals in society endorse water resilience and if individual levels of endorsement can be increased. Addressing this gap is urgent and critical in the face of accelerating global water challenges.

Hence, this study focuses on the role of individual agency as a catalyst in shaping a water resilience-based governance and explores the demographic factors that influence individual mindset and endorsement towards the resilience principles, with a view to achieving transformational change in the management of water resources. Accordingly, the objective of this study is to measure the level of individual endorsement for the underlying principles of

water resilience using the vignette questionnaire, and to examine how key demographic factors (i.e., age, sex, income, religious attendance, education, political ideology) affect, influence or predict this endorsement.

4.1 Methodology

In this section, the method and procedure used in this study will be described in detail. The chapter begins with a description of the research design, and then outlines the data collection methodology. Thereafter, a description of the data analysis is given, and the results of the study are discussed.

4.1.1 Research Design

The purpose of this research was achieved through the use of an exploratory single case study design by means of a quantitative methodology. An exploratory case study (much like a pilot study), is appropriate when the researcher intends to deeply understand a study subject, or how certain situations play out in real life context for the purpose of developing models, hypotheses or theories (Gagnon, 2010; Yin, 2009). Case studies are also useful when a researcher has very little control over the events surrounding the research (Yin, 2009).

4.1.2 Case Study Location and Participants

For the purpose of this research, the single case was the Town of Lincoln in the Niagara Region of Ontario, Canada and the units of analysis were individual respondents from the town. The Town of Lincoln is located at the heart of the Niagara Region between the southern shore of Lake Ontario and the Niagara Escarpment, and has one of the most diverse economies in Niagara with several wineries, vineyards, fruit orchards, vegetables and heritage sites. The Town of Lincoln contributes greatly to the wine industry in the Niagara Peninsula (Statistics Canada, 2018; Town of Lincoln, 2019a). Lincoln has the largest concentration of greenhouse operators in Canada and serves the communities of Beamsville, Vineland, Jordan, Campden, Tintern and Rockway. According to the Canada 2016 census report, the population of Lincoln is 23,787 covering an area of 162 km² (Statistics Canada, 2018).

The Town of Lincoln was chosen because it is currently on a strong economic development path, being the fourth fastest growing municipality in Niagara, projected to increase in population by approximately 50% in the next 15 years (Town of Lincoln, 2019b). This increase in population, economic and agricultural growth in recent years is causing increased stress on Lincoln's water resources (Newsnow, 2018), and with such a growing economy and population, it is critical that Lincoln focuses on environmental sustainability. In addition, the Town of Lincoln's town council is very sustainability-minded and has been actively engaging with and encouraging local research like the Brock Lincoln Living Lab partnership (Brock University, 2018) and the Meopar-Lincoln community sustainability project (Brock University, 2019).

Participants were recruited online via a social media (Facebook) advert that targeted residents in the Town of Lincoln, and the advert ran for a period of ten days. A total of 216 individuals participated in the study via an online questionnaire hosted on Qualtrics. The study took approximately 15 minutes to complete, and participants were entered into a draw to win one of two \$200 Amazon gift cards. In order to be eligible to participate, participants had to be resident in the Town of Lincoln and be at least 18 years of age. All participants consented to the study

prior to participating, and this study was approved by the Human Research Ethics Board at Brock University.

4.1.3 Stimuli and Data Collection Design

To determine individual endorsement for the water resilience principles, a quantitative methodology using a questionnaire was designed (refer to chapter Three of this thesis for the questionnaire design process). The questionnaire consisted of two sections: 1) a demographics questionnaire and 2) a vignette questionnaire with a total of six vignettes. Each respondent randomly received a pair of Lincoln and non-Lincoln vignettes from a total of six vignettes (three Lincoln and three non-Lincoln). The questionnaire can be viewed in Appendix A.3.6. The demographics questionnaire was developed to gather the following personal data: age, sex, years residing in the Town of Lincoln, highest level of education, income, level of meaning of local water bodies to respondents, religious attendance, residence length and political ideology (left or right wing). These questions were based on similar questions from the Canadian Census and related research (e.g., Baird et al., in press; Statistics Canada, 2018) to ensure that they were culturally appropriate and clear. In addition, these demographics have been shown to influence pro-environmental behavior in previous studies and will likely influence endorsement for the resilience principles (e.g., Baird et al., in press; Curado et al., 2014; Petrosillo et al., 2007; Tarannum et al., 2018).

The vignette survey had a total of six vignettes designed to assess participants level of endorsement for the principles of water resilience. The vignettes were brief descriptions of real-life challenging water situations: three vignettes were Lincoln specific (L1 to L3) and three were non-Lincoln specific (G1 to G3). Participants received two randomly-selected vignettes, one of each category, in a randomized order. Each vignette was followed by a series of ten questions based on the seven principles of water resilience. Principles One to Three had two questions each - an ecological and a social/governance question, while Principles Four to Seven had one social/governance question each.

Each question had four potential responses based on the context of the vignette. The responses were assigned ranking values for analysis on a scale of 1 to 4 as follows: 1) no endorsement of the principle; 2) endorsement of a 'low level' of the principle; 3) endorsement of a 'medium level' of the principle; and 4) endorsement of a 'high level' of the principle (See Appendix A.3.6). Participants selected all the responses that best represented what they would endorse, and thereafter participants ranked the selected responses in the order of preference, with the most preferred response ranked first. The action statement they ranked as their most preferred action was used to determine their endorsement score for each principle. Participants who completed the questionnaire were entered into a draw to win one of two \$200 Amazon gift cards. Pilot studies were carried out to ensure that a lay audience could easily understand the language used in the questionnaire. Details of the design and implementation of the vignette survey can be viewed in sections 3.3 and 3.4 of this thesis.

4.2 Data Treatment and Analysis

A total of 215 respondents successfully completed the survey (sample demographics and histograms can be viewed in Table A.4.1 and Figures A.4.1 to A.4.7 in Appendix 4). All participants were current residents of the Town of Lincoln aged eighteen years and above.

Normality tests indicated that the sample was normally distributed for some of the demographics, and all data analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software platform for Windows, version 26.0. Except where stated otherwise, a significance level of $p = 0.05$ was used for the data analysis. Respondents to the study randomly received one Lincoln vignette and one non-Lincoln vignette in a randomized order (Table A.4.2 in Appendix 4 - vignette distribution data).

4.2.1 Resilience Endorsement Scores

Respondents endorsement score for each principle was based on the action statement that they selected as their most preferred action statement for that principle. For example, if a respondent selects action statement 4 as their most preferred action statement, they were given a score of 4 for that principle. The overall resilience endorsement score was an average of respondents' Lincoln and non-Lincoln endorsement scores for all the principles. Endorsement scores for each principle of the Lincoln and non-Lincoln vignettes were averaged to get a Lincoln and non-Lincoln endorsement score for each principle. Respondents had two endorsement scores for Principles 1-3 (based on the ecological and social questions), hence the endorsement scores for Principles 1-3 was an average of respondents ecological and social endorsement scores.

A two-way ANOVA was used to determine if there was a significant interaction effect between the seven resilience principles based on the location of the vignettes. A paired samples T test was performed to examine differences in means between Lincoln and non-Lincoln endorsement scores for each of the resilience principles. Also, the endorsement scores for the resilience principles for each Lincoln and non-Lincoln vignette was computed.

4.2.2 Overall Endorsement and Demographics

Respondents were re-grouped into categories based on their demographics (Table A.4.3 in Appendix 4). A one-way ANOVA and Turkey post hoc test was conducted to determine the association between overall endorsement scores with the demographics. The assumption of normality was satisfied for the data (Figures A.4.8 and A.4.9 in Appendix 4). Respondents were divided into three endorsement groups: low, medium and high, using a 33% percentile grouping (Table A.4.4 and A.4.5 in Appendix 4).

Kruskal-Wallis tests were conducted to determine if there are significant differences between the three resilience endorsement groups (low, medium and high) based on their demographics. The Kruskal-Wallis test is a rank-based nonparametric test that can be used to examine differences between two or more groups of an independent variable on a categorical or ordinal dependent variable. Finally, a standard multiple regression was performed to determine which of the demographic measures best predicted overall endorsement of the resilience principles.

4.3 Results

4.3.1 Overall Resilience Endorsement Scores

The mean overall resilience endorsement score was 3.37 ($SD = 0.70$) out of a possible 4.0, indicating that on the whole, respondents indicated a medium level of endorsement for the resilience principles (1= none; 2 = low; 3 = medium; 4 = high) (Table 4.1).

Table 4.1. Descriptive statistics for overall endorsement and for each resilience principle

Resilience Principles	<i>N</i>	<i>Mean (SD)</i>	Median
Overall Resilience Endorsement	215	3.37 (0.70)	3
Maintain Diversity & Redundancy (P1)	215	3.36 (0.70)	4
Manage Connectivity (P2)	215	3.47 (0.65)	4
Manage Slow Var & Feedbacks (P3)	215	3.43 (0.21)	4
Foster Complex Adapt. Systems Thinking (P4)	214	3.37 (0.78)	4
Encourage Learning (P5)	214	3.27 (0.82)	3
Broaden Participation (P6)	214	3.23 (0.89)	3
Promote Polycentric Governance (P7)	214	3.46 (0.83)	3

4.3.2 Lincoln and Non-Lincoln Resilience Endorsement Scores

The bar chart (Figure 4.1), indicates that the majority of respondents chose the medium and high endorsement options as their most preferred endorsement actions for both Lincoln and non-Lincoln. Overall resilience endorsement scores for Lincoln and non-Lincoln was 3.17 ($SD = 0.56$) and 3.33 ($SD = 0.55$), indicating that overall for both Lincoln and non-Lincoln, respondents rated the resilience principles to at least a medium level of endorsement, but with a higher overall endorsement for non-Lincoln than for Lincoln (Table A.4.6 and A.4.7 in Appendix 4).

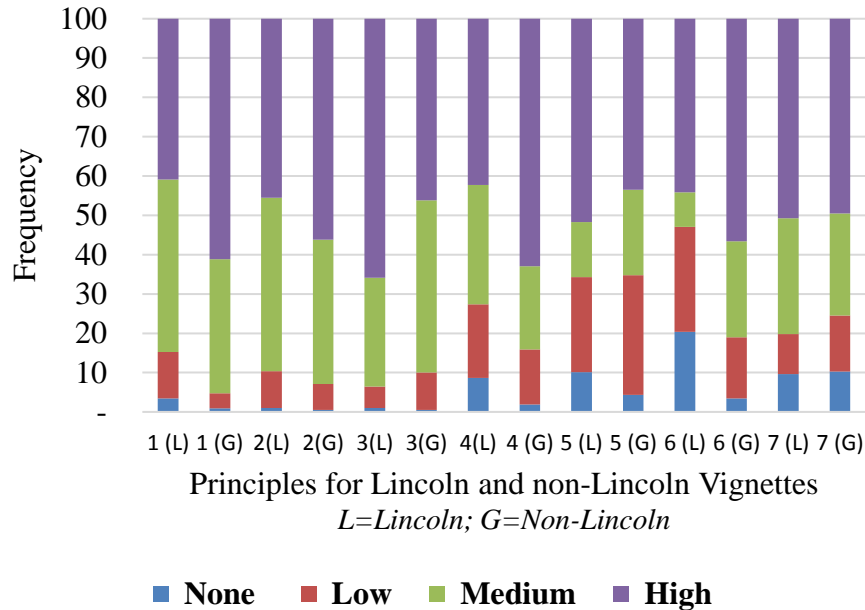


Figure 4.1. Frequency of responses (most preferred option) for the seven resilience principles for Lincoln and non-Lincoln (Note: L = Lincoln; G= Non-Lincoln)

4.3.3 Lincoln Versus Non-Lincoln Endorsement

A two-way ANOVA was used to determine if there was a significant interaction effect between the seven resilience principles based on the location of the vignettes. The main effect of the

principles showed a difference in endorsement scores, $F(6, 1098) = 16.02, p < .001, \eta_p^2 = 0.80$, indicating that endorsement scores (regardless of location) differ as a function of principle. The main effect of location (Lincoln and non-Lincoln) showed a difference in endorsement scores of the principles, $F(1, 183) = 16.25, p < .001, \eta_p^2 = 0.82$, indicating that endorsement scores (regardless of principle) differ as a function of location. There was a significant two-way interaction between location (Lincoln or non-Lincoln) and the resilience principles, $F(6, 1098) = 10.596, p < .001, \eta_p^2 = 0.55$, indicating that endorsement for the principles differ as a function of location.

A paired samples T test was performed to examine differences in means between Lincoln and non-Lincoln endorsement scores for each of the resilience principles. The results showed there were differences between Lincoln and non-Lincoln with respect to five of the seven resilience principles (Table 4.2). Mean endorsement scores for the resilience principles was calculated for each Lincoln and non-Lincoln vignettes (Tables A.4.8 and A.4.9 in Appendix 4).

Table 4.2: Mean endorsement for each resilience principle for the Lincoln and non-Lincoln vignettes and results of the paired sample T-test

Resilience Principles	Lincoln	Non-Lincoln	Paired t-tests
Overall Resilience Endorsement	3.17 (0.56)	3.33 (0.55)	$t(204) = -3.12, p = 0.002, d = .29$
Maintain Diversity & Redundancy (P1)	3.22 (0.79)	3.55 (0.62)	$t(198) = -4.78, p < 0.001, d = .46$
Manage Connectivity (P2)	3.34 (0.69)	3.49 (0.64)	$t(196) = -0.22, p = 0.031, d = .23$
Manage Slow Var & Feedbacks (P3)	3.58 (0.64)	3.36 (0.67)	$t(196) = 3.90, p < 0.001, d = .36$
Foster Complex Adapt. Systems Thinking (P4)	3.06 (0.98)	3.45 (0.80)	$t(201) = -4.02, p < 0.001, d = .44$
Encourage Learning (P5)	3.07 (1.08)	3.04 (0.95)	$t(199) = 0.43, p = 0.665, d = .29$
Broaden Participation (P6)	2.77 (1.21)	3.34 (0.86)	$t(196) = -5.70, p < 0.001, d = .54$
Promote Polycentric Governance (P7)	3.21 (0.98)	3.15 (1.01)	$t(196) = 0.93, p = 0.355, d = .06$

Note that bold font indicates statistically significant differences

4.4 Demographics and Resilience Endorsement Scores

In this section, the association between demographics and the overall resilience endorsement scores, as well as the significant unique predictors of overall resilience endorsement are reported. The distinct demographic characteristics of respondents in the low, medium and high endorsement groups are also reported.

4.4.1 Association of demographics with overall endorsement scores

Demographic categories were created for each demographic variable, and these were used to perform a one-way ANOVA to determine if the overall resilience endorsement scores were different for the different demographic categories. The results indicate that the overall

endorsement scores were different in three demographic categories: age: $F(3, 204) = 2.53, p = .05, d = 0.42$; sex: $F(1, 203) = 31.905, p < 0.001, d = 0.90$ and water meaning: $F(1, 203) = 9.110, p = .003, d = 0.46$ (Table A.4.9 in Appendix 4). For the age category, overall endorsement mean scores increased from 3.23 ($SD = .42$) for those aged 18 to 39, to 3.31 ($SD = .36$) for those aged 30 to 39, and then to 3.43 ($SD = .29$) for those aged 40 to 54. However, scores decreased from those aged 40 to 54 to 3.32 ($SD = .51$) for those aged over 55.

The Turkey post hoc test showed significant differences ($p = .03$) between those aged 18 to 29 and those aged 40 to 54. With respect to sex, overall endorsement mean scores for females 3.41 ($SD = .33$) was higher than males: 3.07 ($SD = .48$) indicating that females had higher endorsement than males. For water meaning, overall endorsement scores increased from 3.30 ($SD = .48$) for those who attached some meaning to local water bodies to 3.38 ($SD = .35$), for those who attached considerable meaning to local water bodies, indicating that those who attached more meaning to local water bodies tended to have higher endorsement (Table A.4.10 in Appendix 4)

4.4.2 Low, Medium and High Endorsement Groups

Respondents in the study were divided into three resilience endorsement groups based on their overall resilience endorsement scores: low endorsement ($n = 69$), medium endorsement ($n = 72$) and high endorsement ($n = 71$) groups (Table A.4.4 in Appendix 4).

A Kruskal-Wallis test was done to determine if there were variations in the demographics between the three resilience endorsement groups, and the result showed differences for five demographic variables (Table 4.3). The results indicate that those in the high endorsement group tend to be highly educated and attach more meaning to water than the other groups, while those in the low group tend to be male and attended more religious services than those in the other groups.

Table 4.3. Independence sample Kruskal-Wallis comparing demographics of the three resilience endorsement groups

Demographic	N	χ^2	Df	P	Mean Rank Scores		
					Low	Med	High
Sex	210	9.237	2	.010*	117.59	105.67	93.24
Education	213	10.012	2	.007*	96.24	99.74	124.98
Income	206	6.280	2	.043*	89.74	114.14	105.90
Religious Attendance	209	9.364	2	.009*	121.47	93.20	101.37
Water Importance	210	8.110	2	.017*	91.95	110.29	113.95
Resident length	210	0.373	2	.830	106.41	107.57	102.50
Age	213	1.422	2	.491	112.94	101.02	107.20
Political ideology	211	3.798	2	.150	116.07	105.02	97.19

* Significant at alpha levels of .05

Subsequently, pairwise comparisons with Bonferroni correction level of .02 (.05/3) for multiple comparisons was performed to discover how the groups differed. The test showed significant variations between the low and high endorsement groups indicating that high endorsers tended to

be female, more educated, and attached more meaning to water than the low endorsers (Table 4.4)

Table 4.4. Paired Comparisons of Endorsement Groups

Demographics	Paired Comparison	Paired Endorsement Groups		
		Low – Medium	Low – High	Medium - High
Education	Test Statistics	-3.50	-28.7	-25.24
	Adj. Sig (p)	1.00	.01*	.03
Water Meaning	Test Statistics	-18.33	-22.00	-3.67
	Adj. Sig (p)	.08	.02*	1.00
Sex	Test Statistics	11.92	24.35	12.43
	Adj. Sig (p)	.39	.01*	.35
Income	Test Statistics	-24.36	-16.21	8.24
	Adj. Sig (p)	.0	.32	1.00
Religious Attendance	Test Statistics	28.27	20.09	-8.17
	Adj. Sig (p)	.01*	.105	1.00

* Significant at adjusted alpha levels of .02 (significance values have been adjusted by the Bonferroni correction for multiple tests)

4.4.3 Predicting Resilience Endorsement Scores

A standard multiple regression was performed with the all the grouped demographic variables entered as predictors, and the overall resilience endorsement scores entered as the criterion. The multiple correlation coefficient, R of the model was .387. The results indicated that the model explained 15.0% of the variance in overall resilience endorsement scores, $F(8, 194) = 4.27, p < .05$. Sex ($sr^2 = .05$), political ideology ($sr^2 = .04$), and the water meaning ($sr^2 = .02$) made the most unique contribution to the total variation in the endorsement scores. They emerged as the most significant unique predictors of overall resilience endorsement (Table A.4.11 of Appendix 4).

4.5 Discussion

This section presents a discussion of the results of this study. The section begins with a discussion of the overall level of individual endorsement for the water resilience principles followed by a discourse of the differences in endorsement for Lincoln and non-Lincoln. This section also discusses the relationship between overall resilience endorsement and the demographic measures, as well as the major demographic predictors of overall resilience endorsement that emerged from the study. The section concludes with a summary of the major findings.

4.5.1 Overall endorsement of the resilience principles

This study sought to examine how individuals in the Town of Lincoln endorse the water resilience principles. The study found that overall, individuals in the town indicated considerable endorsement for water resilience principles in both the local and non-local contexts. However, overall endorsement was lower for Lincoln than for non-Lincoln. Despite the dominance of the engineering resilience perspective with regards to local and global policy frameworks (Rodina,

2018), it is reassuring to find that the Town of Lincoln endorsed water resilience governance as an acceptable approach for governing their water resources.

Though a high level of endorsement would have indicated greater acceptance of a water resilience governance approach, there are a few possible explanations why this study indicated a medium level of endorsement. A water resilience-based governance approach is still evolving, and the resilience principles are yet to be fully understood and practiced in water governance (Biggs et al., 2012; Rodina, 2018). Moreover, in the management and governance of SES, the high level endorsement actions of the principles are challenging to implement in practice and may require much resources and time to achieve (Biggs et al., 2012; Bodin & Crona, 2009; Little & McDonald, 2007; Ulanowicz et al., 2009). Thus, it is possible that the high endorsement actions may not have seemed to be viable immediate practical solutions to respondents. In addition, the none and low level actions also do not appear to be viable immediate solutions to the challenging water situations. This may explain why the average overall endorsement was at the medium level rather than at the high or low level. Further studies are required to confirm these findings and to ascertain if cost, time or other variables were important factors in determining individual endorsement of the resilience principles.

4.5.2 Differences in Endorsement for Lincoln and non-Lincoln

Sense of place research has found that attachment to a place implies an opposition to environmental degradation and a concern for the environment, especially for local areas (Vorkinn & Riese, 2001). Studies have also indicated that a bonding with the natural environment in a place (e.g., parks and water bodies) usually causes people to be more protective towards the place (Goralink & Nelson, 2011). In addition, a sense of place has been theorized as being useful in understanding individual differences in environmental behavior (Lieberman et al., 2007; Masterson et al., 2017; Reser, 1995), and thus would have potential implications for how individuals endorse the resilience principles for water governance.

Based on sense of place, it is expected that respondents in this study will be more willing to endorse actions that support a resilience-based water governance in the Town of Lincoln where they reside than for places outside the town (Giuliani, 2003; Schultz, 2000). Sixty percent of the study respondents have been resident in the Town of Lincoln for at least seven years, and 69.5 percent indicated attaching strong meaning to their local water bodies. These are indicators that could influence a strong sense of place (Goralink & Nelson, 2011; Masterson et al., 2017; Schlutz, 2000), and thus result in higher endorsement scores for their local area. However, the results indicated lower overall endorsement for Lincoln than non-Lincoln, which contrasts with general findings in the sense of place research.

There are a few possible explanations for these results. One possible reason is that place attachment may not necessarily be influenced by the length of residency in a place, but rather by the attachments or special bonds with the place, regardless of length of stay (Halpenny, 2010; Masterson et al., 2017). Thus, it is possible that despite the considerable length of residence, respondents may not have formed personal special bonds with the town to have influenced a strong sense of place (Stedman, 2008). Another possible reason for the results could be that sense of place depends not just on the meaning people give to a natural environment but is more related to the time spent in the natural environment (Raymond et al., 2010). It is possible for

individuals to attach meaning to their natural environment but may not have spent considerable time in the natural environment to have bonded with it. Although the majority of respondents in this study indicated attaching meaning to their local water bodies, this is not an indication of how much time they spend in nature. It is therefore possible that there is a weak nature bonding in the town which was reflected in the lower endorsement scores for Lincoln than for non- Lincoln.

Sense of place differs between communities and in different contexts (Vorkinn & Riese, 2001), and it may not necessarily predict the type of pro-environmental actions that would be supported in different communities facing different environmental challenges (Schultz, 2000; Vorkinn & Riese, 2001). People may be strongly attached to a place but may support certain pro-environmental behaviours and not others. Thus, it is possible that a sense of place attachment in the Town of Lincoln may not be prevalent with regards to freshwater resources but may be prevalent in other environmental contexts (Vorkinn & Riese, 2001). Further studies in different contexts are required to confirm this.

The results of this study indicate that, although sense of place is generally considered a requirement for prompt environmental action and concern (Masterson et al., 2018), it may not be a requirement or indicator for the endorsement of the resilience principles. However, this result may be sample and context specific (Vorkinn & Riese, 2001). Further studies using different samples and communities is required to more accurately assess the relationship of sense of place with individual endorsement of the resilience principles.

4.5.3 The Effect of Context and Conceptualization on Endorsement

This study also indicated that individual endorsement of the resilience principles may be influenced by the context and type of water challenges being examined. An examination of the highest and lowest endorsement in the different vignettes supports this hypothesis. For example, for the Lincoln vignettes, Principle 6: Broaden Participation received the lowest overall mean endorsement score (below the medium average score) for Lincoln 1 vignette (Appendix A.3.6). Respondents seemed to favor a less involved (limited to providing inputs and comments while allowing the town to make the major decisions) public involvement in the town's decision-making process for water issues, preferring to leave major decision making to the town's council.

A reasonable explanation for this may be that the Town of Lincoln currently holds public meetings with residents where the actions, decisions and options of the town council are presented to the public and their comments and complaints are heard and documented. In addition, residents have opportunities to submit their comments and concerns regarding issues in the Town (Town of Lincoln, 2019). The successful implementation of this approach in the town so far may explain that they are comfortable with the status quo and hence, the lower endorsement action that supports this ongoing practice was selected more often than higher endorsement actions involving much deeper participation of respondents.

Also, Principle 4: Foster CAS Thinking from Lincoln vignette 3 (Appendix A.3.6) also received lower than average mean endorsement scores where respondents chose to focus on increasing agricultural productivity in the face of disturbances, rather than seeking more broad-based solutions to the challenges. This result may be due to the predominantly agricultural community of the Town of Lincoln, focused on becoming a centre of excellence for agriculture in Niagara

and beyond. This focus on agriculture may have made the respondents less favorable to any option that showed a likelihood of negatively impacting agriculture yields in the town (Town of Lincoln, 2018). It is also possible that the difficulty of clearly conceptualizing P4: Foster CAS Thinking in practice may have also affected how respondents viewed the options presented to them (Biggs et al., 2015).

Conversely, an easily conceptualized principle like P3: Slow Variables and Feedback, received a high overall mean endorsement for the Lincoln 2 vignette (Appendix A.3.6), where respondents highly endorsed extensive flood management plans based on regular monitoring and projected weather conditions in the region (the high endorsement option). This result may be due to the relative ease of conceptualizing and practically presenting evidence of this principle to respondents (Biggs et al., 2015). In addition, respondents' recent experiences of flooding in the town may have contributed to their very high endorsement of this principle in a bid to urgently address the issue (Niagara This Week, 2018; Town of Lincoln, 2018b).

These results indicate that the conceptualization and implementation of the principles may differ in different contexts. The results also show that overall, individual endorsement of the water resilience principles could be influenced by context, individual experiences and perceptions, and variations in the practical conceptualization and understanding of the resilience principles (Biggs et al., 2015; Ostrom, 2007; Walker & Meyers, 2004). Context matters in the application of the principles and promoting resilience of SES depends on how each of the individual principles are implemented and also on how they integrated in practice (Biggs et al., 2015). In addition, the easier it is to conceptualize and explain a principle, the easier it may be for individuals to understand and accurately indicate their endorsement.

The lack of empirical evidence for some principles contributes to difficulties in conceptualizing them clearly. In their exposition of the resilience principles, Biggs et al. (2015) highlighted that the processes of certain principles like P2: Connectivity, P3: Slow variables and Feedbacks, and P6: Broaden Participation are quite well understood, and have considerable proof that show their importance. Hence, it is easier to conceptualize these principles. However, while there is considerable evidence for the importance of P1: Diversity and Redundancy, P4: Foster CAS Thinking and P7: Polycentric Governance, the most significant ways that show how these principles build up resilience in SES are not very apparent and may be thus more difficult to conceptualize. Hence, how a principle is endorsed and understood depends on how it is translated, how it is applied in practice, and how its application in practice is understood (Biggs et al., 2015). This highlights the need for further understanding of the processes underlying the different principles, and practical ways of defining and conceptualizing them in order to measure their impacts.

4.5.4 Demographic Associations and Predictors of Overall Resilience Endorsement

A primary aim of this study was to examine the association of certain demographic factors with overall resilience endorsement. The results indicate that there were individual differences in endorsement associated with variations in demographics. This is consistent with the results of Baird et al's (in press) study which showed considerable endorsement for the resilience principles from respondents in Canada and the United States with variations in endorsement with regards to some demographic variables.

Some demographic variables, specifically sex, education, age, and time spent in nature, have been hypothesized to be related to the level of people's perception of the environment (Curado et al., 2014; Petrosillo et al., 2007; Tarannum et al., 2018). Researchers have consistently found that females, people with high earnings, well educated people, political liberals and lovers of nature, have more environmental concern than their counterparts (Bliuc et al., 2015; Casey & Scott, 2006; Jones & Dunlap, 1992; Tranter & Booth, 2015; Van Lier & Dunlap, 1980). Research also demonstrates that age, resident status and religion are associated with pro-environmental behaviour (Hay, 1998; Poortinga et al., 2011; Wang & Kim, 2018). Hence, it would be expected that the results of this study would support these findings, showing these demographics as more likely to endorse the resilience principles.

The results of this study showed that higher overall endorsement for the resilience principles was positively associated with respondents that were females, older, and those who attached meaning to their local water bodies. However other demographics like income, education, political ideology and religious attendance did not show significant associations. The relationship of sex and water meaning to overall resilience endorsement are largely consistent with past research on how demographic factors relate to pro-environmental behaviour (Curado et al., 2014; Petrosillo et al., 2007; Tarannum et al., 2018). The sense of place literature also indicates that attaching more meaning/importance to the environment, e.g. local water bodies is usually positively correlated with higher environmental concern (Scannell & Gifford, 2010), which is consistent with the results of this study.

However, though the result with respect to age is consistent with Baird et al. (in press)'s study which found that younger people highly endorse the water resilience principles than older people, the results are contrary to past research that have predominantly reported that younger people show more concern for the environment than older people (e.g., Blaikie, 1992; Dunlap et al., 2000; Van Liere & Dunlap, 1980). Researchers argue that younger individuals are less integrated into the dominant social order which views environmental solutions as threatening by older people (e.g. Jones & Dunlap, 1992; Van Liere & Dunlap, 1980). Another possible reason for the disparity of this study's results may be related to subgroup differences in the Town of Lincoln due to the nature of water challenges prevalent in the community such as irrigation challenges which may be of more concern to the older generation.

Some demographic factors that have been shown in past researches to be positively associated with pro-environmental behaviour, such as political ideology, religion, income and education (Tranter & Booth, 2015; Wang & Kim, 2018), did not show significant associations with resilience endorsement in this study. Research has indicated that environmental concern increases with social class as shown by indicators like income and education, and the hypothesis is that concern for the environment, unlike their counterparts, is something this class of people can afford (Jones & Dunlap, 1992). Interestingly, this study did not align with these previous research as neither education nor income showed a significant association with resilience endorsement. It is also surprising as the proportion of the sampled population were quite educated and in the middle to top income class. However, there are studies that also found no association between education and income with pro-environmental behavior (e.g. Blaikie, 1992; Tranter, 1996).

This study also sought to examine the ability of certain demographic factors to predict levels of individual endorsement for water resilience principles, by examining their contributions to the variability in overall endorsement scores. Sex, political ideology and water meaning made unique contributions towards the explained variability in resilience endorsement scores with sex being the highest contributor followed by political ideology and water meaning.

These findings are partially consistent with the full range of demographic variables that have frequently been suggested as being important predictors of environmental concern: age, sex, education, income, political ideology, and connection to nature (Jones & Dunlap, 1992; Dunlap et al., 2000; Mohai & Teight, 1987), with age, political affiliation and education often emerging as the best predictors (Jones & Dunlap, 1992). Regarding political ideology, Forgas & Jolliffe (1994) found that people who have very deep-seated political views tended to have more concern for the environment, and studies in the United States show that liberals were more environmentally concerned than conservatives (Dunlap et al., 2000; Jones & Dunlap, 1992; Van Lier & Dunlap, 1980). In addition, Dalton (1994) in his study noted that to an increasing extent, being a liberal implies a commitment to environmentalism and green political values. Thus, political ideology seems to be very influential in people's perception of environmental issues and their level of environmental concern and the results of this study correlates this finding. Sex as a predictor of resilience endorsement is consistent with research that indicates sex as a strong predictor of environmental concern, with females showing more concern for the environment than males (e.g., Blaikie, 1992; Blocker & Eckberg, 1997; Bord & O'Connor, 1997; Tranter, 1996). Research also indicates that women may be more concerned with the environment because they are predisposed to be more caring, sympathetic, more protective than males (Casey & Scott, 2006).

Though connection with local water bodies has not been widely reported as a predictor of pro-environmental behaviour, research on sense of place indicates that attaching more meaning/importance to the environment, e.g. local water bodies is usually positively correlated with higher environmental concern (Scannell & Gifford, 2010). Hence, the indication from this study that water meaning is a predictor of overall resilience endorsement is consistent with the sense of place literature.

4.5.5 Low, Medium and High Endorsement Groups

Based on the results of this study indicating marked differences between the low and high endorsement groups, this section focuses on the differences between these two groups. This study indicates that high endorsers are likely to be highly educated, females and those who attach meaning to local water bodies, while low endorsers are likely to be males and those who attach less meaning to local water bodies.

The finding is consistent with the trend in results from previous research. Several researchers have found that the more educated a person is, the higher environmental concern they have (e.g., Dunlap et al., 2000; Van Liere & Dunlap, 1980). Also, having more women in the high endorsement group than the low group is not surprising, and is consistent with past trends in gender/environmental research results that show that females tend to have higher levels of environmental concern than males (e.g. Casey & Scott, 2006; Dunlap et al., 2000). Interestingly, sex was the only demographic variable that was positively associated with resilience

endorsement, a significant unique predictor of resilience endorsement and showed a difference in the high and low endorsement groups. Sex may therefore be a significant factor in individual endorsement of the principles.

The high endorsement group rated their local water sources as more meaningful than the low endorsement group. These findings agree with the results of Baird et al.'s (in press) study that found that the respondents in the high endorsement group rated their local water sources as more meaningful than those in the low endorsement group. This also agrees with research on sense of place that has shown that individuals with higher sense of place (those who ascribe more meaning to their environment) are more inclined to participate in pro-environmental actions (Halpenny, 2010, Schlutz, 2000). Thus, it is not surprising that individuals who are more attached to their local water sources would be in the high endorsement group, with more interest in supporting a governance approach that can better manage and govern their local water resources.

Practically, these results are valuable for planners and decision makers with regards to managing and governing water resources. Policy planners, decision makers and water managers often need accurate information to guide them in formulating policies, and in developing initiatives and plans. However, plans and initiatives that align with the needs of people in society are usually well accepted by them and thus, usually well implemented (Betsill et al., 2020). Thus, the knowledge of the demographics of the different resilience endorsement groups will be valuable for governments and water managers to tailor and/or revise policies, plans, initiatives and programs that align with certain demographics depending on their endorsement group. Knowledge of the demographics of the high and low endorsers can lead to new ways of viewing and classifying people in a community and can help in predicting the level of endorsement and general attitudes towards water resilience in the community. This knowledge is very valuable and can be integrated into more accurate policy formulation, focused planning, predicting changes in endorsement based on population projections and more effective decision making.

Overall, the knowledge of the demographic variables that predict overall endorsement, as well as how the demographics are associated with resilience endorsement, can provide valuable understanding to develop specific strategies to change people's perspectives towards water resilience and its principles. One way this can be done is by creating messaging and education programs that are relevant to different demographics or creating different messages for younger and older people. Other ways are by targeting certain political ideologies with particular initiatives or by focusing on enhancing how people bond with local water bodies in the community to help change individual perspectives. Doing these could lead to greater support for water resilience-based governance approaches. Research on leverage points (Meadows, 1999) has already indicated the potential of changing individual mindsets in order to effect transformational change. Adequately utilizing the knowledge generated by this study as described above has the potential to possibly help shift the mindset of those with low resilience endorsement perspectives.

4.6 Conclusions

Though freshwater ecosystems provide significant ecosystem services for humanity, they are currently experiencing serious crisis (Bates et al., 2008; Vörösmarty et al., 2005). Consequently,

a new water paradigm, a social ecological resilience-based governance focused on water resources (water resilience) has been proposed as been able to address these current and future water challenges. A water resilience approach acknowledges and considers the complex, dynamic and uncertain nature of social-ecological systems, and will ensure that the resilience principles are reflected in related policies, plans, and actions at all levels of society (Berkes & Folke, 1998; Folke et al., 2005). Important to the implementation of this approach however is the potential of individual agency and the ability to shift the mindsets of individuals to successfully implement this governance approach (Bandura, 2000; Cleaver, 2007; Meadows, 1999). Thus, gaining individual endorsement for water resilience and its principles (Biggs et al., 2012) is critical for facilitating strategies and policies to enable the substantive shift to a water resilience-based governance approach (Eriksson et al., 2014). A paucity of research in determining individual endorsement for water resilience motivated this study.

This study aimed to determine and measure the extent to which individuals endorse water resilience principles, and findings suggest that overall, the water resilience principles were endorsed to a medium level, but with lower endorsement in local than non-local contexts. The medium level endorsement actions appear to present the most agreeable actions to respondents which is consistent with research findings (Biggs et al., 2012, 2015). Based on the argument that the influence of individuals, as actors with agency, can be powerful forces for change (Abson et al., 2016), and armed with the knowledge of how they endorse the resilience principles, the government can develop initiatives and awareness raising programs that seek to enhance commitment towards water resilience based governance acceptance in local communities. The government can also adjust current policies and initiatives to reflect medium and high endorsement actions which have been selected by the greater proportion of respondents in the study.

There were differences in the endorsement of the principles with different vignettes depicting different water challenges, indicating that the context of the water challenge could also influence resilience endorsement. In addition, endorsement may be influenced by the concept of the resilience principles, with principles that are easier for respondents to perceive being easier for them to accurately endorse than principles that are harder to perceive. More research is needed for a better understanding of the individual principles, their interactions and how they can be applied practically in different contexts (Biggs et al., 2015). This is particularly relevant for principles for which a lack of conceptual clarity has made it difficult to generate understanding of how the principles enhance the resilience of ecosystem services (Biggs et al., 2015).

The study also aimed to determine how demographic factors are associated with endorsement measures and findings indicate sex, political ideology and water meaning are major predictors of individual resilience endorsement scores. Age, sex and water meaning emerged as demographic factors associated with overall endorsement with females, older adults and those who attached more meaning to water tending towards higher resilience endorsement. Evidence from this study also shows that high endorsers (those in the high endorsement group) tended to be female, more educated and attached more meaning to water than those in the low endorsement group. Low endorsers (those in the low endorsement group) however, tended to be male and attached less meaning to local water bodies.

The results of this study provide some important academic and practical implications for the resilience literature and the governance of SES more broadly. Academically, this study implies a need to focus on further understanding of the processes of each principle, how they impact resilience, and practical ways of defining and conceptualizing them in order to measure their impacts and enhance their practical application (Biggs et al., 2015; Ostrom, 2008; Ostrom et al., 2007; Walker & Meyers, 2004). This clarity and practicality will also improve the ability of researchers to better conceptualize and present the principles to respondents in future studies.

Policies and plans need public support for them to be feasible and successfully implemented (Betsill et al., 2020). Thus, understanding individual endorsement of water resilience would help policy planners and water managers to better understand people's perceptions of water resilience governance and the resilience principles. This would better inform policy formulation, information framing, messaging and education initiative efforts that identify and utilize individual demographic differences.

4.7 References

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5 Chapter Five: General Discussions and Conclusions

5.0 Thesis Summary

Fresh water resources are increasingly facing challenges and threats both locally and globally ranging from intense floods, droughts, water pollution, decreasing water safety and quality and water shortages (IPCC, 2018; Rockstrom et al., 2009; Rockström et al., 2014; Vörösmarty et al., 2013). These issues have caused concerns and have exposed the need to explore more flexible and effective ways of managing and governing freshwater water resources that overcome the challenges of the command and control approach to managing them (Bucknall, 2006; United Nations World Water Assessment Programme, 2003).

Over the years, a few governance approaches like the adaptive governance method, the co-adaptive governance method and the IWRM have been utilized as viable approaches to managing natural resources including freshwater resources. Despite their challenges, these methods have paved the way for a water resilience-based governance approach as a potential solution to these complex water challenges (Berkes & Folke, 1998; Folke et al., 2005). A water resilience approach will ensure that the resilience principles, which are a measure of the level of resilience in a SES, are reflected in water related policies, plans, and actions. Also important is the notion of individual agency, showing that individuals have the power to collectively bring about changes in society (Bandura, 2000; Betsill et al., 2020; Cleaver, 2007). It is also critical to recognize that one of the most effective ways to effect change is the ability to adjust the mindsets of individuals in line with the required shift (O'Brien, 2018; Meadows, 1999).

In this regard, gaining individual endorsement for water resilience principles (Biggs et al., 2012) is critical for facilitating strategies and policies to enable the substantive shift to a water resilience-based governance approach (Eriksson et al., 2014). However, little attention has been paid to determining the extent to which individuals endorse the concept of water resilience and this presented an urgent need for this study in the face of accelerating global water challenges. Due to its nature, resilience may not be interpreted as a single number or result (Walker & Salt, 2012); however, in this study, the seven resilience principles (Biggs et al., 2012) were used as a basis for quantitatively measuring the extent to which individuals endorse a water resilience-based governance approach. This thesis addressed the identified research gap by focusing on two objectives: (1) to develop a data collection instrument and methodology to measure level of resilience endorsement by individuals and examine the factor loadings of the resilience principles and (2) to determine the level of individual endorsement for water resilience principles in a case study and examine how demographic factors relate to and predict overall endorsement.

Chapter Three (Study One) addressed Objective One by developing a two-section vignette questionnaire and conducting one pilot study each in and outside the Town of Lincoln, Ontario. Some potential methodologies including the adaptive staircase method (Cornsweet, 1962), the conjoint analysis approach (Smith & Fennessy, 2011) and a traditional multiple-choice questionnaire method (Baird et al., in press) were considered and reviewed before the vignette questionnaire was selected as the most appropriate methodology for this study because of its ability to simplify the resilience principles in particular contexts (Hughes & Huby, 2004; Martin, 2006). The vignette questionnaire was developed to elicit responses to measure the endorsement for water resilience principles using descriptions of local and non-local challenging water events.

The questionnaire was determined to be reliable and the factor loadings of the resilience principles showed that they loaded on two distinct factors.

Chapter Four (Study Two) addressed Objective Two by administering the finalized version of the vignette questionnaire developed in Study One in an online survey to respondents in the Town of Lincoln, Ontario. The questionnaire collected demographic data (age, sex, income, religious attendance, education, political ideology, residence length and water meaning), and asked respondents to select and rank action statements that followed a set of three local and three non-local vignettes describing local and non-local water challenges. Statistical tests carried out to examine how the demographics of respondents related to overall endorsement showed that sex, age and water meaning were correlated with the overall scores, with females, older adults and those who attached more meaning to water tended towards higher endorsement scores. Also, sex, political affiliation and water meaning emerged as unique significant predictors of resilience endorsement. Those in the high endorsement group (high resilience endorsers) tended to be female, well-educated and attached more meaning to water than those in the low endorsement group (low resilience endorsers). On the other hand, those in the low endorsement group were predominantly male and attached less meaning to water than those in the high endorsement group.

5.1 Synthesis and Discussions

Developing an Instrument to Measure Individual Resilience Endorsement

Study One responded to the need to develop an appropriate methodology to determine the level to which individuals endorse the principles of a water resilience governance approach. This was in response to the complex disturbances being experienced in successfully managing freshwater resources using a command-and-control governance approach (Cox 2016; Holling & Meffe, 1996) and the potential of a water resilience-based governance approach to address these challenges (Pahl-Wostl et al., 2010; Schoeman et al., 2014). Individual agency and the potential for changing mindsets for transformational change (Meadows, 1999) are important elements for successfully implementing a water resilience-based governance approach (Dale, 2013; Osterblom & Folke, 2013). After considering other options like the adaptive staircase method (Cornsweet, 1962; Mangham et al., 2008), the conjoint analysis approach (Moore, 2004; Smith & Fennessy, 2011) and a traditional multiple-choice questionnaire method used in a related study (Baird et al., in press), a vignette questionnaire was selected as the most appropriate methodology. These methods have been successfully used in research in different fields, including marketing, psychology and medicine, to elicit perceptions and to determine perceptual thresholds (Cornsweet, 1962; Mangham et al., 2008; Smith & Fennessy, 2011).

Study One found that vignettes can be effective to measure individual resilience endorsement in particular contexts that allows respondents to define and interpret the vignette situations for themselves (Alexander & Becker, 1978; Finch, 1987; West 1982). A few challenges were experienced in the process of developing the vignettes for this study as follows: describing and contextualizing the resilience principles in particular contexts using neutral everyday vocabulary; developing single robust but brief vignettes and question options that addressed all seven resilience principles in a style that would prevent fatigue and boredom for the respondents; and applying the resilience principles to different types of water issues. The findings from Study One illuminated the potential of the vignette questionnaire methodology as a suitable quantitative

instrument for determining and measuring endorsement levels for the resilience principles, although further research is needed to overcome the identified challenges and confirm the results.

Study One also classified the resilience principles into two distinct categories: principles relating to the ecological properties and system dynamics of social-ecological systems (P1 to P4) and principles pertaining to the governance and social components of social-ecological systems (P5 to P7). This categorization differs slightly from Biggs et al (2012)'s categorization; however, the literature indicates that P4: Foster CAS Thinking, shares similar features with P1 to P3 and thus justifies this classification (Biggs et al., 2015; Jentoft et al., 2007). Biggs et al (2012)'s initial evaluation of the principles affirmed that their categorization of the principles was not set in stone, as an appropriate combination of the principles may depend on the particular context being considered as well as on how the principles are applied. They also acknowledge that other classifications of the principles may emerge from further research. However, further research is necessary as these results could be sample specific. This finding makes a unique contribution to the literature and will likely have implications for further evaluation and categorization of the resilience principles.

Measuring Individual Endorsement for Water Resilience Principles

Study Two addressed the interpretation and conceptualization of the resilience principles using a vignette questionnaire with action statements that measured resilience using quantifiable metrics. The vignette questionnaire was utilized to measure individual endorsement for the resilience principles in the Town of Lincoln. The Town of Lincoln was chosen because the ongoing increase in population, economic and agricultural growth in the town in recent years is causing increased stress on its water resources (Newsnow, 2018), and it is critical that Lincoln focuses on addressing these challenges.

Findings from the study indicate a considerable endorsement for water resilience principles, but with lower endorsement for Lincoln when compared to non-Lincoln. This was in contrast to the sense of place literature that indicated that a connection with a place usually leads to more pro-environmental behaviour (Liberman et al., 2007; Reser, 1995; Roszak, 1992). The study also found interesting variations in how the principles were endorsed for different vignettes depicting varying water challenges, indicating that endorsement is influenced by context, individual experiences, and the conceptualization of the principles (Biggs et al., 2015; Ostrom et al. 2007; Walker & Meyers, 2004).

Sex, political ideology and water meaning emerged as major predictors of individual resilience endorsement scores which is consistent with the pro-environmental literature (Bliuc et al., 2015; Jones & Dunlap, 1992; Tranter & Booth, 2015; Van Lier & Dunlap, 1980). Important demographic factors that emerged from the study as having significant associations with overall resilience endorsement include age, sex and water meaning, which also correlates with the literature, however, while this study found that older people endorse the principles more than younger people, the majority of research indicates that younger people show more environmental concern than older people (Blaikie, 1992; Dunlap et al., 2000; Van Lier & Dunlap, 1980). However, there are some studies that have found older people to be more environmentally friendly than younger people (e.g. Baird et al., in press).

5.2 Conclusions and Key Contributions

Due to the shortcomings of the command and control governance approach to effectively manage fresh water resources (Cox, 2016; Holling & Meffe, 1996; Resilience Alliance, 2010), several alternative governance approaches have been proposed, for example, the adaptive management, adaptive co-management and IWRM. Each of these governance approaches have contributed to creating a pathway for establishing an integrated systems governance approach that is able to focus on the complexity of the connections between the ecological and social domains of SES, and also has the potential to be more effective in managing disturbances and planning for change (Berkes & Folke, 1998).

The water resilience governance approach achieves these objectives and thus presents an important viewpoint for policy planners and water managers to have in dealing with both known and unexpected changes and disturbances in managing water resources. Successfully implementing the water resilience governance approach requires the endorsement (support and agreement) of individuals in society, who have agency and the ability for mindset shifts towards potentially effecting transformational changes (Bandura, 2000; Cleaver, 2007; Meadows, 1999). Policies and plans need public support for them to be feasible and successfully implemented as people will support and promote policies they agree with and even get others to support it too (Bestill et al., 2020).

This study contributes to the resilience scholarship by providing empirical evidence of quantitative measures of how individual endorse the resilience principles with regards to managing and governing water resources. Although water resilience is conceptually an emergent concept, developing a vignette questionnaire based on the seven resilience principles (Biggs et al., 2012) presented a viable basis to measure individual water resilience endorsement in practical water challenging situations. The development of the vignette questionnaire methodology in this regard makes a novel contribution to the resilience scholarship. It offers researchers a foundation for implementing further research with the intention of improving the measurement and understanding of individual endorsement for the resilience principles and to identify the demographics that influence individual endorsement.

The two factors that emerged from the study classifying the resilience principles into two distinct categories also makes a really important contribution to the resilience literature, as Biggs et al (2012) acknowledged that different categorizations of the principles may emerge from further research. This study has argued that Principles 4 can be classified as an ecological/system dynamic principle as it directly focuses on SES dynamics and an understanding of how ‘the system works’, rather than just being focused on how the system ‘is governed’. However, further research is necessary as these results could be sample and context specific. Still this finding makes a unique contribution to the literature and will likely have implications for further evaluation and categorization of the resilience principles.

Findings from the study also indicate a medium level of endorsement for the resilience principles, with lower endorsement scores for the local than the non-local contexts. This was in contrast with the sense of place literature, and further research is required to examine why place attachment did not positively influence individual endorsement of the resilience principles in the local context.

This study contributes to the growing body of knowledge on the importance and impact of individual mindsets and attributes as levers for effecting transformational change. There is now growing interest in and research on the potential of individual agency and the ability for system change to be achieved at the individual level (Abson et al., 2017; Betseill et al., 2020; Meadows, 1999; Scoones et al., 2020). Practically, an understanding of how different demographics endorse the resilience principles provides resource managers and policy makers with useful insights and information that can better inform how they can more effectively structure communication, education and community programs to address areas where positive change can be implemented with better rates of success (Holling, 2001; Meadows, 1999). For example, since this study has shown that a connection with local water bodies may positively influence endorsement, resource managers in the Town of Lincoln may focus on developing ways to restore better and stronger connections with local water bodies (Nisbet & Zelenski, 2013; Schultz, 2000). Also, initiatives directed towards males and younger people in the community may be different from those designed for females and older adults, but all geared towards helping to transform individual mindsets towards a desirable level of endorsement for water resilience governance.

Policy measures or actions intended to enhance individual endorsement for water resilience are likely to be more effective for different community subgroups depending on their current level of endorsement, therefore knowing the demographics of high endorsers in the community could provide a pathway for government to partner with the appropriate sub-groups in the community to help enhance overall resilience endorsement. Though the government is the key actor in policy development, current water challenges have highlighted the need for them to partner with a diverse range of actors including individuals in society, in order to be successful in governance (Betsill et al., 2020). Hence, partnering with, and utilizing the agency of the high endorsers will be useful in shifting the mindsets of the low endorsers, as high endorsers could provide useful insight into their own perceptions of water resilience to help in shaping more effective initiatives for low endorsers. By aligning policy impacts and outcomes with a community's endorsement, both the policies and the governance of the community's water resources can be dramatically improved.

Study One highlighted some important considerations in developing a vignette questionnaire and the importance of considering a range and combination of methodologies and instruments in resilience research. Study Two indicated the importance of clearly conceptualizing the principles in order to improve understanding and endorsement of them and showed that certain demographics endorse the principles differently. Overall, this thesis demonstrates the importance of understanding the endorsement of individuals for the resilience principles in order to improve water governance and management, as well as to inform other aspects of water management (e.g. formulating policies, creating education programs, framing messaging, etc.). It also reinforces the requirements for a range of perspectives to deal with the complex interactions that occur in social-ecological systems (Berkes et al., 2003).

5.2.1 Limitations of the Study

This research presents an innovative approach to determining individual endorsement for water resilience principles and contributes to the scant research in this area. As such, there are some limitations to the study. Limitations are restrictions or constraints to the research that are out of the researcher's control but that may affect internal validity (Ellis, 2009). While best efforts were

made to overcome the identified limitations, there are opportunities for future research to replicate and elaborate on this research and address these limitations.

First, the development of the vignettes and question options involved having to simplify the water resilience concept and the resilience principles to aid participants understanding. Consequently, there is the possibility of having oversimplified the resilience principles to aid understanding and to fit into the context of the vignettes, and this may affect how respondents viewed and perceived the principles. This challenge was also experienced in conceptualizing the principles, as Biggs et al (2015) highlighted that none of the principles are fully established, and more research is required to understand fully how each principle applies in different contexts.

Secondly, because this study was focused on one medium sized case study community in Canada, it cannot be assumed that the findings from the study can be generalized to other communities in or outside Canada (McLeod, 2008). Future large-sample national and international studies of individual endorsement for the principles of water resilience are needed to confirm these preliminary findings and enhance the understanding of individual endorsement of the resilience principles at a broader scale. Thirdly, the respondents for the study were recruited via a Facebook advertisement, and it is possible that respondents could be skewed towards only people with access to Facebook, however Canadians have been reported as the most active Facebook users in the world (Adweek, 2013), so this may not be a critical limitation.

Finally, there was little variation in endorsement as endorsement was measured over a 4-level scale with the majority of respondents choosing the medium or high endorsement actions. Future studies may consider expanding the range of endorsement options to increase this variability. Endorsement levels could include none, very low, low, high, very high; or other combinations of the endorsement levels could be used to increase variability

5.2.2 Recommendations for Scholarship, Future Research and Practice

This thesis aimed to contribute to research efforts towards social-ecological resilience with regards to water resources. Specifically, it contributes to the understanding of how individuals in society endorse water resilience principles and the demographics that influence and predict this endorsement. The results of this study have implications for the targeting of appropriate water related initiatives and adapting environmental messaging to be tailored to how individuals in the community endorse water resilience principles. Policy measures or actions intended to increase individual endorsement for water resilience are likely to be more effective when designed or tailored to different community demographic subgroups depending on their level of endorsement. Over the longer term, this study shows the potential for measuring individual endorsement of the resilience principles in different contexts. Based on the findings of this study, some suggestions and directions for research in the future are suggested in the following subsections.

Methodology for Measuring Individual Resilience Endorsement

This research contributes a methodology and data collection instrument for determining and measuring individual endorsement for water resilience principles. The adaptation of the vignette questionnaire to determine and measure individual endorsement of resilience is an important methodological contribution to resilience research since individual endorsement has not been

measured in this way previously. Also, conceptualizing the principles in the context of vignettes is a practical method of viewing the principles in action and thus elicits realistic responses. Accordingly, the conceptual framework presented in this study offers researchers a starting point to conduct surveys to collect information that will enable the measurement of individual endorsement for the water resilience principles in different contexts.

This research also enables future research opportunities in determining individual endorsement using a variety of other methods while comparing the different methods in a bid to improve the data collection and measurements. It would be desirable to test this vignette methodology in other communities of similar and different characteristics and a broad scale study can compare local and national results. The definition, conceptualization and classification of the resilience principles should continue to be refined in order to enhance their understanding, application in practice and endorsement. Each nuance of the conceptualization of the principles may reveal different factors that affect individuals' endorsement of the principles.

Future studies could explore multi-level vignettes that combine different kinds of water challenges and can explore how the principles are endorsed in single and multiple water challenging situations. In addition, the use of video simulation like virtual reality, may be a more effective way of presenting the vignettes to respondents, as it would illustrate a stronger 'real-life' experience and hopefully, elicit deeper meaning responses and more accurate endorsement scores. In addition, including a qualitative method like an interview might provide deeper insights into respondents' perceptions and endorsement of the water resilience principles.

Additional questions that could be included in further studies include confidence questions to elicit the level of confidence respondents have in their answers. It would also be valuable to probe the extent to which economics and costs influence endorsement. Given the fact that other factors like experience, psychological and environmental attitudes may have the potential to influence resilience endorsement, further research should take these factors into consideration while designing the study (Tanner, 1999). Acknowledgement and inclusion of these different factors might allow for more nuance in determining individual endorsement for the resilience principles.

Individual Endorsement for Water Resilience Principles

This research has provided initial evidence that individuals endorse water resilience principles to a medium level and has identified some demographic variables that associate with and predict this endorsement. Future research can further investigate how resilience is endorsed in varying contexts, while incorporating other factors, like personality and psychological factors, that may also influence resilience endorsement. It is also possible to test how endorsement changes in response to policy adjustments that reflect the resilience principles.

Recognizing the ability of individuals to effect change in society, it is important to get deeper insights into how this agency can be fully utilized to positively impact individuals' perceptions of a water resilience-based management approach. Hence, future research can probe if there are differences in agency for different demographics in society and how this can be utilized to influence endorsement for water resilience governance.

Though the sense of place literature generally hypothesizes that attachment to a place leads to pro-environmental behavior (Halpenny, 2010), this study found the opposite, and this requires further investigation. However, it is possible that this result is peculiar to the study sample. Therefore, more empirical evidence is needed to better explore the effect of location and sense of place on endorsement of the resilience principles. It is important to understand any differences in how individuals endorse the resilience principles in local and non-local contexts, how physical distance from a place affects endorsement, and how different demographic groups differ in their endorsement in different localities within the same region. This will further confirm the relationship of a sense of place attachment to endorsement of water resilience. Other questions to probe in future studies include, ‘is resilience endorsement static or does it vary over time?’, do different levels or types of sense of place (e.g., attachment to the municipality versus attachment to a specific natural area) play a different role in determining endorsement for the resilience principle?, ‘do different demographics display differences in sense of place and does this affect endorsement levels?’

It is possible that sense of place varies by communities or that certain peculiarities in the Town of Lincoln may have resulted in lower endorsement for the local area. It is also possible that respondents in this study viewed the water challenges as a universal issue, thus a local perspective did not affect their endorsement scores. It is also likely that respondents may have had more confidence in the ability of their local government than in the governments in the distant places to deal with these issues, thus the higher endorsement levels for non-local places. It is also probable that the high endorsement actions were viewed as more challenging to achieve and thus respondents chose more of the challenging actions for the non-local places than for their local environment. Answering these questions may generate a deeper understanding of any correlation between people’s relationship or attachment to a specific place and their willingness to endorse a water resilience governance approach for that place.

Future studies could frame the vignettes and the questions to focus on responses that reflect the community rather than the individual, to examine if a sense of place is more evident for community based rather than individual based perspectives. Further research can also test if endorsement differs in stressed and non-stressed water regions, and how this affects the effectiveness of a water resilience-based governance approach.

Based on the results of this study, it is recommended that, in promoting local water related initiatives, policy makers and planners in the Town of Lincoln need to align to the different demographics that emerged from this study. Policy measures or actions intended to improve water governance and to increase individual endorsement for water resilience are likely to be more effective for different demographics in the town depending on their current level of endorsement than communicating and messaging to a generalized audience. Hence, initiatives and interventions can be tailored specifically to speak to low endorsers and high endorsers separately. Future research could focus on gaining appropriate knowledge of common personality and psychological characteristics of different demographic groups that might allow the optimization of effects of intervention strategies tailored to improve endorsement. Further studies can also probe not only the degree to which individuals endorse water resilience and its principles, but also the reasons why they have endorsed the principles to the level that they have

by exploring the differences in endorsement for each principle in the local and non-local contexts.

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6 Appendices

6.0 Appendix 3: Appendices for Chapter 3

Table A.3.1: Ranking system used for determining individual endorsement levels with respect to the seven resilience principles proposed by Biggs et al. (2012). The system describes endorsement levels as (1) a lack of agreement with the principle itself; (2) endorsement of a ‘low level’ of the principle; (3) endorsement of a ‘medium level’ of the principle; and (4) endorsement of the principle to a ‘high level’.

Resilience Principle	Ranking Categories
1. Diversity and Redundancy Diversity (Ecological): Refers to the variety of ecological elements in a system e.g. species and landscape. Also refers to the population and proportion of the different elements. Redundancy (Ecological): ability of system components to substitute for other components (functionally and in response) Diversity (Social): a variety of social elements like government structures and approaches, cultural groups, stakeholder responses and livelihood options.	4 = A high presence of a variety of different species and/or landscape forms. 3 = A moderate presence of a variety of different species and/or landscape forms. 2 = A low presence of a variety of different species and/or landscape forms. 1 = No support for this principle – does not care about species or landscape variety. 4 = Substantial ability of system elements to substitute for other elements. 3 = Moderate ability of system elements to substitute for other elements. 2 = Low ability of system elements to substitute for other elements. 1 = No ability of system elements to substitute for other elements. 4 = Decision-making and planning incorporates a variety of stakeholder perspectives and interests; and there is a high diversity of livelihoods. 3 = Decision-making and planning incorporates some stakeholder perspectives and interests; and there is some diversity of livelihoods. 2 = Decision-making and planning incorporates few stakeholder perspectives and interests; and there is a low diversity of livelihoods.

Redundancy (Social): the ability of social elements to substitute for failing elements in the face of disturbances.	<p>1 = Decisions are made from the top down with little to no effort to incorporate stakeholder perspectives and interests. There is a lack of diversity of livelihoods.</p> <p>4 = Social elements are able to fully compensate for the failure or inability of other components in the system.</p> <p>3 = Social elements are able to somewhat compensate in certain aspects the failure or inability of other components in the system.</p> <p>2 = Social elements have minimal opportunities to compensate for the failure or inability of other components in the system.</p> <p>1 = There is no provision for elements of the system to compensate for the failure or inability of other components</p>
<p>2. Manage Connectivity</p> <p>Manage connectivity (ecological): refers to the ability of species to migrate, link, spread or interact across habitats and patches.</p>	<p>4 = The system components are well connected, and species easily migrate and interact across patches.</p> <p>3= the system components have some connections that allow species to adequately migrate and interact across patches.</p> <p>2 = The system components have minimal connections and species experience maximum difficulties in migrating and interacting across patches.</p> <p>1 = The system components are separate with no connections between them. Species and system elements are unable to connect, migrate or interact.</p>
<p>Manage connectivity (social):</p> <p>refers to the nature and strength of links between and within actors in the system</p>	<p>4 = There is maximum connectedness among different actors across vertical and horizontal scales; Connections are very closely tied that information flows adequately throughout the whole system.</p> <p>3=There is some connectedness among different actors across vertical and horizontal scales; Connections are closely tied that information flows fairly well throughout the whole system.</p> <p>2 = There is limited connectedness among different actors in the system; Connections are loosely tied that information flow is limited.</p> <p>1 = Connectedness among different actors is nonexistent.</p>
<p>3. Manage slow variables and feedback</p> <p>Manage slow variables and feedback (Ecological): Slow variables like soil</p>	<p>4 = Full systems in place to monitor and detect thresholds and feedback information is used to respond to changes in a timely manner.</p>

composition and changing climate are monitored for their closeness to thresholds. Feedbacks are monitored and they are strengthened and weakened as appropriate.	3 = Adequate systems in place to monitor and detect thresholds. Feedback information is gathered but is not organized or integrated in a timely manner into the decision-making process. 2=Weak systems to monitor and detect thresholds. Few feedback information is gathered and hardly integrated into decision making in a timely manner. 1 = No capacity to monitor and detect thresholds, hence no information to respond to feedback in a timely manner.
Manage slow variables and feedback (Social): Slow variables like values, legal system and legislations are monitored. They are acknowledged and incorporated into the long-term governance of the system. Feedbacks are monitored and they are strengthened and weakened as appropriate.	4 = Slow variables are very actively acknowledged and incorporated into the long-term governance of the system. Feedback systems are very strong. 3= slow variables are sometimes acknowledged and incorporated into the long-term governance of the system. Feedback systems are moderate. 2 = Slow variables are hardly recognized and hardly incorporated into the long-term governance of the system. Feedback systems are very weak. 1 = Slow variables are not acknowledged or incorporated into the long-term governance of the system. No feedback systems.
4. Foster an understanding of SES as CAS: Refers to a holistic system view acknowledging varied interactions and unpredictability. Decisions are made with the understanding that change and surprise are inevitable, and solutions are context dependent.	4 = Very holistic view of the coupled social and ecological systems. Decision making highly acknowledges unpredictability and surprise due to varied system interactions. 3= Moderately holistic view of the coupled social and ecological systems. Decision making acknowledges some unpredictability and surprise due to varied system interactions. 2 = Very weak view of the coupled social and ecological systems. Decision making hardly acknowledges unpredictability and surprise due to varied system interactions. 1 = Views social and ecological systems separately and does not acknowledge unpredictability in decision making.
5. Encourage learning and experimentation Refers to a willingness to learn and openness to experiment novel ways to deal with complexities and issues. Encourages	4 = Learning and experimentation are actively encouraged and incorporated into the decision-making process. Local knowledge is highly sought, and innovative ideas are pursued and embraced.

knowledge sharing among actors and across scales.	<p>3=Learning and experimentation are sometimes encouraged and sometimes incorporated into the decision-making process. Local knowledge is sometimes sought, and innovative ideas are sometimes pursued and embraced</p> <p>2 = Learning and experimentation are hardly encouraged and/or incorporated into the decision-making process. People are hesitant to accept innovation and change within the system.</p> <p>1 = Learning, experimentation, and change are discouraged and the systems in place tries to maintain the status quo.</p>
<p>6. Broaden Participation</p> <p>Relevant stakeholders (interested in or involved with the system) are actively engaged and able to provide applicable local and scientific knowledge in all stages of governance and decision making.</p>	<p>4 = The system highly encourages and creates systems for a high level of participation and involvement of all stakeholders in all the different decision-making stages.</p> <p>3 = The system encourages and creates systems for some level of participation and involvement of all stakeholders, but only in certain decision-making stages or certain issues.</p> <p>2 = The system has limited avenues for participation and involvement of stakeholders. Participation is very limited.</p> <p>1=The system lacks avenues for stakeholder participation.</p>
<p>7. Promote polycentric governance system</p> <p>The presence of multiple governing authorities at different scales with horizontal and vertical linkages. There is deliberation and decision making among multiple groups at different scales, each having different sources of authority. This allows decision making to match the scale of the problem.</p>	<p>4 = Institutions and governance include a great level of redundancy in their governance structures and there is a very good mix of multiple governing bodies and groups with authority.</p> <p>3 = Institutions and governance include some redundancy in their governance structures and there is a good mix of multiple governing bodies and groups with authority.</p> <p>2 = Overlap in governance and authority is weak and not clearly defined.</p> <p>1 = Institutions are rigid and governed from the top down with no redundancy in roles or overlapping authority</p>

Appendix A.3.2: Consent Form for First Pilot Study

Informed Consent

Please read carefully before proceeding to the survey.

Research Title: Determining Individual Endorsement of Water Resilience Principles – A Case Study of the Town of Lincoln

Principal Investigator: Dr. Julia Baird (Email: jbaird@brocku.ca)
Environmental Sustainability Research Centre, Brock University

Principal Student Investigator: Oluseyi Obasi (Email: so18xf@brocku.ca)
Environmental Sustainability Research Centre, Brock University

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study examining individual endorsement of the water resilience principles. You have been asked to participate because you are an English-speaking adult above 18 years of agesiding in Canada. This research will exclusively take place online. This study has received ethics clearance (REB # 17-192-BAIRD) from the Brock University Research Ethics Board, and is being conducted by a Masters Research Student in the Environmental Sustainability Research Centre (ESRC) at Brock University.

WHAT'S INVOLVED?

If you decide to participate in this research you will be asked to complete a multi-part, online questionnaire (please note you can skip any questions you are not comfortable answering). The questionnaire should take approximately 15 minutes to complete.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time before submitting the questionnaire. Should you choose to withdraw from the study, your data will not be used as part of the data analysis.

POTENTIAL RISKS AND BENEFITS

You may experience mild fatigue while completing the questionnaire. Please feel free to take a short break whenever you require one. If you are uncomfortable answering any questions, you may skip over them without penalty. We are primarily interested in general perceptions, so we will not be collecting personal information such as your name, telephone number, or email address. As such, your responses will be anonymous and confidential. We will however, be collecting some personal demographic information such as your age, income, education level, etc.

There are no direct benefits to participation. However, your participation will enable us to better understand how individuals endorse and perceive the water resilience principles. Your responses will also help us in pressing and updating the study questionnaire. As such, there may be broad, indirect benefits to participating in this study.

CONFIDENTIALITY

To maintain anonymity, we will not collect your name, email address, telephone number, etc. The information we collect from you in this study (your responses) will be coded using a random number identifier and kept on a password-protected computer/secure server. Data and records created by this project are the property of the principal investigator and the research team, and individual responses may only be accessed by the research team.

PUBLICATION OF RESULTS

You will have full access to the summary reports and results at the conclusion of the study via the Environmental Sustainability Research Centre website at <https://brocku.ca/esrc/>. Your right of access extends only to the data combined from all participants, and not to your individual data or the individual data of other participants.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

If you have any questions about this study or require further information, please contact the principal investigator or the principal student investigator using the contact information provided above. If you have questions about your rights as a research participant, please contact the Brock Research Ethics Officer in the Office of Research Services (905) 688-5550 ext. 3035.

CONSENT

I have checked the box below to indicate that I voluntarily agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time before completing and submitting the questionnaire. If you do not consent to participate, please select the "I do not wish to participate in this research study" option.

☐

I voluntarily consent to participate in this research study

☐

I do not wish to participate in this research study

Appendix A.3.3: Semi-Structured Interview Script Guide

Interview Questions:

1. Can you describe your experience completing the questionnaire?
 - Ease of understanding the questionnaire: language, instructions, flow, and relevance.
 - Length of the vignette/questionnaire.
 - Any suggestions for changes in the questionnaire?
2. What was your experience in ranking your options?
 - Easy or difficult to differentiate between options
 - Would you have preferred to just select one option rather than rank all the options?
3. Did your attention and concentration level diminish at any point during your completion of the questionnaire?
 - If yes, at what point and why?
 - If no, why not?
4. What are your perceptions of the vignettes?
 - Did you identify with any of the vignettes? How?
 - Was there a difference in the way you responded to vignettes that were specific to Lincoln and those not specific to Lincoln? If so, how were your responses different?
5. What factors influenced your choices?
 - Are your answers more related to your own personal likely reaction, or were you thinking more on how a community would respond, or are these just the ideal responses you would expect?
 - Do you think that your responses reflect the larger community?
 - Would you classify yourself as an urban or rural resident?
6. Do you feel that the issues raised in the vignettes are valid water related issues? If yes/no, why?
 - Have you personally felt the impacts of issues related to water: flooding, water pollution and/or drought
 - Do you have any particular water related concerns?
7. Do you have any other comments you would like to make?

Appendix A.3.4: Consent Form for Second Pilot Study

Research Title: Determining Individual Endorsement of Water Resilience Principles – A Case Study of the Town of Lincoln

Principal Investigator: Dr. Julia Baird (Email: jbaird@brocku.ca)
Environmental Sustainability Research Centre, Brock University

Principal Student Investigator: Oluseyi Obasi (Email: so18xf@brocku.ca)
Environmental Sustainability Research Centre, Brock University

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study examining individual endorsement of the water resilience principles. You have been asked to participate because you are an English-speaking adult above 18 years of age. This study has received ethics clearance (REB # 17-192-BAIRD) from the Brock University Research Ethics Board, and is being conducted by a Masters Research Student in the Environmental Sustainability Research Centre (ESRC) at Brock University.

WHAT'S INVOLVED?

If you decide to participate in this research, you will be asked to complete a multi-part questionnaire (please note you can skip any questions you are not comfortable answering) administered in person. The questionnaire should take approximately 20 minutes to complete.

In addition, you will be asked to participate in an interview which is expected to take approximately 15 minutes. The interview will take place immediately after completing the questionnaire and will be audio recorded. Interview questions will focus on your experience in completing the questionnaire, as well as your perceptions of the water resilience principles used in the questionnaire. The interview will be recorded using an audio recorder and transcribed for the purpose of analysis. Both your interview answers and the answers you provide to the questionnaire will be used to refine the study questionnaire.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time. Should you choose to withdraw from the study, the responses you provided will not be used.

POTENTIAL RISKS AND BENEFITS

Your participation will enable us to better understand how individuals endorse and perceive the water resilience principles.

You may experience mild fatigue while completing the questionnaire. Please feel free to take a short break whenever you require one. If you are uncomfortable answering any questions, you may skip over them without penalty. We are primarily interested in general perceptions, so we will not be collecting personal information such as your name, telephone number, or email address. As such, your responses will be anonymous and confidential. We will however, be

collecting some personal demographic information such as your age, income, education level, etc.

COMPENSATION

Participants who complete the questionnaire and interview will receive a \$20 Tim Horton's gift card. Compensation will be provided after the interview is completed, and will not be affected if you skip questions that you do not feel comfortable answering or if you withdraw from the study.

CONFIDENTIALITY

To ensure privacy, the questionnaire and interview will be administered individually in a mutually consenting non-public location. To maintain confidentiality, the information we collect from you in this study (your responses) will be coded using a number identifier without any identifying information and will be stored on a password-protected computer/secure server that will only be accessible to the research team. This will allow the investigators to refer back to the data if potential errors in the analyses are revealed, to reanalyze the data to gain further understanding of the variables measured and for future research purposes, or if further clarification is necessary after publication (i.e., following requests from other researchers). Data and records created by this project are the property of the principal investigator and the research team, and individual responses may only be accessed by the research team.

PUBLICATION OF RESULTS

You will have full access to the summary reports and results at the conclusion of the study via the Environmental Sustainability Research Centre website at <https://brocku.ca/esrc/>. Your right of access extends only to the data combined from all participants, and not to your individual data or the individual data of other participants.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

If you have any questions about this study or require further information, please contact the principal investigator or the principal student investigator using the contact information provided above. If you have questions about your rights as a research participant, please contact the Brock Research Ethics Officer in the Office of Research Services (905) 688-5550 ext. 3035.

CONSENT FORM

I have checked the box below to indicate that I voluntarily agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

☐

I voluntarily consent to participate in this research study

☐

I do not consent to participate in this research study

Appendix A.3.5: Finalized Questionnaire

Section One

Please answer the following questions.

Select the most appropriate option for Questions 1 to 9 below:

Q1. How old are you in years?

1. 18-24
2. 25-29
3. 30-34
4. 35-39
5. 40-44
6. 45-49
7. 50-54
8. 55-59
9. 60-64
10. 65+

Q2. Please indicate your sex

1. Female
2. Male
3. Other
4. Prefer Not to Answer

Q3. What is the highest level of education you have completed?

1. No certificate, diploma or degree
2. High School diploma
3. Apprenticeship or other trade certificate
4. College diploma
5. Bachelor's degree
6. Master's degree or higher

Q4. What is your average household income?

1. Under \$20000
2. \$20,000 - \$39,999
3. \$40,000 - \$59,999
4. \$60,000 - \$79,999
5. \$80,000 - \$99,999
6. Over \$100,000

Q5. Approximately how many years have you resided in the Town of Lincoln?

1. Less than 6 months
2. 6 to 12 months
3. 1-3 years
4. 4-6 years
5. 7 years or more

Q6. How important or meaningful are your local bodies of water to you, personally?

1. Very unimportant
2. Somewhat unimportant
3. Neither important nor unimportant
4. Somewhat important
5. Very important

Q7. On average, you attend religious services or a place of worship (aside from weddings, funerals, and the like):

1. Never
2. 1-3 times a year
3. Once a quarter
4. Once or twice per month
5. Once a week
6. More than once a week

Q8. Move the ball to the position that best represents where you stand in terms of your political beliefs.

Ext. Left Wing	left	neutral	right	Ext Right Wing
1	2	3	4	5

Additional Information: **Left-wing** believes that society is best served with an expanded role for the government (broadly favoring social reform and activist government). **Right-wing** believes that the best outcome for society is achieved when individual rights and civil liberties are paramount (broadly favoring social tradition and limited government).

Q10. Please provide your name and email address below if you wish to be included in the draw to win one of two \$200 Amazon gift cards.

QUESTIONNAIRE

Section Two

You will be presented below with details of different water related events and challenges in certain places around the world. Please thoroughly read the description of each scenario, and then answer the questions that follow. Based on each scenario, what options would you agree with from the options given? You will then be required to rank your selections in order of preference (where 1 is the most preferred option and 4 is the least preferred).

Non-Lincoln Vignette -G1

The *Amudarya River* flows through the territory of Central Asia (Afghanistan, Tajikistan, Turkmenistan and Uzbekistan). Water from the river is used for commercial fishing and irrigated agriculture (using water from the river for commercial farming). The river is managed by a regional government agency, the Water Management Authority. There has been a reduction in the number of fishes in the river over time, and some fish species are in danger of disappearing completely. Overfishing, as well as increase in water and chemical use for agriculture has led to deterioration in suitable fish habitat. This has resulted in disagreements between the fishers and farmers who use the water, and the government agency that manages it.

Source: (Schluter & Herrfahrdt-Pahle, 2011).

What should be done about the disappearing fish?

1. Allow fishers to continue to fish as usual and add fish to the river if needed.
2. Set a catch limit for the disappearing fish species only; fishers can still catch unlimited amounts of other fish species.
3. Give incentives and put some restrictions for fishers to stay within the catch limits for all fish species until they adequately recover.
4. Provide fishers with support and training for fishing the non-disappearing fish species, and to build skills for other professions.

How should decisions about water use in the river be made?

1. Let the government water management authority make all decisions based on their current knowledge and government resources available to them now.
2. Let multiple government agencies (including all agencies related to water) team up and work together to make decisions based on a selection and comparison of the knowledge available from all the different agencies.
3. Let the different government agencies compare and combine their expertise and knowledge with that of water related industries, business leaders and education institutions in the community.
4. Let everyone who is affected by and interested in the river, including community residents, community leaders, organizations, NGOs, education institutes, government agencies and industry representatives provide their viewpoint, expertise and knowledge to the decision making according to their expertise.

What should be done about fish habitat in the river?

1. Continue to allow fishing and water use for agriculture as usual and do nothing about fish habitats.
2. Identify the areas along the river that are in the worst shape for fish habitat and carry out targeted restoration work in those areas.
3. Carry out extensive fish habitat restoration to ensure that there are good linking passages along the river for fish to travel and consider putting limits on agricultural chemicals and water use during dry times of the year.
4. The water management authority should think about what the future of Amudarya River may look like (in terms of water quantity, quality and how changes in river structure might affect fish habitat). Based on the worst future situation imagined, carry out necessary fish habitat restoration work and limit chemicals and water use for agriculture along the entire river.

To what extent and how should information be shared among river users?

1. Each group of users (like fishers or farmers) should get and share information about the condition of the river within their own groups, and not from other groups.
2. Governments should share information about the condition of the river with the different user groups (e.g. with farmers or with fishers) separately.
3. Governments and the main user groups (fishers and farmers) should share useful information about the condition of the river with each other.
4. All users of the river and those affected by it (including community residents) should have clear ways and options to communicate and share information with each other about the river.

Fertilizer used in agriculture has been overflowing into the river, and if this continues over several years, it might lead to the growth of free-floating algae that will have negative impacts on the fish population and quality of the water in the river. Reversing this change might be very difficult. What actions do you support regarding this?

1. Allow fertilizer use to continue as usual, in order to maintain agriculture productivity.
2. The water management authority should contact farmers and provide guidance about when and how much fertilizer is used in the farms surrounding the river.
3. The water management authority should make monitoring guidelines and dedicate resources to **yearly** monitoring the river and fertilizer use, and later make regulations if needed.
4. The water management authority should make monitoring guidelines and dedicate resources to **monthly** monitoring the river to identify likely problem areas early and take action to ensure that fertilizer use does not go beyond acritical limit, and then make regulations if needed.

Some fishers are ignoring fishing regulations, and their actions may be contributing to overfishing. What should be done?

1. These fishers are a minority, nothing should be done.
2. Economic incentives should be offered to fishers to obey the current regulations.

3. A community monitoring system should be set up to periodically monitor compliance with regulations. Offenders should receive warnings, and then be fined if they continue to ignore the regulations.
4. A community monitoring system should be set up to continuously monitor compliance with regulations. Offenders should be fined when identified, with fines increasing with new offenses.

Those who make decisions about the Amudarya River should think about the river and how it is changing as...

1. Predictable (inevitable, not a surprise) and manageable with no or very little change to how the river is currently used.
2. Predictable (inevitable, not a surprise) and can be dealt with by focusing on specific ways the river is being used.
3. Slightly unpredictable (a surprise) and requires a good understanding of how people use the river, but still able to be managed and to continue to use the river for the same purposes in the future.
4. Sometimes unpredictable (a surprise) involving a whole lot of factors that can affect the quality and state of the river. People who make decisions about the river need to consider many different options for future use of the river.

The water management authority has been collecting information about the river for many years to help make decisions. What is needed going forward?

1. The water management authority likely knows everything they need to know to manage the river. They should continue to use what they know to make decisions.
2. The water management authority should continue to collect information about the river and use it to help make decisions going forward.
3. The water management authority should consider small changes to the ways in which they manage the river and learn from these 'management experiments', as well as from traditional knowledge of fishers and farmers.
4. The water management authority needs to be open to trying whole new ways of managing the river and collecting information about how well (or poorly) these new ways work to address potential changes to the river over time.

Who should be involved in river management and to what extent?

1. The government – in this case the water management authority - should have total control in management decisions and others (river users, the public) should receive information and provide input only when it is considered appropriate by the government.
2. The government should consult with river users on major decisions that will impact them, but day-to-day decisions should be made by the government alone.
3. The government should include different river users and the public at the early stages of decision making so that the river users and public have more influence over decisions.
4. The government should include a wide range of river users and the public at all stages of management, from determining the main concerns for river management through to implementing decisions, giving river users and the public equal power as the government in decision making.

In the current Amudarya River system, the water management authority is the only agency with authority over the river. They hold all the decision-making power. From your perspective, what would be the most appropriate governance structure?

1. The water management authority should keep sole authority over the river in all localities.
2. The localities, regions and provinces should have independent authority within their particular geographical locations.
3. The localities, regions and provinces should each have regulations and authorities covering their locations, but their regulations must be approved by the next higher government level (localities approved by provinces and provinces approved by regions).
4. Different groups, agencies and NGOs should have roles to play and authority within their own specialty and membership, e.g. fishers and farmers associations, NGOs, community organizations and the water management authority. The government should coordinate decision making with these local level groups.

Non-Lincoln Vignette -G2

Although there is abundant water in Taihu Lake of Southern China, its poor-quality means that most water in the Lake cannot be used as drinking water. This has been caused by weather drought conditions, severe industrial pollution, and some accidental water pollution events. Taihu Lake is connected to other river systems, and the water flow can be controlled with existing or future physical structures. Yixing City, China, has water supplied from Taihu Lake, however the amount of drinking water that meets the national quality standard is insufficient and restricted to only a few reservoirs, causing drinking water scarcity, especially during drought years. To make matters worse, water treatment processes are very expensive in Yixing City. The scarcity of drinking water has become a serious issue, requiring society's attention. The lake is regulated by the Taihu Lake Basin Water Resources Protection Bureau.

Source: Lou, Huang, Liu & Zhong, 2019

What should be done about the sources of drinking water in Yixing City?

1. Continue to depend solely on Taihu Lake since scarcity is most severe only during the drought months.
2. Make plans to construct one or two other drinking water reservoirs connected to Taihu Lake – water in these reservoirs will be treated.
3. Use other water reservoirs located away from Taihu Lake that have a different water source as alternative sources of drinking water for Yixing City.
4. While planning the restoration of Taihu Lake by addressing water pollution using natural remedies, start using other good drinking water sources to supplement Taihu Lake.

In terms of providing and being a source of knowledge for this issue, which of these options will be best for dealing with the water scarcity issue in Yixing City?

1. Since the Taihu Lake Basin Water Resources Protection Bureau already has data on the water quality issues, this information is enough to address the issue.
2. Let the Taihu Lake Basin Water Resources Protection Bureau get additional data and knowledge from other environmental organizations and NGOs active in the region on an 'as needed' basis.

3. Let environmental organizations and higher education institutions (researchers) provide the primary knowledge and research data, combined with the knowledge of the Taihu Lake Basin Water Resources Protection Bureau for dealing with the issues.
4. Let the Taihu Lake Basin Water Resources Protection Bureau combine its knowledge with data from ecological institutions, researchers, as well as local knowledge from the community and expertise of industry leaders, in order to deal with the issues.

6.0 To control water scarcity, Taihu Lake should

1. Stand alone; it should not be connected to other water sources in the city.
2. Be connected to all other water sources for inflow only, so that it can receive water especially during periods of low rainfall.
3. Be connected to all other water sources for both inflow and outflow, so that it can supply and receive water from the other sources.
4. Be connected to some water sources only, in order to reduce spread of polluted water. The remaining water sources should be stand-alone water reservoirs disconnected from Lake Taihu.

Concerning how water quality information from Taihu Lake is communicated, the best option would be....

1. Water quality information should continue to be shared by the Water Resources Protection Bureau to others as needed.
2. Water quality information should be discussed among those collecting it, and then shared to others as needed.
3. Water quality information should be centralized and shared openly with whoever wants to access it, but government agencies should be in charge of Taihu Lake water management.
4. Water quality information and discussions about Taihu Lake should be open to whomever wants to access it at any time, and specific opportunities should be put in place for interested groups and individuals to meet and discuss water quality concerns.

What could be done about pollution affecting water quality in the Lake?

1. Nothing. The residents are used to the issues and moreover, the Lake is so polluted that it may no longer be possible to restore it.
2. Develop systems to monitor and record the quality of different water sources and take action against pollution only when national water quality standards are not met.
3. Develop systems to both monitor and predict the quality of different water sources based on current knowledge. Make plans ahead to ensure national water quality standards are adhered to, based on these data.
4. Develop systems to monitor and investigate the long-term influence of global climate change, other weather conditions and human activities on the quality of water in Taihu Lake and take actions/make plans accordingly.

Based on the present situation, the best way for the Government to ensure Taihu Lake remains beneficial and valuable for the residents is to....

1. Continue with the current system – inadequate rules and regulations which are not properly enforced.

2. Make regulations that focus on water quantity by ensuring steady water supply to Taihu Lake to meet the reasonable demand of the local water users to alleviate the shortage of drinking water.
3. Make regulations that focus on water quality by promoting water purification technology to ensure safe water supply with adequate ongoing monitoring. This will protect the water environment and ensure safety.
4. Concentrate on enforcing laws and regulations for water quality and quantity by developing rigorous industrial monitoring and control systems and ensure defaulters are penalized.

In making decisions about Taihu Lake, decision makers need to consider that the present water issue is.....

1. Largely based on natural processes and can only be temporarily managed with little changes.
2. A human-caused event based on how the Lake is being used and can only be managed by focusing on specific human activities in relation to the Lake.
3. Caused by industrial development and rising population, leading to increased water demand. Can be managed by focusing on how to manage the growing demand for water.
4. Both a natural and human-caused event. Managing this should be based on identifying possible future scenarios and making trade-offs among many solution options.

With industrial development and rising population, the water demand in Yixing City is continually increasing. Since 2012, the Chinese government has spent a lot of money on research for the Taihu Lake Basin. What is needed going forward?

1. The government has spent so much on research already. They can probably stop research and concentrate on implementation.
2. The government should continue some similar research as before while implementing what they have already learnt from previous research.
3. There has been some research in other countries about new technology for managing similar issues. The government should experiment with this new technology.
4. Local scientists and researchers should experiment with several new technologies, learn from these experiments, and continue to improve approaches that are suited to Taihu Lake.

What level of contribution and participation should be involved in managing the Taihu Lake issue?

1. The government should make no outside consultations – they should handle the management and decision making alone.
2. The government should only consult with industry leaders and community heads, who will represent all other Lake users under their industry and area.
3. Lake users and local community groups should be involved in the early consultation stages only. They should not be involved in the final decisions and management stages.
4. There should be public participation and active engagement of all relevant stakeholders (Lake users, community groups, industries, institutions, NGOs, etc) at all stages of the decision making and management process.

The most appropriate governance structure for Taihu Lake is...

1. Solely governed by the Chinese government through the Taihu Lake Basin Water Resources Protection Bureau.
2. By officially approved joint-management between the Taihu Lake Basin Water Resources Protection Bureau and local environmental management institutions. The local environmental management institutions must get approval from the Taihu Lake Basin Water Resources Protection Bureau before making decisions or taking actions.
3. By officially approved joint-management between the Taihu Lake Basin Water Resources Protection Bureau and local environmental management institutions. The environmental institutions should have the power and authority to respond quickly to issues without getting approval from The Protection Bureau.
4. By officially dividing the power to make decisions between the Taihu Lake Basin Water Resources Protection Bureau and the local environmental management institutions. Each of them handles different aspects of the issues and has power to make decisions and take actions concerning the aspects they manage.

Non-Lincoln Vignette -G3

The Gomti River in India serves as a major source of domestic water supply for the city. Untreated domestic wastewater from the city is dumped in the river, along with industrial waste from surrounding industries. The river is fed by groundwater and also receives water overflow from agriculture activities in surrounding farmlands. Studies have found that the water is unfit for drinking and some fish and other aquatic species are in danger of disappearing completely. The river is managed by the National Rivers Conservation Program (NRCP), and the city residents would like these issues to be addressed.

Source: Singh, Malik & Sinha, 2005

What should be done about the aquatic life in the river?

1. The focus should be on water quality for drinking; other organisms in the water don't matter.
2. Attempt to address algal blooms (resulting from pollution) and hope that existing species recover over time.
3. Address the conditions causing the algal blooms and build up existing fish species over the short term.
4. Proactively deal with algal blooms by whatever means necessary to quicken the recovery of fish and other organisms living in the river.

What kind and combination of knowledge should be used in managing the Gomti River issues?

1. Let the National Rivers Conservation Program (NRCP) use their current knowledge and experience to address the issues of the Gomti River.
2. Let the NRCP consult with similar government agencies in other cities and provide solutions based on this combined knowledge.
3. Let the NRCP consult with groups with technical expertise and knowledge (engineers and ecologists) to provide the necessary solutions for the Gomti River.

4. Bring together different knowledge, expertise and disciplines including engineering, environment, ecology, management, Government and the community to develop the structures and approaches to develop and manage the Gomti River.

6.0 Decreased rainfall and weakening connection with neighboring rivers has reduced the amount of groundwater flowing into Gomti. What should be done about this?

1. Rainfall will eventually be normal again, so nothing should be done.
2. Look for a remote water source to feed Gomti during the period of decreased rainfall.
3. Limit the amount of water that flows out of Gomti River for agriculture and other industrial uses.
4. Increase the connections to the neighboring rivers that flow into Gomti River.

What kind of local level interactions would be most beneficial for those affected by Gomti River?

1. Residents and users should seek information from their families and friends.
2. Residents should be able to get essential information from the government office on an 'as need to know' basis.
3. Residents and users should form dedicated community-led research and information groups that source and get information and advice for the residents.
4. All users of the river should have meetings and forums available, to be able to get and share information and advice about the river on a regular basis.

What could be done about industrial pollution?

1. Allow continued dumping of industrial waste as the industries have no other options.
2. Have pollution control requirements for monitoring, record-keeping, and reporting, and implement penalties for industries. Additionally, require industries to monitor themselves.
3. Provide alternatives for industrial waste. Then strictly monitor all industries and prohibit dumping of waste only when waste dump limits (100% of limit) are reached.
4. Provide alternatives for industrial waste. Then strictly monitor all industries and prohibit dumping of waste when a certain waste dump level (about 75% of limit) is reached.

The following actions will encourage better treatment of Gomti River

1. Acknowledge feedback information on how the river is being treated, but do not act on the feedback.
2. Inform residents and industries that there will be stricter changes to existing regulations, in order to encourage better treatment of the river.
3. Adjust existing regulations to be stricter (including warnings and fines) and set a time in the future to start implementation.
4. Adjust existing regulations to be stricter (including warnings and fines) and start implementation immediately.

Based on your knowledge of similar situations, you think that the present condition of, and changes in the Gomti river may be

1. Not surprising at all and the worst changes may be over. Such situations can easily be managed by enforcing existing policies.

2. A bit of a surprise but the worst changes may be over. Such issues can be managed by making and enforcing stricter policies focused on the major problem areas.
3. Unexpected and may become worse over time. In such situations, people and industries may have to change their actions towards the river.
4. Complex as a result of different activities and events that may occur. In such situations, new problems are likely to arise, and managing and restoring the river may require changing people's mindset, behavior, actions and the way the river is managed.

The National Rivers Conservation Program (NRCP)'s previous plan to restore the river was unsuccessful. However, there is a new Director and team in place. The best way forward is to.....

1. Abandon the plan of the former regime. The new team should use ideas from their previous positions and not consult with the old team about lessons learned.
2. Adjust the old plan based on recent monitoring data about the river as well as knowledge of the new team.
3. Experiment with a new approach/technique that recent research suggests could be very likely to succeed but also likely risky too.
4. Test two or three new approaches/techniques that recent research suggests could be very likely to succeed but also likely risky too. Choose the best method from the test based on learnings and adjustments from the river monitoring data.

After a plan of action has been agreed, what level of participation is required during its implementation?

1. Carry on with implementing the plan. No need for any further engagement, contribution or consultation in carrying out the plan.
2. Ask for public contribution as a formality – implementation planning will not be affected or amended based on their contribution.
3. Get further contributions and involvement from only the experts involved in the day to day implementation of the plan.
4. Hold public consultations to collectively agree on the steps of the plan for all stages of the plan implementation.

The Gomti River cuts across local, provincial and regional territories, each with a different authority level. There is now a conflict in determining the most appropriate way for the river to be governed.

1. The governing authority belongs solely to the region, which has the highest authority level. They make and enforce the regulations themselves.
2. The region, which has the highest authority level, makes the regulations but the power to enforce and implement all regulations is given to the province only.
3. The region, which has the highest authority level, makes the regulations but the power to enforce and implement all regulations is given to each affected locality independently.
4. The region, which has the highest authority level, makes the regulations and gives power to enforce and implement all regulations to the province. The province allocates authority to each affected locality separately.

Town of Lincoln Vignette - L1

Konkle Creek in Beamsville has experienced very serious flooding and erosion, resulting in an unhealthy habitat for the fish species and an unstable trail that is unsafe for the public. The creek has some vegetation and woody debris that has built up over time, acting as a barrier to fish passage. The pathway along the creek has been closed to the public and the town plans to repair the damage before the trail can be reopened to the public. The Town of Lincoln Council is in charge of decision making concerning the Creek.

Source: Town of Lincoln, 2018.

If the number of fish and other aquatic species in the creek reduced drastically.....

1. It wouldn't really matter.
2. It might be a problem for some people, but I'm not really that concerned about it.
3. It could be a problem and I think it would be worth considering options to improve their habitat in the creek.
4. It would definitely be a problem, and their habitat should be restored.

How should decisions about the creek be made?

1. Let the Town Council maintain control and make decisions concerning the creek rehabilitation and management.
2. Let council-appointed boards and committees give input and recommendations on minor decisions, but the council maintains control and decision-making authority on major decisions.
3. Let all decisions be taken by a team of members of the Town Council, council-appointed committee members and community leaders in the Town.
4. Let everyone who is affected by the creek be involved in decision making, including community residents, community leaders, community organizations and NGOs, as well as the Town Council and industry representatives.

What should be done about fish movement and passage in the creek?

1. Do nothing. Keep the creek as it is.
2. Remove woody debris that has obstructed fish passage where absolutely necessary.
3. Investigate the fish species and their needs before considering options to improve fish passage through the creek. Take actions that fit the needs of the most important fish species.
4. Investigate the fish species and their needs before considering options to improve fish passage through the creek. Take actions to suit all fish species that are likely to inhabit the creek.

The proposed trail will improve the level of connection to different parts of the community. However, residents have raised safety, maintenance and privacy concerns regarding the location of the new trail. To what extent should these connections be maintained in the light of these issues?

1. The trail should be relocated to the opposite side of the creek to improve safety and privacy, even though it might reduce the level of connection to different parts of the community.

2. The trail should be relocated to the opposite side of the creek to improve safety and privacy, and additional foot bridges should be constructed, with additional funding, to help connect communities to the trail.
3. Fix the existing trail and construct a fence to protect the affected properties, as requested by property owners. This will discourage trespassing and help with privacy, but fair level of connection will be maintained.
4. Fix the existing trail with no barriers or fences to restrict entry, to maintain the advantage of the ability for people to connect easily to different parts of the community.

What can be done about the rate of flooding and erosion in the creek?

1. The flooding and erosion should be dealt with only when the impacts are noticed, and not incorporated into the long-term plans.
2. The flooding and erosion rate should be monitored yearly, and records maintained but no long-term planning made based on the monitoring.
3. The flooding and erosion rate should be regulated and monitored twice a year. Action should be taken for temporary fixes based on short term planning.
4. The flooding and erosion rate should be regulated and monitored monthly. Active long-term plans should be made on how to correct issues as soon as they occur.

Some common community behaviors like littering have been identified as causes of fish habitat blockage and flooding. What should be the response to this information?

1. It is important to maintain current community behavior; hence nothing should be done.
2. Examine how this behavior may actually affect future flooding and other problems in the creek; then note what possible changes may need to be made, what residents feel about possible changes, and the level of changes they are prepared to make or not.
3. Determine desired values and behavior changes; communicate and educate residents on behavior and value changes to focus on.
4. Determine both the action and behavior changes that may need to be made and educate and guide residents on engagement with these actions.

In managing the creek, decision makers should consider that

1. Simply better controlling stormwater will prevent serious erosion in the future.
2. Better stormwater protection and increasing the number of plants and trees along the creek would prevent serious erosion in the future.
3. Better stormwater protection through more natural approaches such as wetlands and planting more plants and trees along the creek and encouraging landowners to voluntarily use good stormwater management practices around the creek would prevent serious erosion in the future.
4. Better stormwater protection through a combination of infrastructure and more natural approaches such as wetlands and growing more plants and trees along the creek is a good start for preventing serious erosion in the future. We also need to find effective ways (e.g., incentives, penalties) to change landowners' behavior and actions around the creek.

The Town Council has been gathering information about reconstructing and managing the creek for many years now. What is needed going forward?

1. The Council has gathered enough information and should use the information they have to make decisions.
2. The Council should continue to collect information to help their decision making, especially from other methods that have been used in the past.
3. The Council should take major learnings from methods used in the past. These learnings should be combined with traditional knowledge for decision making.
4. The Council should make necessary changes to the past methods and combine this with new approaches and techniques.

Who should be involved in decision making and managing the creek, and to what extent?

1. Residents should be able to view information about the proposed rehabilitation works on the Town's website or in the local paper and will have 30 days to submit concerns and comments.
2. There should be a public information centre (PIC) where the Council will present its decisions and rehabilitation plans and options, including preferred option, to the residents. The PIC will be a courtesy to residents and will not be used to make decisions.
3. There should be a public discussion between the Council and residents, with decisions made based on new issues. No changes should be made to previous decisions.
4. There should be a public discussion between the Council and residents, with decisions made based on joint agreements. Required changes can also be made to any previous related decisions.

Currently, the Town Council has authority and decision making power over the creek. From your perspective, what would be the most appropriate way to oversee the management of the creek?

1. The Town Council should have sole authority over the creek.
2. The Town Council should appoint some privately managed organizations to be in charge of managing specific aspects related to the creek (e.g. debris maintenance, habitat maintenance, etc).
3. The Town Council should collaborate with appropriate NGOs who will be in charge of aspects related to their own objectives (e.g. NGOs focused on fish, habitat, landscape, etc).
4. Different community groups, private institutions and NGOs should work together, by being given different power, roles and responsibilities as regards the Creek.

Lincoln Vignette - L2

In 2015, the Town of Lincoln experienced severe back-to-back spring rain storms, which, coupled with high water levels in Lake Ontario, caused serious flooding and erosion damages to the waterfront, shoreline and nearby roads. The flood caused washout damages to the shoreline and roads, eroding paths and portions of Lakeshore road. This resulted in damages of about \$1 million and led to the Town's first-ever voluntary evacuation notice for about 50 houses near the shoreline. Sections of roadway had to be closed temporarily to protect public safety. Due to

disruption of fish habitat, there was an overflow of fishes onto the banks of the Lake. Reports have indicated that Lake Ontario's high-water levels may continue to be an issue for flooding along the shore and the town is continuing to work to reduce impacts of the floods.

Source: Town of Lincoln 2019

What should be done about aquatic habitats along the shoreline?

1. The focus should be on the flooding and erosion issues, and not on aquatic organisms.
2. Consider options to improve aquatic habitats in the near future.
3. Identify the worst affected aquatic habitats and carry out targeted restoration work in those areas.
4. Start an extensive aquatic habitat restoration program to improve fish and other aquatic habitats.

In flood situations like this, the responsibility for emergency response should:

1. Be solely left to the government agency and officials that have the required technical expertise and knowledge.
2. Be the joint responsibility of different government agencies with shared and overlapping roles, each being able to stand-in for the others in emergency situations.
3. Be the joint responsibility of different government agencies and private sector organizations with each having separate and shared roles and are being able to stand-in for one another in emergency situations.
4. Involve **partnership** of different government agencies with NGOs, the private sector, communities, and individual citizens who can step in if any other group is unable to respond.

The habitat for fish and other water organisms is damaged when erosion and flooding occurs, and this damage is most severe in specific locations along the shoreline. What do you feel is an appropriate response?

1. No response required. I am most concerned about the impacts on flooding to the community.
2. Targeted restoration efforts would be appropriate after all community flood recovery efforts are complete.
3. Targeted restoration efforts are appropriate and should be considered as part of the flood recovery planning.
4. Habitat that is more prone to disturbance by flooding should be identified and protected prior to flooding. Restoration required after a flood should be undertaken with all other recovery efforts to ensure habitat is available to fish and other water organisms.

The best arrangement for information flow and communication in the community during flooding situations should be that.....

1. Government agencies should only communicate with the community on the issues they are responsible for on an as-needed basis, determined by that government agency.
2. Government agencies should be communicating with limited representatives of the community (such as businesses, residents, community groups) as needed and these representatives should be in charge of communicating back to the government agencies.

3. There should be formal ways in which communication about information and ideas for flooding preparedness and response happens in the community (including with government agencies).
4. There should be formal and informal ways in which communication about information and ideas for flooding preparedness and response happens in the community, with government agencies, regardless of whether or not a flood is anticipated.

Most models indicate that water levels in Lake Ontario are likely to continue to rise, along with the risk of flooding. Based on this information,

1. Plans should be based on historical data and not models predicting the future that may not be accurate.
2. Water levels should be occasionally monitored over time and the trend should be considered when contemplating next steps.
3. Water levels should be regularly monitored, and the feedback and trends should be applied in developing short term flood management plans.
4. Water levels should be closely monitored and short and long term flood management plans should be developed based on the feedback of likely risks and the data from the models.

Projections for the next century show continuous water level rise and increases in precipitation severity leading to more severe flooding. How should the community react?

1. Since these changes will occur over a long period of time, it should not affect the current municipal policies.
2. Plan to make only minimal policy adjustments if it is required.
3. Propose some required policy changes and test community preparation and acceptance of these changes.
4. Examine how this information may affect current municipal policies; plan to make all required changes and integrate these changes.

Based on predictions of rising precipitation and water levels, the best mindset for decision makers in preparing for potential future flooding will be...

1. To see the situation as normal and manageable; we can manage the impacts through infrastructure and emergency management plans.
2. To plan to develop coping strategies for specific flooding situations as they arise with an integrated approach that considers different possible solutions.
3. To evaluate a range of possible flooding situations (best and worst case) that could occur, a wide range of impacts, and explore a combination of approaches that include infrastructure needs, emergency plans and policies.
4. Evaluate a range of possible flooding situations (best and worst case), with a view that new unexpected issues may also arise, and impacts are uncertain. Explore possible adjustment arrangements that could be made among a range of the possible solution approaches.

I believe that...

1. We already have the information and knowledge we need to address flooding and related issues.
2. We should be open to new technologies and ideas from other places that have been well-tested to address flooding and related issues.
3. We should seek out new technologies, techniques and ideas that may not yet be well tested, and experiment with them on a small scale to assess their potential to provide solutions to flooding and related issues.
4. We should encourage knowledge sharing and experimenting with new techniques and management approaches that have the potential to provide solutions to flooding and related issues, learn from these experiments and implement successful ones on a larger scale.

The community should be involved in making decisions around the issues of flooding as follows:

1. Involving community members by informing them of decisions already taken and actions that are required of them.
2. Engaging and involving community members in a consultation process about decisions to be made.
3. Engaging and involving community members in only the earliest phases of identifying solutions and making decisions.
4. Engaging and involving all concerned and interested community members in all the phases of identifying solutions and making decisions.

The most appropriate management structure for flood preparation and response planning would be that...

1. Responsibility for developing and coordinating the plan should be overseen by an appointed dedicated Flood Emergency Management Coordinator office at the municipal level.
2. Responsibility for developing the plan should be overseen by the provincial government independent of the municipality, but coordination and implementation of the plan should be carried out and overseen by the municipal government.
3. Responsibility for developing the plan should be overseen by both the provincial and municipal government, with each having separate authorities, roles and responsibilities.
4. Responsibility for developing and coordinating the plan should be overseen by a committee of key officials from different government agencies and other relevant organizations across the local and provincial level, participating together in the development and coordination of the plan.

Lincoln Vignette L3

2016 was a record breaking dry year for Niagara, including the Town of Lincoln, caused by an extended period of below-normal precipitation (rainfall). The Town's drought was represented by intense heat, insufficient soil moisture and surface water to meet the needs of crops, thus affecting crop and fruit growth, and irrigation water available for farmers. Most tender fruit crops suffered and even growers that had access to irrigation to maintain crop quality, had difficulty keeping up with demand. Researchers suggest that climate change may result in more extreme

weather which may result in more reduced precipitation and drought. Many farmer organizations, including the Ontario Tender Fruit Growers and the Ontario Fresh Grape Growers' Marketing Board are working in collaboration with the Government to reduce the impacts of drought on their yields.

In order to reduce the impact of the drought on fruit yields, farmers should:

1. Concentrate on planting *only* the key or dominant fruit species variant that produces the most yields and stop the planting of vulnerable species until after the drought has passed.
2. Plant different variants of the key or dominant fruit species, with the intention that a failure of any one or a few variants would not have disastrous impacts on the total yields.
3. Focus on planting both the key or dominant fruit species as well as the most suitable species that is the best substitute for the key/dominant species in case of dwindling yield of the dominant species.
4. Plant a variety of different fruits (including dominant and non-dominant), with the intention that a failure of any one fruit would not have disastrous impacts on the total yields.

In the face of dwindling farm yields, and to protect farmers in case of future drought situations, it is best to:

1. Allow farmers to continue to farm as usual and provide financial support as much as possible.
2. Provide farmers with social programs support and training to diversify into different farming methods, to improve production yields.
3. Provide farmers with support and training to improve production yields as well as to build skills in other alternative farming related professions and livelihood options.
4. Provide financial incentives for farmers to train for and engage in alternative non-farming related livelihood options and continue to provide support and training to improve farm yields.

When a drought occurs:

1. Each farmer should use the water already available to them – no new infrastructure should be created for farmers to irrigate.
2. Farmers without access to any water for irrigation should be provided with an opportunity to access water when needed (by permit from Lake Ontario or by accessing a connection to the water distribution system of the municipality – whichever option makes more sense), but the responsibility is on them to access it (via new infrastructure, etc).
3. Farmers should have access to irrigation water and a priority should be placed on this by governments, farmer associations, and others to support farmers in accessing water when needed.
4. Farmers should be supported for access to irrigation water (for those that do not have access) to a certain point, but if a drought persists, it is important to be aware of other uses, including the needs of the ecosystem and reduce availability as needed.

The best arrangement to facilitate collaboration and how information, ideas and resources about the drought situation flow among farmers and the larger community should be

1. Each local farmer group (based on location or type of produce) should share information and ideas with only members of their own local groups.
2. The representatives of the local farmer groups should act as mediators and intermediary between the government and the farmers.
3. Different local farmer groups (based on location or type of produce) should have formal and informal communication mediums to share information with the government and between the different groups.
4. There should be a stakeholder forum where all farmers and farmer groups could meet to discuss among themselves and with government officials.

If irrigation is not a feasible option for farmers, what action should they take given that climate models predict increased extremely hot days, less precipitation in summer?

1. Nothing, this is just a cycle and will pass
2. Keep an eye on predictions and purchase crop insurance in case of drought conditions
3. Carefully consider options (planting other varieties more suited to dry conditions, water conserving practices) while continuing to farm.
4. Consider a set of options including different varieties of produce, water conserving practices and the effects of long-term drought on the success and performance of farming operations and choose the most viable option

With climate models predicting more prolonged drought periods and less summer precipitation making it difficult for farmers to produce crops, what forms of support should be provided?

1. Farmers should be prepared to endure through the expected drought periods.
2. Complete a risk assessment and impact analysis related to expected drought and create an awareness program to inform and enlighten farmers of the facts and likely consequences.
3. Develop an education program to train farmers on coping strategies, less water intensive agricultural practices and to encourage them to adapt these new practices.
4. Adopt a range of approaches including education, funding, advice, regulations, monitoring and feedback mechanisms to shift farming practices towards more drought-friendly practices.

In managing such drought situations, decision makers should consider

1. That droughts happen periodically and extra financial funding support for farmers may be needed during these times.
2. That drought mainly affects food production; hence it is important to focus on appropriate farming practices that can boost production during these times.
3. That due to a range of factors, it may be difficult to predict the intensity or timing of droughts, hence it is best to adopt a structured process of exploring and evaluating different possible scenarios and solutions.
4. That droughts are caused by a range of factors that also impact food production and other aspects of social life. Likely solutions need to consider both the effects on food production as well social life.

Farmers are eager to learn about effective practices and ways to cope with predicted future drought trends. To do this, they should:

1. Continue with current farming practices and wait for the government to tell them what to do next.
2. Seek out and learn from related research carried out by specialist agencies and university researchers and apply lessons learned as small modifications to current practices.
3. Try out alternative farming practices on different scales and then observe and compare outcomes with current practices.
4. Create a learning hub where farmers reflect on their experiences and share ideas/recommendations with one another. Farmers can adjust and experiment with farming practices learned from each other's experiences and ideas/recommendations.

Who should contribute to and participate in decision making during drought events and to what extent?

1. The government and its relevant ministries should be solely involved in making decisions, which are then communicated to the community.
2. The government should consult with the leadership of the Ontario Tender Fruit Growers, the Ontario Fresh Grape Growers' Marketing Board and leaders of other farmer organizations in the decisions making process.
3. The government should collaborate with individual farmers and grower groups in the decision making process.
4. The government should collaborate and consult with farmers, growers, community residents, researchers, industries and everyone affected by the drought to make decisions before decisions are made.

The most appropriate governance approach and decision-making authority should be:

1. Immediate and sole decision-making authority should rest with the Town's department that has authority and responsibility for farming and drought issues.
2. The Niagara Peninsula Conservation Authority should make the decisions in consultation with the Niagara Region and the Town, while conforming with provincial and regional requirements.
3. The Niagara Peninsula Conservation Authority should make the decisions in collaboration with the Niagara Region and the Town, while conforming with provincial and regional requirements.
4. Jointly made by government agencies (municipal, regional) and the Niagara Peninsula Conservation Authority with input from other relevant organizations and associations. These groups should operate in coordination with each other and report to the Provincial government.

6.1 Appendix 4: Statistical Results for Chapter 4

Table A.4.1: Summary Demographics of Study Respondents ($N=215$)

Demographics	Frequency	Percentage
Gender		
Male	58	27.6
Female	152	72.4
Age		
18-24	27	12.7
25-29	31	14.6
30-34	29	13.6
35-39	28	13.1
40-44	21	9.9
45-49	16	7.5
50-54	19	8.9
55-59	8	3.8
60-64	14	6.6
65+	20	9.4
Education		
No certificate, diploma or degree	1	0.5
High School diploma	38	17.8
Apprenticeship/other trade cert	11	5.2
College diploma	61	28.6
Bachelor's degree	80	37.6
Master's degree or higher	22	10.3
Average household income		
Under \$20000	17	8.3
\$20,000 - \$39,999	17	8.3
\$40,000 - \$59,999	34	16.5
\$60,000 - \$79,999	27	13.1
\$80,000 - \$99,999	39	18.9
Over \$100,000	72	35
Years in Lincoln		
Less than 6 months	14	6.7
6-12 months	5	2.4
1-3 years	40	19.0
4-6 years	25	11.9
7 years and above	126	60.0
Political Ideology		
Ext. left wing	19	9.0
Left wing	53	25.1
Neutral	67	31.8
Right wing	57	27.0
Extreme right wing	15	7.1

Water Meaning		
Very unimportant	0	0
Somewhat unimportant	0	0
Neither important nor unimportant	9	4.3
Somewhat important	55	26.2
Very important	146	69.5
Attendance of Religious Activities		
Never	108	51.7
1-3 times a year	43	20.6
Once a quarter	5	2.4
Once or twice a month	13	6.2
Once a week	29	13.9
More than once a week	11	5.3

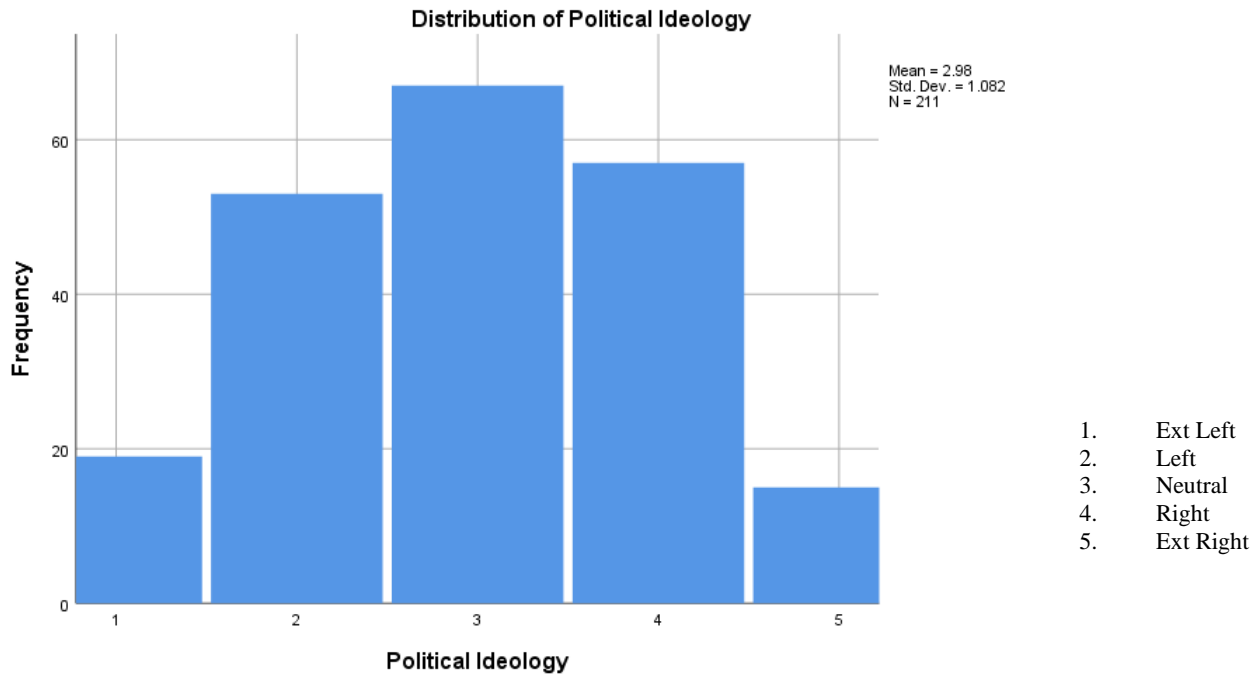


Figure A.4.1. Histogram of political ideology distribution

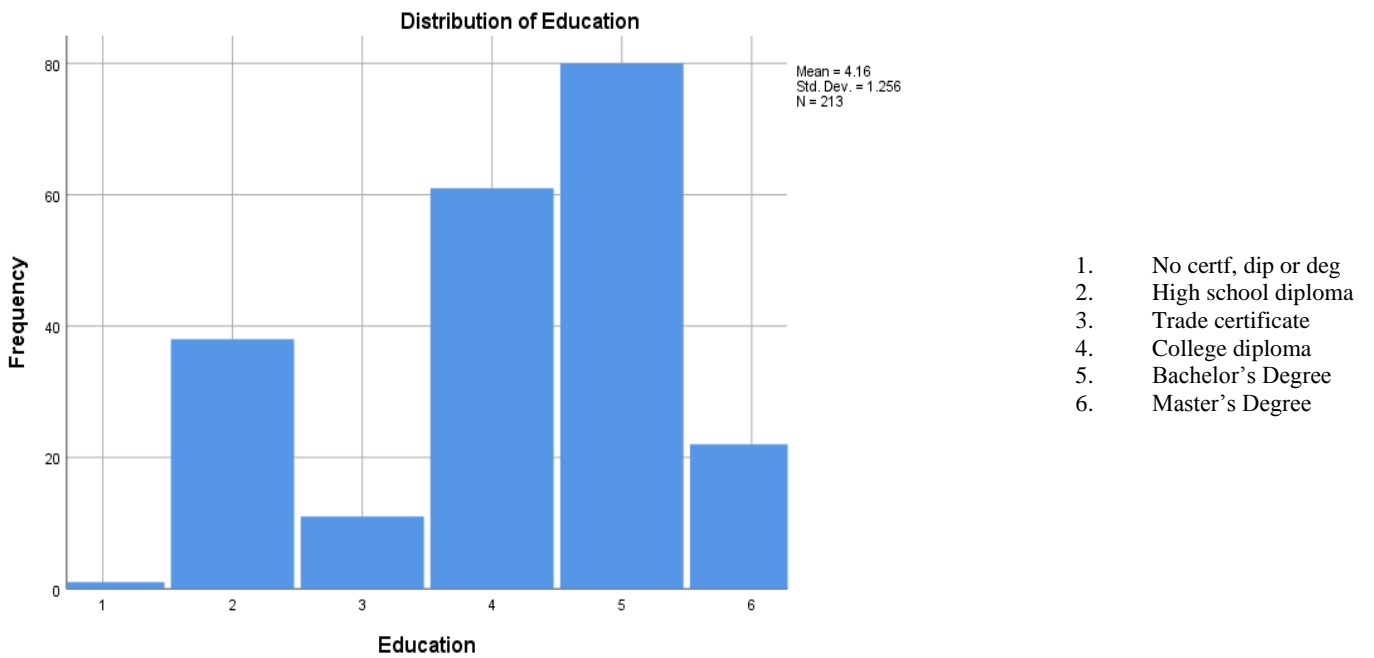


Figure A.4.2. Histogram of education distribution

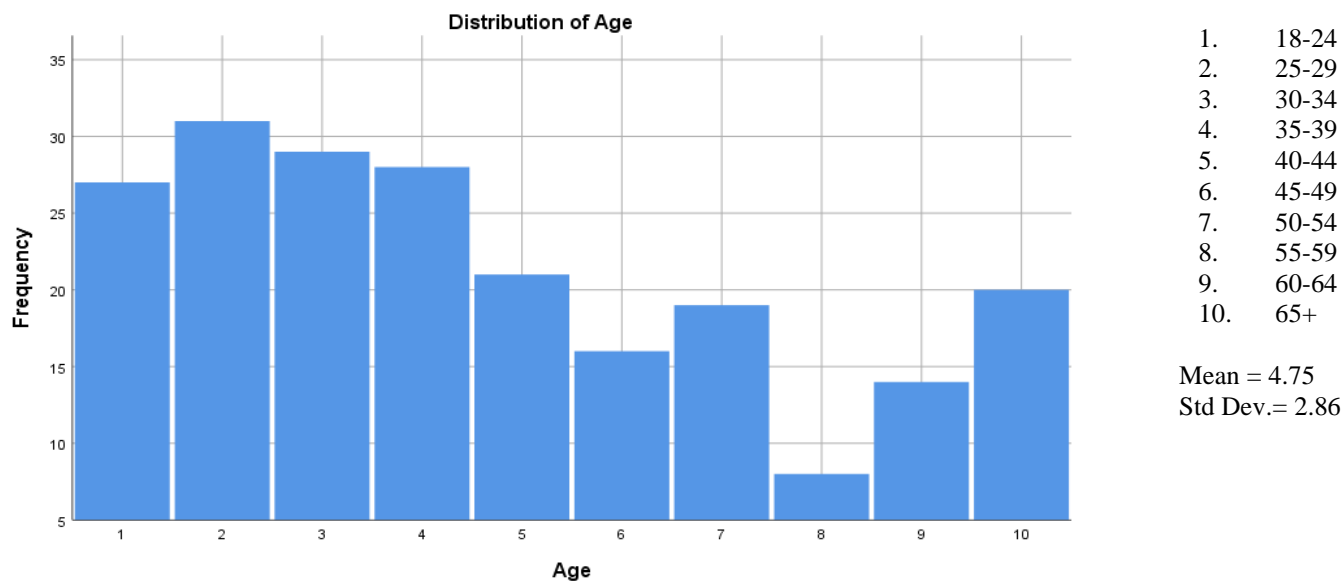


Figure A.4.3. Histogram of age distribution

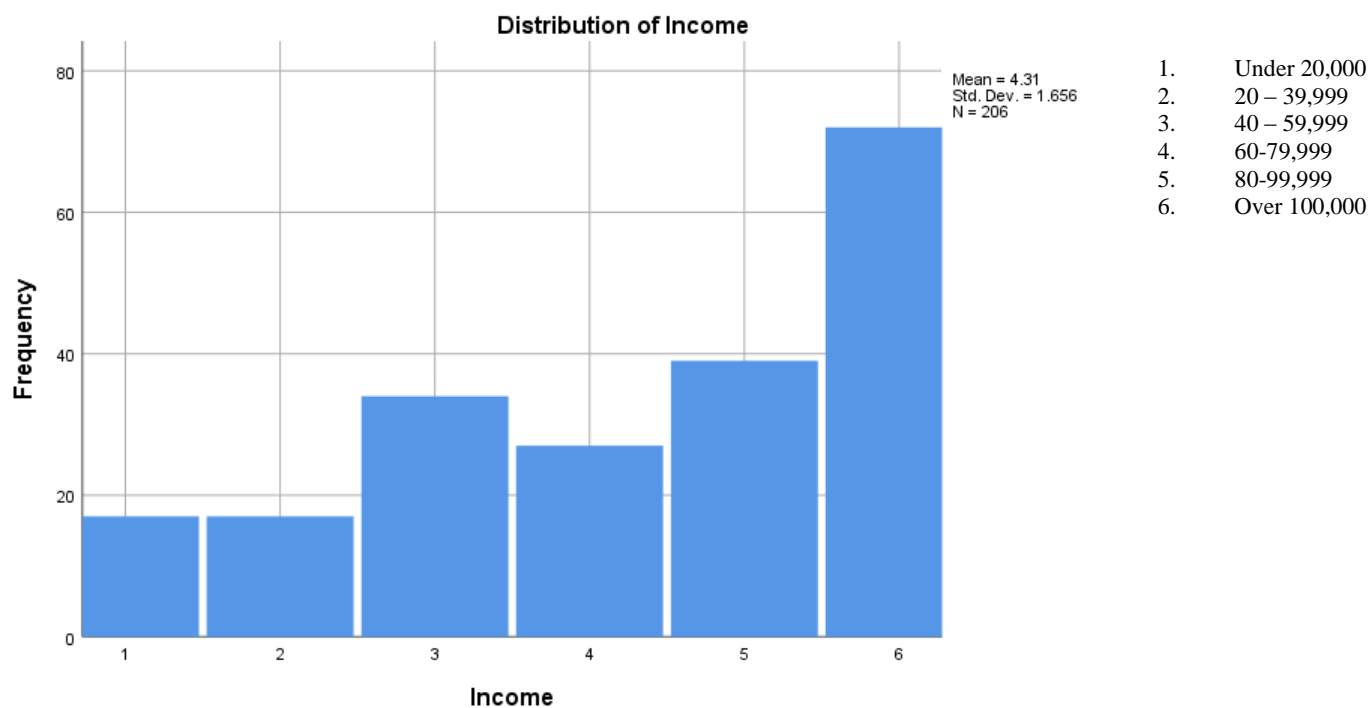


Figure A.4.4. Histogram of income distribution

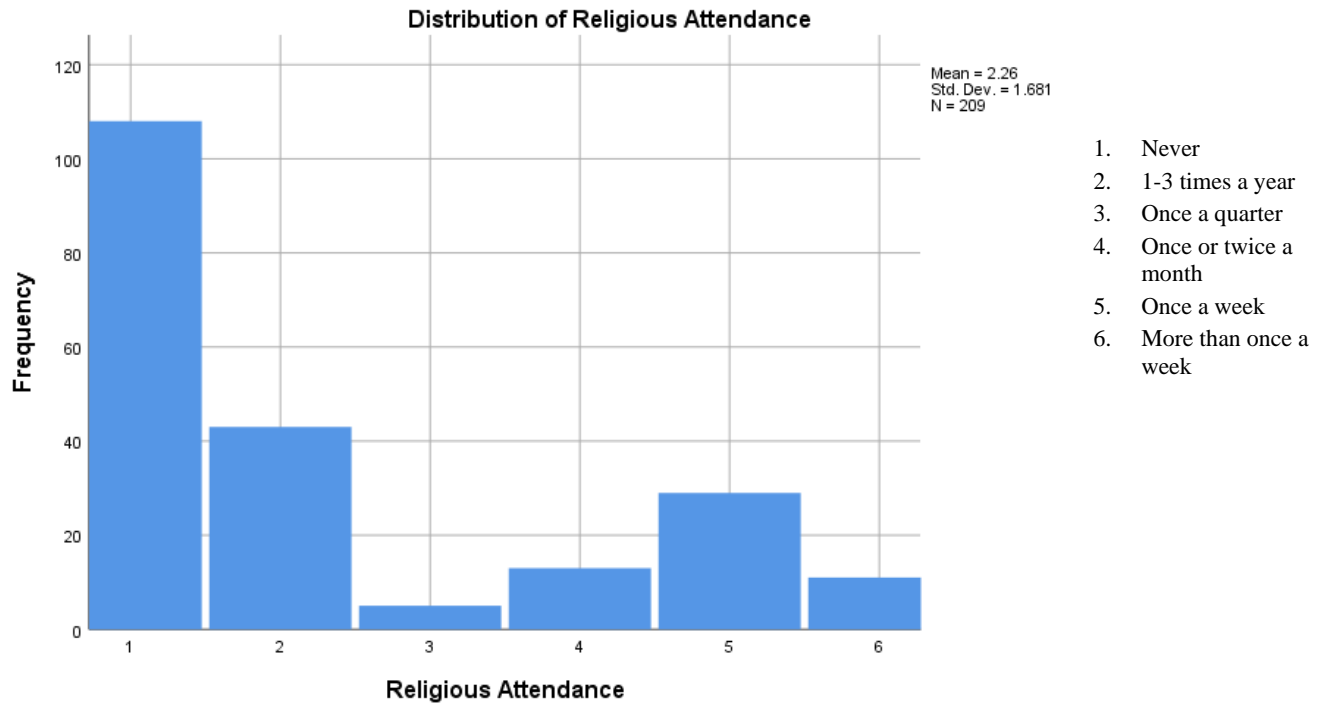


Figure A.4.5. Histogram of religious attendance distribution

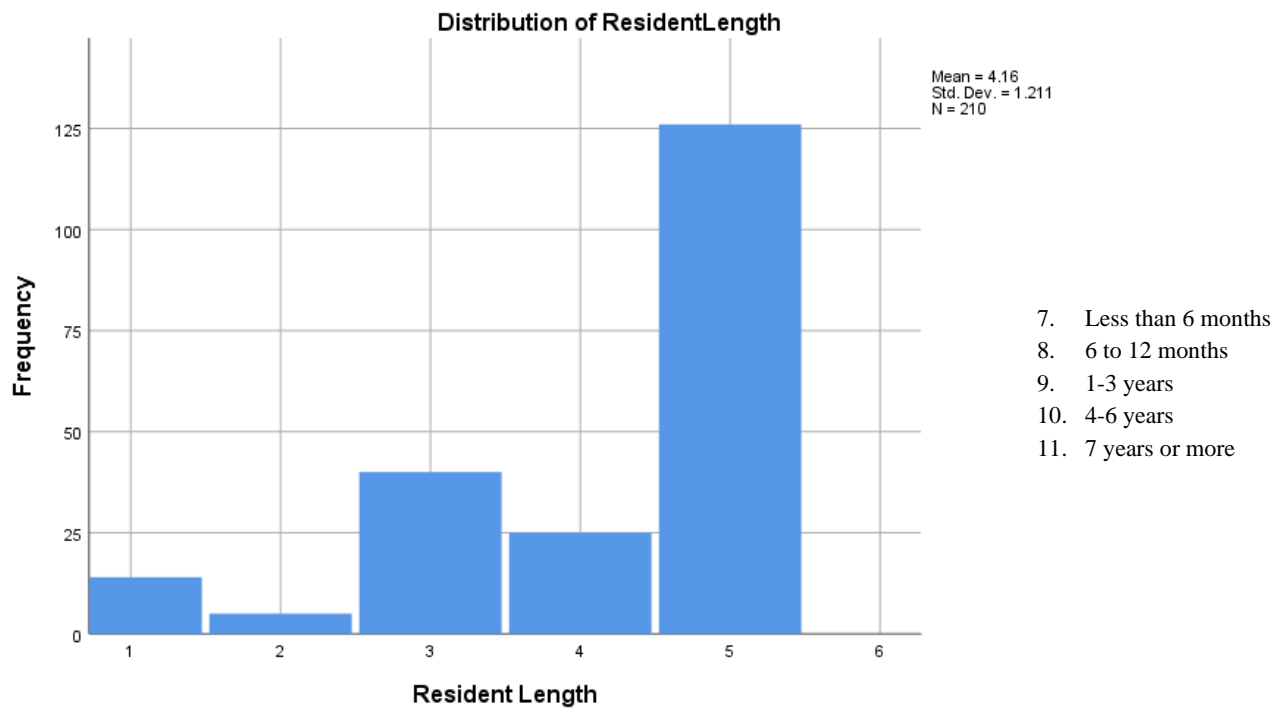


Figure A.4.6. Histogram of resident length distribution

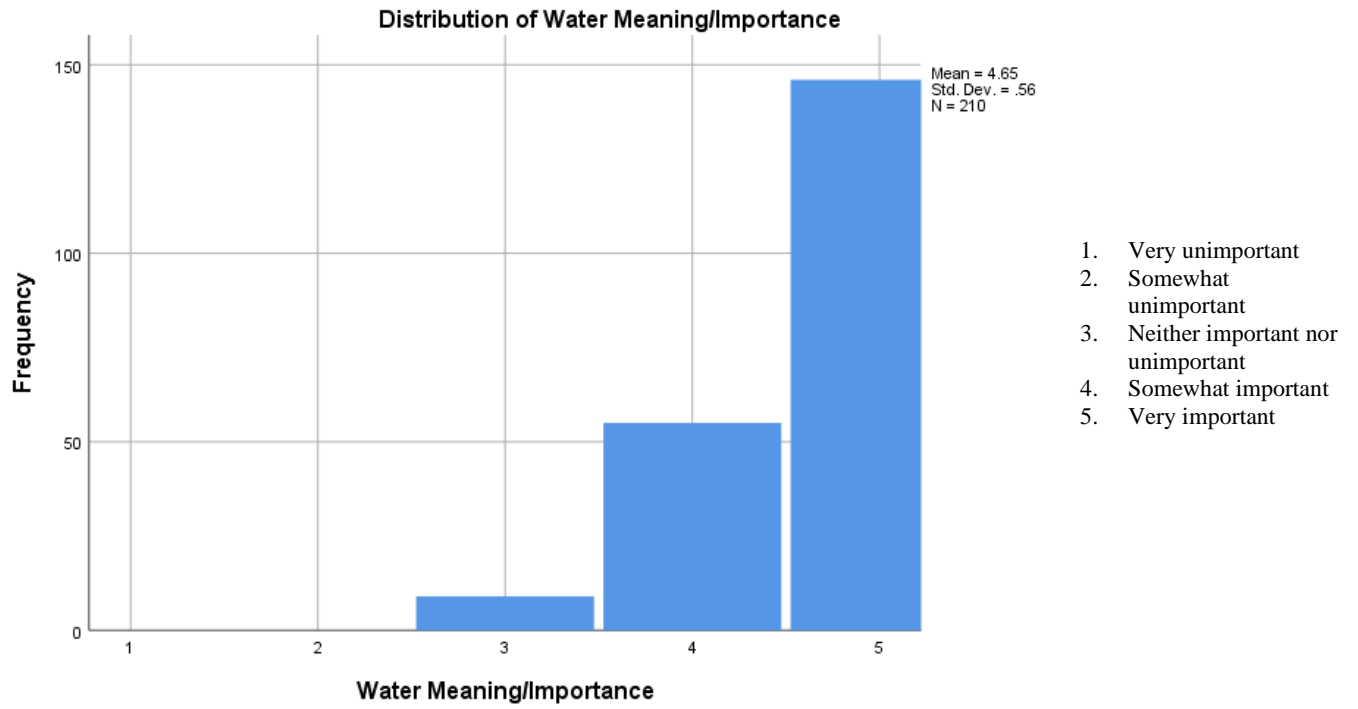


Figure A.4.7. Histogram of water meaning distribution

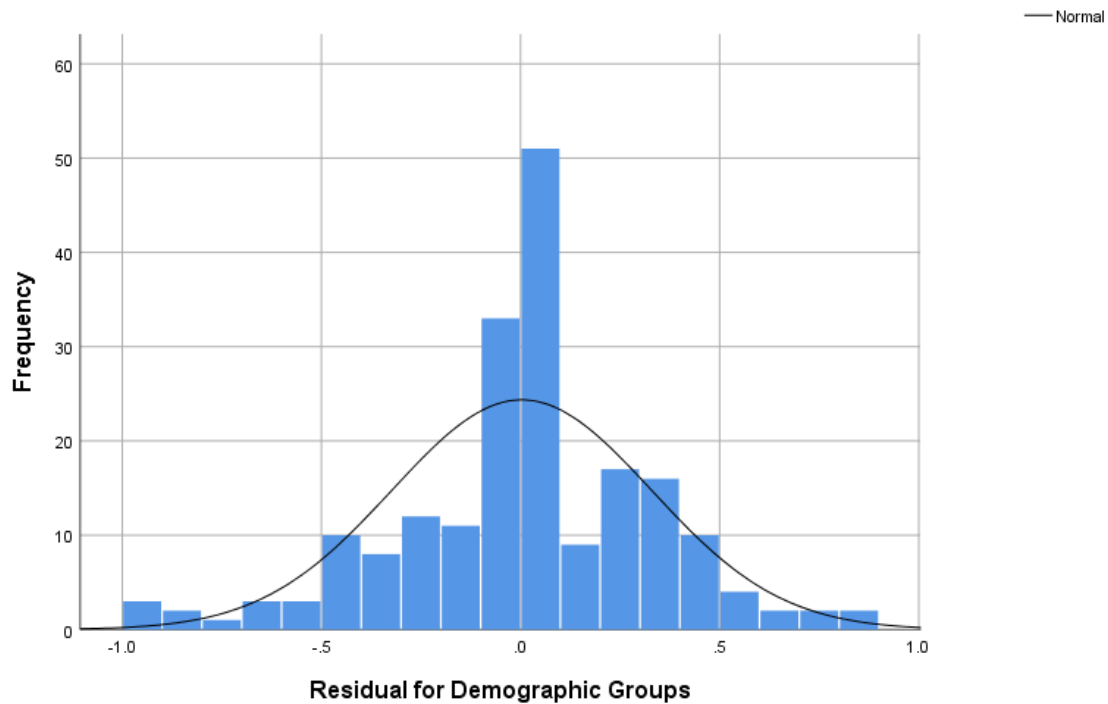


Figure A.4.8. Histogram for Residual for Demographic Categories

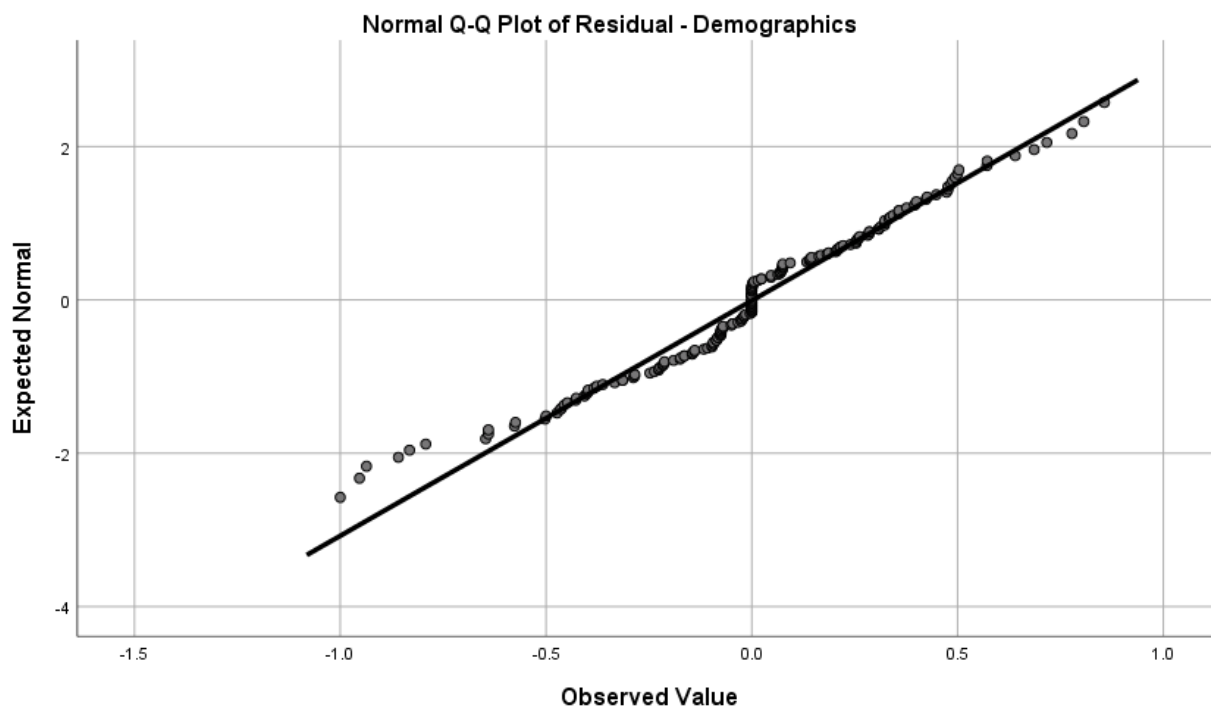


Figure A.4.9. Normal Q-Q Plot of Residuals for Demographic Groups

Table A 4.2: Distribution of the six vignettes to participants.

Vignette (Lincoln)	N	Vignette (Non-Lincoln)	N
L1	75	G1	78
L2	72	G2	65
L3	68	G3	72

Table A.4.3. Demographic Groups of Study Respondents

Demographic Groups	Frequency	Percentage	Comments
Gender			
Male	58	27.6	
Female	152	72.4	
Age			Groups are based on life cycle age categories: young adults, adults, middle aged adults and older adults; also considering the data distribution.
18-29	58	27.3	
30-39	57	26.7	
40-54	56	26.3	
55+	42	19.8	
Education			Division of the groups was based on judgement
No University Education	111	52.1	
University Education	102	47.9	
Average household income			Grouping was based on income class of: low income earners, middle class and upper class.
0 - \$59,999	68	33.0	
\$60,000 - \$99,999	66	32.0	
Over \$100,000	72	35.0	
Years in Lincoln			Majority of respondents were in the 7 years and above category. All other categories were grouped together
0-6 years	84	40.0	
7 years and above	126	60.0	
Political Ideology			The extreme left and left wings, as well as the extreme right and right wings were combined
Left wing	72	34.1	
Neutral	67	31.8	
Right wing	72	34.1	
Water Meaning			Group categories was based on judgement considering the data distribution
Somewhat important	64	30.5	
Very important	146	69.5	
Attendance of Religious Activities	108	51.6	No religious attendance was the majority response. At least once a month is considered frequent and at least once a quarter is considered rare attendance.
Never	48	23	
Rarely	53	25.4	
Frequently			

Table A.4.4. Statistics for the three endorsement groups

Endorsement Group	<i>N</i>	<i>Mean</i>	<i>SD</i>
Low Endorsement	69	2.59	.523
Medium Endorsement	72	3.03	.138
High Endorsement	71	3.60	.200

Table A.4.5. Key Demographic Information of Respondents in the Low, Medium and High Resilience

Demographics Categories		Frequency	Frequency		
			Low Group	Medium Group	High Group
Gender					
	Male	58	27	20	11
	Female	152	42	52	58
Age					
	18-29	58	10	23	16
	30-39	57	16	19	22
	40-54	56	16	17	23
	55+	42	19	13	10
Education					
	No University Education	111	41	40	30
	University Education	102	29	32	41
Average household income					
	0 - \$59,999	68	26	20	22
	\$60,000 - \$99,999	66	26	20	20
	Over \$100,000	72	15	31	26
Years in Lincoln					
	0-6 years	84	27	27	30
	7 years and above	126	42	44	40
Political Ideology					
	Left wing	72	17	26	29
	Neutral	67	25	20	22
	Right wing	72	27	25	20
Water Meaning					
	Somewhat important	64	30	18	16
	Very important	146	39	52	55
Attendance of Religious Activities					
	Never	108	25	45	38
	Rarely	48	20	14	14
	Frequently	53	22	13	18

Table A.4.6. Summary statistics for Lincoln resilience endorsement scores per principle

Resilience Principles	<i>N</i>	Mean (<i>SD</i>)	Median
Overall Endorsement	209	3.17 (0.56)	3.00
Maintain Diversity & Redundancy (P1)	203	3.22 (0.79)	3.00
Manage Connectivity (P2)	202	3.34 (0.69)	3.00
Manage Slow Var & Feedbacks (P3)	202	3.58 (0.64)	4.00
Foster Complex Adapt. Systems Thinking (P4)	208	3.06 (0.98)	3.00
Encourage Learning (P5)	207	3.07 (0.98)	4.00
Broaden Participation (P6)	206	2.77 (1.21)	3.00
Promote Polycentric Governance (P7)	207	3.21 (0.98)	4.00

Table A.4.7. Summary statistics for Non-Lincoln resilience endorsement scores per principle

Resilience Principles	<i>N</i>	Mean (<i>SD</i>)	Median
Overall Endorsement	211	3.33 (0.55)	4
Maintain Diversity & Redundancy (P1)	211	3.55 (0.62)	4
Manage Connectivity (P2)	210	3.49 (0.64)	3
Manage Slow Var & Feedbacks (P3)	210	3.36 (0.67)	4
Foster Complex Adapt. Systems Thinking (P4)	208	3.45 (0.80)	3
Encourage Learning (P5)	207	3.04 (0.95)	4
Broaden Participation (P6)	205	3.34 (0.86)	3
Promote Polycentric Governance (P7)	204	3.15 (0.97)	3

Table A.4.8: Mean endorsement for each resilience principle for Lincoln-specific vignettes,

Resilience Principles	L1	L2	L3
Vignette overall endorsement	3.11 (0.56)	3.25 (0.61)	3.16 (0.51)
Maintain diversity & redundancy P1)	3.55 (0.70)	3.15 (0.85)	2.93 (0.68)
Manage connectivity (P2)	3.20 (0.62)	3.63 (0.64)	3.24 (0.74)
Manage slow var & feedbacks (P3)	3.51 (0.70)	3.70 (0.59)	3.57 (0.61)
Foster complex adapt. systems thinking (P4)	3.35 (0.88)	3.21 (0.90)	2.60 (1.00)
Encourage learning (P5)	2.76 (1.27)	3.11 (0.98)	3.39 (0.82)
Broaden participation (P6)	2.30 (1.31)	2.94 (1.21)	3.14 (0.91)
Promote polycentric governance (P7)	2.96 (0.95)	3.20 (1.07)	3.52 (0.98)

Table A.4.9: Mean endorsement for each resilience principle for non-Lincoln-specific vignettes

Resilience Principles	G1	G2	G3
Vignette overall resilience endorsement	3.37 (0.51)	3.38 (0.49)	3.24 (0.62)
Maintain diversity & redundancy P1)	3.58 (0.57)	3.61 (0.52)	3.48 (0.73)
Manage connectivity (P2)	3.67 (0.55)	3.34 (0.67)	3.41 (0.67)
Manage slow var & feedbacks (P3)	3.46 (0.66)	3.55 (0.50)	3.07 (0.73)
Foster complex adapt. systems thinking (P4)	3.29 (0.86)	3.46 (0.82)	3.62 (0.68)
Encourage learning (P5)	3.04 (0.96)	3.09 (0.97)	3.00 (0.95)
Broaden participation (P6)	3.09 (0.97)	3.60 (0.71)	3.39 (0.80)
Promote polycentric governance (P7)	3.35 (0.96)	3.02 (0.88)	3.03 (1.44)

Table A.4.10: One Way ANOVA results - Association of demographic groups with overall endorsement scores

Demographic Groups	<i>N</i>	Mean (<i>SD</i>)	ANOVA Results
Gender			
Male	54	3.07 (.46)	*<i>F</i> (1, 203) =31.905, <i>p</i> < 0.001, $\eta^2 = .014$
Female	151	3.41 (.33)	
Age			
18-29	56	3.23 (.42)	* <i>F</i> (3, 204) =2.528 <i>p</i> = .050, $\eta^2 = .036$
30-39	57	3.31 (.36)	
40-54	55	3.43 (.29)	
55+	40	3.32 (.51)	
Education			
No University Education	108	3.30 (.37)	<i>F</i> (1, 206) =.759, <i>p</i> =.385, $\eta^2 = .004$
University Education	100	3.35 (.42)	
Average household income			
0 - \$59,999	67	3.34 (.39)	<i>F</i> (2, 198) = 2.012, <i>p</i> =.136, $\eta^2 = .020$
\$60,000 - \$99,999	64	3.24 (.46)	
Over \$100,000	70	3.38 (.34)	
Years in Lincoln			
0-6 years	83	3.31 (.31)	<i>F</i> (1, 204) = 0.131, <i>p</i> =.718, $\eta^2 = .001$
7 years and above	123	3.33 (.43)	
Political Ideology			
Left wing	70	3.36 (.36)	<i>F</i> (2, 203) =.851, <i>p</i> =.428, $\eta^2 = .008$
Neutral	66	3.35 (.33)	
Right wing	70	3.27 (.49)	
Water Meaning			
Somewhat important	61	3.20 (.48)	*<i>F</i> (1, 203) =9.110, <i>p</i> =.003, $\eta^2 = .043$
Very important	144	3.38 (.35)	
Attendance of Religious Activities			
Never	106	3.36 (.37)	<i>F</i> (2, 202) =2.70, <i>p</i> =.070, $\eta^2 = .026$
Rarely	48	3.30 (.34)	
Frequently	52	3.11 (.44)	

*significant at the .05 level

Table A.4.11. Summary of standard multiple regression analysis of overall resilience endorsement and demographic groups.

Demographic	<i>B</i>	<i>P</i>	<i>sr</i>²
Sex	-.224	.001*	.047
Political Ideology	-.212	.002*	.042
Water Importance	.140	.043*	.018
Education	.069	.313	.004
Religious attendance	-.066	.330	.004
Resident Length	-.032	.651	.000
Income	.008	.904	.000
Age	-.022	.755	.000

* $p < .05$. β = standardized coefficient. sr^2 = semi partial correlation (squared)