Climate Change and Droughts

In Guelph and Waterloo Region: Adaptation Strategies. A *SWOT* Analysis.

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FINAL READING APPROVAL

To the faculty of Rural Planning and Development in the School of Environmental Design and Rural Development.

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in its final form and have found that it meets the standards of the Rural Planning and Development M.Sc. program in all respects.

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Abstract

Climate change is considered one of the most important environmental issues of our time. There is strong evidence that human activity is one of the major causes of climate change. The impacts of climate change on water resources can lead to many issues, especially extended droughts. Both Guelph and the Waterloo Region are potentially at risk of drought due to the rise in average global temperatures. Both regions have incorporated climate change adaptation strategies into their plans for water management and conservation. Droughts have the ability to destroy crops, increase the risk of disease, create poor soil conditions and decrease the availability of fresh drinking water. An adaptation SWOT Analysis was done of the strategies of the two. Neither Guelph nor Waterloo meet what have been identified as seven requirements for effective climate change adaptation strategies but are well on their way towards it. The use of a SWOT analysis allowed for a comparison between the two study areas. Guelph appears to have a strong water conservation program. However, both areas need to incorporate risk management, adaptive management and population influences into their plans to increase the effectiveness of their current conservation strategies.

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Acronyms

C02 – Carbon Dioxide

DAG – Drought Advisory Group

GRCA – Grand River Conservation Authority

GHG – Greenhouse Gases

LWC – Low Water Committee

MOE – Ministry of Environment

OLWRP – Ontario Low Water Response Program

OWDC – Ontario Water Director Committee

OWUP – Outside Water Use Program

PLWLRTF – Provincial Low Water Level Response Task Force

PTTW – Permit To Take Water

SWOT – Strength, Weakness, Opportunities, Threats

WRPMP – Water Resources Protection Master Plan

WRT – Water Response Team

WSMP – Water Supply Master Plan

1.0 Introduction

Climate change is considered one of the most important environmental issues of our time. There is strong evidence that the climate system is warming. There is strong scientific consensus that long-term weather patterns are changing partly as a result of human activity. The anticipated impacts include widespread melting of snow and ice, rise in global sea levels, increases in global average air and ocean temperatures (Government of Canada, 2014). Global warming which is a rise in the average global temperature is one indication of climate change (David Suzuki Foundation, 2014). "Over the period 1948 to 2010, the average annual temperature in Canada has warmed by 1.6 degrees Celsius, a higher rate of warming than in most other regions of the world" (Government of Canada, 2014, pg. 10). Adapting to the current and projected rates of climate change could be challenging (Government of Canada, 2014). The level of climate change that future generations will be exposed to will be determined by the actions that we take over the coming decade in order to reduce the impacts of our climate system (Government of Canada, 2014). Climate change imposes various impacts on ecosystems, communities and economies.

One of the major predicted impacts of climate change is an increase in the intensity and frequency of drought (International Council for Local Environmental Initiatives, 2015). This will directly impact agricultural production, energy supply, water supply, public health and parks and recreations. Droughts will also indirectly impact biodiversity, tourism, fire services, environment, forestry and forestry services and human settlements. Droughts will cause the greatest impacts at the local level. Local

governments have the challenge of preparing for climate change and to incorporate climate change adaptation strategies into their Official Plans.

Climate change impacts water resources in a variety of ways such as changes in average and extreme sea level, ice conditions and wave regimes. It also includes floods, violent storms and drought (Government of Canada, 2004). Commonly recommended adaptation options for the water resource sector include water conservation measures, improved planning and preparedness for droughts and severe floods, enhanced monitoring efforts and management. Demand management is considered an effective, efficient, and environmentally and economically sustainable adaptation option.

The following qualitative study is on adaptation strategies to the impacts of climate change on water resources particularly to extended droughts. The study will focus on the City of Guelph and Waterloo Region within Ontario to gain an understanding of how these areas are managing their water supplies and their preparedness for extended droughts. Specifically, this study examines the ways that the City of Guelph and Waterloo Region are conserving water through various forms of water conservation strategies – the strengths, weaknesses, opportunities and threats. This paper starts with a review of literature that will inform the study.

2.0 Literature Review

2.1 Climate Change

2.1.1 What is Climate Change?

Climate change is defined as "any significant change in long-term weather patterns" (Government of Ontario, 2015). These changes are introduced through natural and human activities. A natural cause of climate change is volcanic activity. Volcanic activity has the ability to influence the amount of incoming energy, in terms of the Earth's energy balance. Volcanic eruptions are episodic and have relatively short-term effects on climate (Government of Canada, 2013).

One measure of climate change is global warming, which is the rise in average global temperatures (David Suzuki Foundation, 2014). Climate change is not only a warming cycle, but it is a warming trend as well (Government of Canada, 2015). Human activity is sensitive to climate change, and adapting to the current and protected rates of climate change can be challenging (Government of Canada, 2014). The level and extent of climate change for future generations will be determined by the actions that we take over the coming decade. Depending on the actions taken, the impacts can be reduced (Government of Canada, 2014).

Carbon dioxide is released into the atmosphere through a variety of activities such as: cutting down trees, and the burning of fossil fuels (oil, coal and gas). "Today's atmosphere contains 42 per cent more carbon dioxide than it did before the industrial era" (David Suzuki Foundation, 2014). Climate changes that have occurred prior to the industrial revolution could be explained by natural causes, but more recently, climate changed cannot be explained by natural causes alone. Human activities have been the

dominant cause of warming to the Earth's atmosphere (United States Environmental Protection Agency, 2015). These activities include the burning of fossil fuels, and the conservation of land for agriculture and forestry (Government of Canada, 2013). Human activities not only influence the emissions released into the atmosphere but also cause changes to the land surface. "These in turn can influence both the amount of incoming energy and the amount of outgoing energy and can have both warming and cooling effects on the climate" (Government of Canada, 2013).

Humans have released massive amounts of carbon dioxide and other greenhouse gases (GHG) into the atmosphere, that now act as a thick, heat-trapping blanket. This has caused extreme weather events (David Suzuki Foundation, 2014). Changes are projected in both average and extreme weather events. These events consist of an increase in droughts, floods, severe storms, and heavy rainfall (Government of Canada, 2015). With a change in precipitation and temperature, both natural and managed habitats will be affected. The fluctuation in weather poses a concern for the increasing population on agricultural areas. Less rainfall and dry soils will disrupt growing seasons, food production, access and stability (Government of Canada, 2015).

2.1.2 Impacts

Climate change has various types of impacts on ecosystems, communities and economies. "Between 1948 and 2008, the average annual temperature in Ontario has increased by 1.4 degrees Celsius. The greatest warming has been in the western part of the province" (Government of Ontario, 2014). The result of rising temperatures does not just mean that there will be warmer winters. Some regions may experience extreme heat, while others may cool slightly. The risk of violent storms and extreme weather can also

be a result of climate change (David Suzuki Foundation, 2014). It is predicted that the climate will be warming, which reduces the land and ocean uptake of atmospheric carbon dioxide; this means that anthropogenic emissions will remain in the atmosphere. This will result in an increased global average warming by 2100 by more than one degree Celsius (IPCC, 2007).

One of the most serious impacts of climate change is on water resources. Water is tied to many other resources and social issues such as health, food supply, ecosystem integrity, industry, and transportation (David Suzuki Foundation, 2014). Climate change can affect human health by creating shortages of freshwater, worsening smog, and it can even lead to an increase in diseases (David Suzuki Foundation, 2014). With the rising temperature, there is a decrease in land precipitation due to the enhanced evapotranspiration and reduced soil moisture. A decrease in land precipitation is one of the major causes of drying trends (IPCC, 2007). Water shortages are a major impact of climate change and as a result of mild, shorter winters it is expected that there will be earlier snow melt, a change in rainfall patterns, less ice cover on lakes, and a change in water movement between bodies of water, soil, plants and air. It will also lead to a decrease in the available water supply for renewable energy production and waterways (IPCC, 2007).

A changing climate makes areas more prone to both droughts and flooding. One sixth of earth relies on melt water from glaciers and seasonal snow packs for their water supply. As a consequence of climate change the projected availability of water supply in some regions will be adverse and severe. With snowmelt projected to be less abundant and earlier in the season, there is an increased risk of droughts (IPCC, 2007).

Climate change not only impacts water supply but water quality as well. An increase in water temperature creates adverse changes in the water quality, which can affect human health, water use, and ecosystems (IPCC, 2007). With lower water levels in lakes and rivers, the re suspension of bottom sediments and liberating compounds will create negative effects on water quality. With more intense rainfall occurring, an increase in suspended sediments within the lakes and reservoirs will occur as a result of soil fluvial erosion. This creates the opportunity for pollutants, such as pesticides, organic matters and heavy metals, to be introduced into lakes or rivers (IPCC, 2007).

"With rapid climate change, one-fourth of Earth's species could be headed for extinction by 2050" (The Nature Conservancy, 2015). Five of the hottest years on record have all occurred since 1997, the two warmest years on record are 2005 and 2010. Scientists have projected that if heat-trapping emissions are not reduced, than the average surface temperatures could increase by 3 to 10 degrees Fahrenheit by the end of the century (The Nature Conservancy, 2015). Lands that are affected by droughts are more likely to be vulnerable to flooding once rain falls (The Nature Conservancy, 2015).

2.2 Drought

2.2.1 What is Drought?

There is more than one definition for drought, since dry conditions develop for various reasons (Wolchover, 2011). The Canadian Encyclopedia defines drought as, "the condition of critically low water supply caused by persistently below-normal precipitation" (Hill, 2010). Drought begins with decreased soil moisture, surface, and underground water supplies. This leads to suppressed plant growth and restrictions in the

use of surface and underground water supplies for agricultural, domestic, municipal, and industrial purposes (Hill, 2010). A drought has the ability to occur in all climates and can lead to severe economic and ecological impacts. There are four main categories of droughts: meteorological, agricultural, hydrological, and socioeconomic droughts.

A meteorological drought is specific to different regions. It is "designed on the basis of the degree of dryness (in comparison to some 'normal' or average amount) and the duration of the dry period (Wilhite and Glantz, 1985). Meteorological droughts are region specific since atmospheric conditions that create deficiencies in precipitation vary from region to region. This measure of drought is more appropriate for regions that are characterized by year-round precipitation such as tropical rainforest, humid subtropical climate or humid mid-latitude climate (Wilhite and Glantz, 1985).

An agricultural drought has various characteristics and focuses on precipitation shortages, differences between actual and potential evapotranspiration, reduced ground water, or reservoir levels and soil water deficits (Wilhite and Glantz, 1985). Agricultural droughts occur when there is not enough air or soil moisture, leading to low plant populations and a reduction in crop yields (Wolchover, 2011).

A hydrological drought occurs when there are precipitation shortfalls within the surface or subsurface water supply (Wilhite and Glantz, 1985). The frequency and severity of hydrological droughts are designed on a watershed or river basin scale. There is a concern with how it will affect the hydrological cycle since it takes longer for precipitation deficiencies to show up in components of the hydrological cycle - stream flow, and soil moisture, groundwater and reservoir levels. These deficiencies can lead to

various economic impacts (Wilhite and Glantz, 1985). A competition for water is created between flood controls, recreation, irrigation, which escalates during a drought and can result in conflict.

Lastly, a socioeconomic drought occurs when the supply and demand for water exceeds the available water supply (Wolchover, 2011). Socio-economic droughts incorporate some aspects of meteorological, agricultural and hydrological droughts as well. Socio-economic droughts are weather dependent and unusual shortages of water can create adverse impacts on society (Wilhite and Glantz, 1985).

Forests have a key role in the water cycle. Forests help to reduce evaporation, store water, and also contribute to atmospheric moisture in the form of transpiration (ESchoolToday, 2015). By cutting down trees, the ability for the ground to hold water is reduced. The removal of trees exposes surface water and increases the risk of evaporation

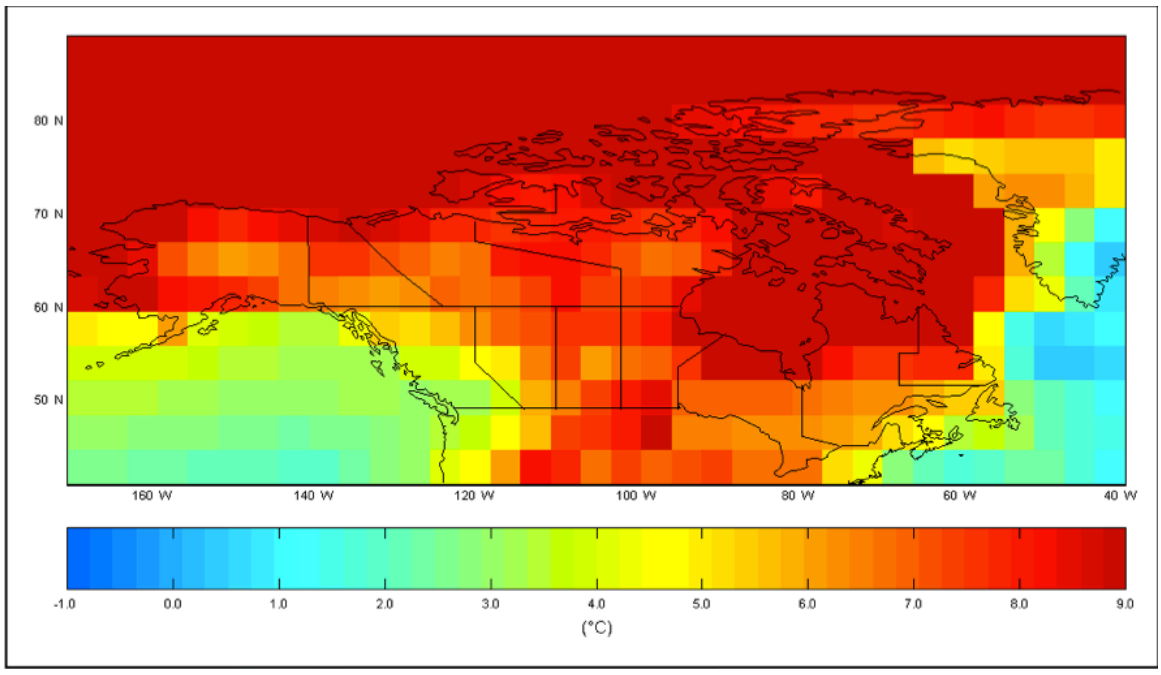
Global warming can lead to drought. The greenhouse gases lead to an increase in temperature. This then leads to more dryness and a greater risk of bush fires, which can speed up drought conditions (ESchoolToday, 2015).

2.3 Predictions for Southwestern Ontario

There have been several predictions made on how the climate will change in Ontario, especially in Southern Ontario. “Due to our latitude, global warming is occurring faster in Ontario than the global average, while the average temperature around the world went up by 0.75 degrees Celsius in the past century, average temperatures in south-central Canada increased by 1.2 degree Celsius” (Miller, 2010).

It is anticipated that the summers will become 2 to 3 degrees warmer by mid-century, and by 2071 the summer will be 4 to 5 degrees warmer (Figure 1). The prime agricultural areas in Ontario are expected to receive deceased precipitation from April to September by 10-20% (Colombo, McKenney, Lawrence and Gray, 2007, pg. 5). In regards to temperatures within the winter season, by mid-century the average temperatures could increase by 3 to 4 degrees Celsius. By 2071, the winter temperatures will increase by 4-5 degrees and even up to as much as 5 to 6 degrees in some parts of Southern Ontario Colombo, McKenney, Lawrence and Gray, 2007, pg. 5).

Figure 1: Annual Temperature Projection for 2080s



Source: (Government of Canada, 2004, pg. viii)

"Climate Change is a matter of concern to Ontarians – individuals, environmentalists, scientists, organizations, industry, governments and so many others have taken small and large steps over many years to help reduce Ontario's impact"

(Ontario, 2015). Southern Ontario is expected to have more days that reach above 30 degrees Celsius. This number is expected to double, which may affect some of the sensitive populations, including seniors. The extreme heat can worsen the quality of air; lead to new and migrating disease vectors and can even cause water and food contamination which overall leads to human health issues (Ontario, 2015). The variability in weather, especially the increase in temperature, can lead to warming of lakes throughout Southern Ontario and lead to the loss of cold water fish. Not only that, but warmer lakes can potentially lead to the arrival of invasive species to Ontario, such as the mountain pine beetle and ticks which may carry Lyme disease (Ontario, 2015).

Although the warmer temperatures in Ontario will create for longer growing seasons, they also create negative impacts. With the temperatures increasing, this will lead to an increase in evapotranspiration, which will decrease the net soil moisture. The increased loss of moisture will create a higher demand for water that may not be available for farmers. The availability of water will decrease due to the decrease of the net moisture available in the soil (Trent Assessment Report, n.d.).

Ontarians will have to embrace a new definition of conservation. "The new conservation ethic must take into account the cumulative impact of our activities, use a precautionary approach every time a decision is made, and ensure we don't penalize future generations" (Miller, 2010). People will be forced to become more responsible and sensible with resource use. This reality is not a choice and it will then be passed down and imposed on our children, our children's children, and us (Miller, 2010). In order to limit climate change in Ontario, it would require substantial and sustained reductions in

greenhouse gas emissions, and incorporating decreased greenhouse gas emissions into adaptation strategies (IPCC, 2014).

2.4 Drought Ontario

A drought has the ability to occur during any season, although a drought is more likely during summer when the water demand is the highest (Gabriel and Kreutzwiser, 1993, pg. 118). Southwestern Ontario is more prone to extended dry periods than any other part of the province, especially during the summer and early fall. The average dry spell in Southwest Ontario is longer than St. Lawrence Ottawa Lowlands and areas east of Georgian Bay to the Ottawa River. The most severe and widespread drought that occurred in Ontario was in 1966. During a 41-day period between June 16 and July 26, most of Southwest Ontario received less than 25mm of rainfall. This was less than one quarter of the normal rainfall that Ontario is used to receiving (Gabriel and Kreutzwiser, 1993, pg. 119). Then again in 1988, SW Ontario had another drought where they received only 40% of their usual average rainfall between early May to mid July.

2.5 Predicted Impacts of Drought

As mentioned above, there are several different types of droughts and various factors that can play a role in the cause of a drought. With that being said, a drought can impact the economy, environment, and society.

Economic impacts are those that can cost people (or businesses) money. In many cases, a farmer may lose money if a drought destroys their crops (National Drought Mitigation Center, 2016). Agriculture is reliant on surface and ground water, and if there is none available they are at risk of economic loss (San Diego State University, n.d.). The

farmer may have to spend more money on irrigation or may even have to drill new wells in order to get the necessary water supply. Farmers and ranchers may also have to spend more money on water and feed for their animals (National Drought Mitigation Center, 2016). Not only are farmers at risk, but also the businesses that are dependent on farming, such as companies that make tractors. Farmers will not require tractors since the drought has damaged their crops. Businesses that depend on farmer's food may also lose money if the crops or livestock are damaged (National Drought Mitigation Center, 2016).

Power companies that normally rely on hydroelectric power may have to spend more money on other fuel sources since there is the risk of a drought drying up their water sources. This would then increase the cost of power for the consumer (National Drought Mitigation Center, 2016).

Droughts may lead to unemployment, which can then lead to income short falls, credit risk, and even the loss of tax revenue for Municipal, Provincial and Federal governments (San Diego State University, n.d.).

Both Guelph and Waterloo are at risk of negative economic impacts from droughts since they both have a large number of farms within their Regions. Both economies rely on agricultural activity. In the 2006 Census data, there were 1,444 farms in the Waterloo Region. The types of farms range from beef, dairy, poultry (and eggs), hogs, pigs, goats, sheep and other animals (Foodlink Waterloo Region, 2016). Seventy four percent of the farms in the region are livestock, while the remaining farms produce field crops, fruits, vegetables and specialty products. Not only that, but the greenhouse industry within the Waterloo Region is continuing to grow.

Guelph is ranked number one in agricultural biotechnology, many of the research facilities are at the University of Guelph, and the agri-food industry represents a $63 billion value chain in Ontario (City of Guelph, 2015). In addition, with its strategic location in the heart of southern Ontario, Guelph brings together all the advantages of location, resources and quality of life to foster the growth of life science, agri-food and innovation companies and associations (City of Guelph, 2015). The agri-food sector in Guelph has more than 90 companies, which employs approximately 6,500 people in government, private sector biotechnology, agri-food technology, education, food processing, research, marketing and more. "Guelph is further complimented by over 100 agricultural, industries and associations (City of Guelph, 2015). If a drought occurs in either of these locations, both study areas are at huge risk of economic impacts.

Droughts can also lead to the loss or destruction of fish and wildlife habitats (National Drought Mitigation Center, 2016). Droughts can also degrade wetlands, vegetation and lakes, which can lead to negative impacts on the air and water quality (San Diego State University, n.d.). There is a lack of food and drinking water for animals and as a result of this, there can be an increase in disease in wild animals (National Drought Mitigation Center, 2016). With a lack of food, animals are forced to migrate to regions they have never been before. With the environmental changes, there is an increase in stress on endangered species and even an increase in the extinction of animals, especially those that are at risk already. Droughts can lead to low water levels in reservoirs, ponds and lakes (National Drought Mitigation Center, 2016).

Droughts can lead to major impacts on the environment and cause degradation of landscape, which includes an increase in soil erosion. This then may lead to a more

permanent loss of biological productivity (San Diego State University, 2016). Poor soil quality can result from drought. This then counters back to the economic impacts since poor soil quality leads to the inability to grow crops and economic losses to farmers and those dependent on agricultural activity (National Drought Mitigation Center, 2016).

Lastly, droughts lead to several social impacts, mostly those that are related to health. Anxiety and depression are a common impact due to the economic losses that are caused by drought (National Drought Mitigation Center, 2016). Several health problems can occur in relation to the low water flows and poor water quality. An increase in dust due to low soil saturation levels can exacerbate health problems (National Drought Mitigation Center, 2016).

There could also be an increased threat to public safety from an increased number of forest fires (National Drought Mitigation center, 2016). Droughts can lead to population migration and people seldom return once the drought is over (San Diego State University, n.d.). This then creates an increased pressure on social infrastructure in urban areas, which can lead to increased poverty and social unrest (San Diego State University, n.d.).

2.6 Climate Change and Droughts

A drought is difficult to predict but early warning systems have become increasingly successful at recognizing the development of potential famines and droughts (Nicolls, Coughlin and Monnik, 2005, pg. 39). A challenge in developing a drought early warning system is the range of spatial and temporal scales of the information that is available. It is necessary to predict temperatures as well as rainfall, even in the areas

where traditionally; rainfall has been the variable leading to drought hardships (Nicolls, Coughlin and Monnik, 2005, pg. 46). More sophisticated drought monitoring will be required in order to take into account the effect of changes in meteorological variables other than rainfall. "Any forecast system will need to take account of the long-term climate changes (in both temperature and rainfall) it will be incorrect to assume that climate is variable but statistically stationary in the future (Nicolls, Coughlin and Monnik, 2005, pg. 46).

Water conservation is an effective mitigation tool that tends to be under utilized. It has the ability to stave off the severe water shortages, public safety risks, and financial losses that have historically assumed to be an inevitable consequence of drought (Nicolls, Coughlin and Monnik, 2005, pg. 178). There are hundreds of hardware technologies and behaviour-driven measures that are able to boost the efficiency of water use. When these are implemented and put into action, they have the ability to drive down short term and can lead to long-term water demands (Nicolls, Coughlin and Monnik, 2005, pg. 178). For almost all examples of water waste and inefficiencies that are found in water systems in homes, landscapes, industries and businesses there is a water conservation device, technology or practice that can be utilized in order to conserve water.

For instance, lawn-watering restricting during one month in July 2002 in Cheyenne Wyoming lowered the average demand to 18.1 million gallons per day compared to the 34 gallons per day for the same month in previous years (Nicolls, Coughlin and Monnik, 2005, pg. 181). Yet water conservation should not only be an emergency response plan but it should be a long-term approach to managing and

alleviating water stresses on the world's finite water supplies (Nicolls, Coughlin and Monnik, 2005, pg. 181).

2.7 Climate Change Adaptation

2.7.1 What is Climate Change Adaptation?

Climate change adaptation is an important series of adjustments that can be used to help benefit the environment and economy. The difference between adapting to changing weather and adapting to a changing climate lies both in the time-frame and in the significance of the changes that are required (Adger, Lorenzoni, and O'Brien, 2009).

Adaptation means, "anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise" (European Commission, 2015). Using well-planned adaptation strategies early on has been shown to save money and lives in the long run (European Commission, 2015). Adaptation strategies are needed at all levels of administration – local and regional levels – in order to be effective. Most of these adaptation strategies that are used will be taken at the local and regional levels (European Commission, 2015).

"Many early impacts of climate change can be effectively addressed though adaptation; the options for successful adaptation diminish and the associated costs increase with increasing climate change" (IPCC, 2007, pg. 19). However, adaptation is not expected to cope with all of the projected effects of climate change. Adaptation is necessary in order to address the impacts that are a result of the warming, which is already unavoidable due to past emissions (IPCC, 2007, pg. 19).

The Environmental Commissioner of Ontario outlines five broad climate change adaptation imperatives to achieve the vision of "policies and programs that minimize risks to our health and safety, the environment and the economy, and maximize the benefits from opportunities which may arise" (Environmental Commissioner of Ontario, 2012, pg. 7).

The broad climate change adaptation imperatives are:

1. Avoid loss and unsustainable investment, and take advantage of new economic opportunities,
2. Take all reasonable and practical measures to increase climate resilience of ecosystems
3. Create a share risk-management tools to support adaptation efforts across the province,
4. Achieve a better understanding of future climate change impacts across the province,
5. Seek opportunities to collaborate with others.

(Environmental Commissioner of Ontario, 2012, pg. 7).

In order for adaptation strategies to be effective it is argued by the International Federation of Red Cross and Red Crescent Societies (IFRC) (2009) that good governance at any level but especially national, will be critical in order to establish the development of effective adaptation strategies across the range of necessary sectors. Overall, "Ontario is relatively well adapted to present climatic conditions however, it may not be ready for the impacts resulting from changes in average and extreme climatic conditions" (Hamilton Conservation Authority, 2011, pg. 31). Many strategies have been used in order to do this and the main themes of climate change adaptation throughout Ontario consist of: risk assessment and management, building system resistance/resilience and adaptive management.

2.7.2 Adaptation: Risk Assessment and Management

Risk is "the likelihood and consequences of an adverse impact as a result of the interaction between climate change and society (Gleeson et al., 2011, pg. 16)

Risk management is a systematic, information and sentience-based tool to help decision- makers analyze risks, and select the optimal courses of action, even when under high levels of uncertainty (Climate Ontario, n.d.). Once the risks are identified and prioritized, adaptation actions or measures can be developed for risks with the greatest consequences and the greatest likelihood of occurrence (Climate Ontario, n.d.). A risk management process consists of six steps: getting started, preliminary analysis, risk estimation, risk evolution, risk control and adaptation decisions and implementation and monitoring. The process helps to select the best actions to be used in order to reduce the risks to acceptable levels, even when there are uncertainties about future climate change (Black, Bruce and Egener, 2010, pg. ii).

Risk assessment is a part of the risk management process, which measures the two attributes that comprise risks: the magnitude of the consequences and the likelihood that it will occur (Climate Ontario, n.d.). Risk assessments are a useful tool for adapting to the negative aspects of climate change since it can be used in order to address a range of climate-related impacts with both a high or low likelihood of occurrence (Climate Ontario, n.d.).

Adaptation is an ongoing process that is part of good risk management, whereby drivers of risk are identified and their likely impacts on systems under alternative management are assessed (Howden et al, 2007). The isolation of other drivers may be

helpful, especially during the beginning stages of assessment when the awareness of the relative importance of certain risk factors is low. In order to adapt to climate change through risk management, a framework is used in order to develop adaptation strategies in response to potential climate changes that create or increase risk. These risks include extreme rainfall events, health issues and heat (Bruce, Egener and Noble, 2006).

2.7.3 Adaptation by Building System Resistance / Resilience

Resistance and resilience are prominent in discussions of climate change adaptation strategies. A resilient system is one that recovers from perturbations. A resilient system will change in response to its external forces but returning to its original state (Lawler, 2009). In respect to climate change, "a resilient system will continue to function, albeit potentially differentially in altered climates" (Lawler, 2009). One of the most obvious approaches to increasing the resilience of an ecosystem is the removal of other, non-climate related threats to a species or system in order to reduce the stress on other species. Removal or reduction to existing environmental stresses and threats to a species and its population, will lead to an enhancement of their resilience to climate change. Resilient responses are widely recommended for climate change adaptation; however, figuring out how to promote gradual change while aiming for post disturbance recovery to a prior condition may be difficult to reconcile "on-the-ground" (Galatowitsch, Frelich and Phillips-Mao, 2009, pg. 2019).

Resistance strategies that "oppose changes associated with a shifting climate, will be most useful for overcoming small magnitudes of climate change and under greater climate change to save native species for the short term – perhaps a few decades until

other adaptation options are found" (Galatowitsch, Frelich and Phillips-Mao, 2009, pg. 2019). Resistant ecosystems can absorb disturbances while remaining relatively unchanged (Gleeson et al., 2011).

Some resistance strategies may include an increase in water supply, fighting insect and disease outbreaks that may overwhelm the native plants communities under stress, as well as reducing herbivory and the abundance of invasive species. Some management actions that promote regeneration may increase the persistence of existing plant communities by decades or even more (Galatowitsch, Frelich and Phillips-Mao, 2009, pg. 2019).

Certain management strategies that focus on the mitigation of drought stress may be necessary in order to prolong the lifespan of the existing plant communities. For instance: "agriculture and urban drainage projects need to be more-critically evaluated to prevent lowering the water tables of remaining wetlands and existing drainage systems may need to be modified so wetlands and wet prairies have improved water supply" (Galatowitsch, Frelich and Phillips-Mao, 2009, pg. 2019) The incorporation of management strategies that promote regeneration may increase persistence of existing plant communities by decades or even more. This could lead to a decrease in the risk of a drought.

2.7.4 Adaptation: Adaptive Management

Adaptive management is the last main climate change adaptation strategy that is common among planners or managers. Adaptive management is "a systematic approach for improving resource management by learning from management outcomes" (U.S.

Department for the Interior, n.d. pg. 1). By using adaptive management in a changing climate, managers and planners learn about the ecological effects of climate change and can respond more appropriately (Lawler, 2009).

Using adaptive management does not require a system to return to its prior state, but since all social and natural systems evolve, it is about allowing them to co-evolve with each other over time. Adaptive management is used in order to respond to an experience or expected impacts of changing climate conditions in order to reduce their impacts. Adaptive management can take advantage of new circumstances to improve climatic systems (Tompkins and Adger, 2003, pg. 3). Adaptive management focuses on learning and adapting through various partnerships. These consist of partnerships between managers, scientists and other stakeholders who all learn together in order to create and maintain a sustainable resource system (U.S. Department for the Interior, n.d., pg. 1). Adaptive management involves not only predicting how ecological or physical systems will respond to interventions but identifies what management options are available and what their desired outcomes are (U.S. Department for the Interior, n.d., pg. 2).

Adaptive management "recognizes the importance of natural variability in contributing to ecological resilience and productivity" (U.S. Department for the Interior, n.d., pg. 4). Adaptive management is useful when there is a considerable degree of uncertainty regarding the most appropriate strategy for managing natural resources (U.S. Department for the Interior, n.d., pg. 4). Adaptive management represents a means to more effective decisions and enhanced benefits rather than an end in itself.

However, a common problem that is associated with the use of adaptive management is that it involves "a temporal sequence of decisions, in which the best action at each decision point depends on the state of the managed system" (U.S. Department for the Interior, n.d., pg 2).

2.8 Population and Drought

By 2050, the global population is expected to reach 8 to 9 billion, with 70% of the population concentrated in cities and slums. This will lead to increased pressure on local water resources, stemming from greater withdrawals and pollution (Growing Blue, 2016). Globally, this will lead to increased water withdrawals for energy, food and industrial production. Water usage is predicted to be stretched to its limits, and tensions will arise between countries that depend on a shared source of water (Growing Blue, 2016). Both the City of Guelph and Waterloo Region's populations are growing, while their water supplies are going to diminish. The population in Guelph in 2011 was 121,688 (Stats Canada, 2016) and is expected to reach 175,000 by 2031 (Malone Given Parsons Ltd., 2000). In 2011, the Region of Waterloo had a population of 527,380 and is expected to grow to 729,000 by 2031 (Region of Waterloo, 2010).

Population growth is a major contributor to water scarcity. A growing population leads to more demand and competition for water for various uses: municipal, domestic, industrial, agricultural and evacuation of waste materials (Population Action International, 2011). Population growth limits the amount of water available per person. Projections show that by 2035, approximately 3.6 billion people will be living in areas with water stress or scarcity. As the population continues to grow, more regions and

countries will have become scarce (Population Action International, 2011). “The path of future population growth will impact water stress and scarcity” (Population Action International, 2011). Global scale changes in population as well as economic development over the next 25 years will dictate the future relation between water supply and demand to a much greater degree than changes in mean climate will (Charles J. Vörösmarty et al., 2000*)*.

There is a strong correlation between population and public water supply, close to 56% of this supply is allocated for domestic purposes (Population Action International, 2011). “Without smarter water resource management, a growing world with more people and more activities will demand more water and create more pollution, breaking the boundaries of sustainability of water resources utilization” (Growing Blue, 2016). Climate change is already affecting some of the planet’s most vulnerable ecosystems, rivers and lakes and will only continue to impact it. Population growth is going to impact the available water supply and the study area’s ability to deal with drought. Although Guelph and Waterloo are conserving water now, these conservation efforts might not be able to mitigate drought in the future as a result of the growing population. With a rising population, the amount of water needed by the public will increase, therefore the supply conserved today, may not be enough for the future. This means planners will need to incorporate the rising population into their climate change adaptation strategies. Planners will need to plan water conservation around the predicted population, not the current population, in order to ensure an adequate water supply in the future.

2.9 Drought Management Strategies (Water Conservation)

"Water is necessary for the sustenance of human life" (Csiszar, 2015) and fresh clean water is a limited resource (The Water Page, 2015). The supply may seem abundant, but water is a limited resource, particularly potable water that is necessary for human life (Csiszar, 2015). There is a large amount of water on Earth, however, most of it is salt water and desalinization is expensive.

Drought limits the access to clean and fresh water. It is important that the proper steps are taken in order to reduce and save as much water as possible (The Water Page, 2015). Without conservation efforts, the limited supply of water available may be used up. People need to conserve water for three main reasons, the first being that water conservation works to reduce energy and can even save household money. Secondly, the less water that is used or wasted, the less clean water will become contaminated. Lastly, conserving water now will allow for more cities and regions to plan for more efficient uses of water resources for the future. If clean water is wasted, than there will be less available for future generations. The conservation of water is important for several reasons including preservation farming, environmental factors, personal cost and infrastructure and technology development.

As a result of urbanization, there has been a decrease in surface water supplies and aquifers from rural farmland. A decrease in ground water levels is also created which results in related groundwater storage (Csiszar, 2015). A decrease in water supply would create an imbalance in the Earth's natural cycle. Overuse of water threatens other life

forms, which help to sustain the Earth (Csiszar, 2015). Conserving water saves money. The conservation of water decreased utility charges.

Lastly, water conservation helps to reduce the demand for water treatment systems, such as individual septic systems and sewage plants (Csiszar, 2015). With a reduction in water usage, the need to replace warn down equipment is reduced. Over-using water can overwhelm local water treatment facilities, which results in some water being forced through before it is fully treated. This can create a risk of health hazards for humans and animals (Csiszar, 2015).

2.9.1 Drought Mitigation at the Provincial Level.

The Permit to Take Water Program (PTTW) is used in order to conserve water to reduce the chances of a drought. Ontario is enhancing the PTTW program in order to ensure that the water takings in Ontario are managed to the standards of the Great Lake-St. Lawrence River Basin Sustainable Water Resources Agreement (Ontario, 2015). One must have a permit if they plan to withdrawal more than 50,000 liters of water in a day from the environment. This includes taking water from a river, lake, steam, pond or groundwater. A permit is only given if it does not negatively affect the environment, negatively affect existing water users or remove water from a watershed that already has a high level of use (Ontario, 2015). However, a permit is not required if you intend to take less than the 50,000 litre limit per day, if you are receiving water from someone with a permit to take water or if the water is being used for poultry, livestock, home gardens and firefighting purposes (Ontario, 2015).

There are three categories of permits:

1. Considered low risk and includes renewals where there is no history of complaints. This permit costs $750.
2. Water taking with a greater potential to cause adverse environmental impacts. This permit costs $750.
3. High risk and costs $3000.

The PTTW was brought into the Province to implement water quantity management policy with the principles of enabling responsible use of water resources and to protect the environment by preventing unacceptable interference with water users. The permit requires the holder to comply with all terms and conditions, especially monitoring and recording and the notification of complaints and its actions to resolve the issue (Ontario, 2015).

One of the most important parts of the permit that is heavily emphasized is with the actual taking of water to not cause a stop in the flow of water from a source or to cause negative ecological effects (Ontario, 2015). This is problematic due to the fact; much of the responsibility of responsible water management lies in the hands of the permit holder (Ontario, 2015).

Once the permit is issued, the holder is able to take water without interference as long as they follow the terms and conditions of the permit (Ontario, 2015). However, in some ways the permit contradicts itself since it allows for the permit holder maximum water taking, even when a source cannot supply efficiently to both the permit holder and the ecosystem. The permit also does not govern the following: installation, construction, operations or integrity of the means the water is taken (does not control how the water taking equipment is built since it is not a construction permit) (Ontario, 2015). This

therefore ties into no regulation with the permit in terms of drainage, return flow discharge or effluent quality but these may be addressed in other approvals and legislation.

The PTTW is a complaint-based system and in a complaint-based system, actions can only happen after some negative impacts have been registered. Generally with this type of system, it takes a significant event such as a dry well in order to require a response from the permit holder (Ontario, 2015). Therefore, the PTTW program is an effective system since it does promote responsible use of water and responsible water management but it still has some flaws in its outline.

Secondly, the Ontario Low Water Response Program (OLWRP) was created as a result of the extended periods of low rainfall and high temperatures they experienced within the late 1990s. This resulted in some of the lowest surface water levels and driest soils that had been recorded for the past several decades (Ontario, 2010, pg. i). As a result of the lower than average levels of precipitation, the Provincial Low Water Level Response Task Force (PLWLRTF) was formed, which is an inter-ministry response to low water levels. They are responsible for making recommendations for long-term management of low water conditions (Ontario, 2010, pg. i).

The Ontario Low Water Response consists of three condition levels, which are:

- Level 1: first indication of a potential water supply problem (conservation),
- Level 2: indicates a potentially serious problem (conservation & restriction),
- Level 3: indicates the failure of the water supply to meet the demand, resulting in progressively more severe and widespread socioeconomic effects (conservation, restriction & regulation).

(Ontario, 2010, pg. ii).

The responsibilities of the Province and its agencies are described within this plan and under the plan they form Ontario's Water Directors' Committee (OWDC). They will then form a Low Water Committee (LWC), which will become active when any watershed enters a Level II condition (Ontario, 2010). There were extreme low water conditions in 2007, which caused shortages of water in some watersheds, this created adverse socio-economic impacts and also impacted the aquatic ecosystems. The OLWRP is used in order to assist in the coordination and support the local communities in the event of a drought (Ontario, 2010).

The plan uses a Water Response Team (WRT), which uses a combination of water data, provincial legislation and regulations and local regulations, communication techniques and local tools to advocate conservation. The success of any WRT depends on local support and commitments to abide by the teams recommendations (Ontario, 2010, pg. 1). In the case of extreme droughts the WRT will ensure that key local and provincial decision makers are actively participating in the process in order to ensure that water management decisions are understood, supported and enforced (Ontario, 2010, pg. 1). The WRT will provide coordinated responses from provincial, conservation authorities, municipal, private and special interest water managers and users. There will also be representatives for local interests and users (Ontario, 2010, pg. 3).

There are several priority uses of water and when low water conditions develop, water managers have to deal with priority water use. Water is divided into three classes: essential, important and non-essential (Ontario, 2010, pg. 18). The goal of this is to balance efficient use, protection of resources and equity among users. For these reasons

decisions on low water and drought response and potential water use restrictions are best made with support and advice of local water managers and users.

Essential water uses are for human and animal life and health (drinking and sanitation) (Ontario, 2010, pg. 18). Important water uses are for social and economic well being (public institutions/health care) (Ontario, 2010, pg. 18). Nonessential water is water that can be interrupted for a short term without any significant impact (lawn watering) (Ontario, 2010, pg. 19).

2.9.2 Other Jurisdictions

Risk management would be the most effective tool due to the fact it helps to prioritize adaptation actions under high levels of uncertainty and identify an optimal course of action. Risk management can "reduce the impact of drought on producers in the short and long term" (Government of Alberta, 2010). Using risk management is pro-active, effective and a fiscally responsible approach to mitigating the effects of drought.

Alberta currently has a drought management plan using risk management in place. The plan has several goals some consisting of "communicated to producers, drought monitoring and reporting is effective and timely, supporting planning and action" (Government of Alberta, 2010). In order for the drought management plan to be effective, the standing multi-stakeholder Alberta Drought Advisory Group (DAG) was formed. The group is used to provide consent and consolidated advice and recommendations to complement government actions on drought-related issues affecting the agricultural producers in Alberta as well as advising and providing recommendations to government on long-term strategies for mitigating the effects of drought (Government of Alberta).

The plan has three approaches to action that are in turn linked to three levels of moisture condition. These consist of drought preparedness, drought monitoring and reporting and drought response (Government of Alberta, 2010). The strategies can be applied on a scenario basis as described by three levels: normal or near normal conditions, exceptional/notable conditions and extreme conditions. "These three levels are determined by the current levels of soil moisture and recent precipitation and temperature trends" (Government of Alberta, 2010). The Drought Action Plan identifies the possible actions of the DAG and partner agencies when each of the levels of drought is identified through monitoring. Guelph and Waterloo Region can use Alberta's Drought Risk Management Plan as an example of how they can integrate risk management procedures in their water efficiency strategies in order to protect their water supplies.

However, this can be a hard strategy to implement due to the fact there can be difficulty in ranking which risks are greatest at a particular moment in time. Determining the probability and potential consequences of events is not always possible and can therefore lead to adverse impacts. However, it is still an effective tool when it comes to climate change adaptation.

3.0 Research Objectives and Methodology

Research Objectives

The goal of this research is to understand how Guelph and Waterloo Region are currently managing their water supplies and what their preparedness plans are for droughts. The primary objective of this study was to determine how Guelph and Waterloo

are adapting to the impacts of climate change and how they are conserving their water supplies.

The questions to be explored are:

1. How is climate change impacting local water supplies?
2. Is water a key area of interest for Guelph and Waterloo Region?
3. How are the water supplies currently being managed in Guelph and Waterloo Region?
4. What are the strengths and weaknesses of the strategies? What threats do they face and opportunities do they bring?

Methodology

To explore the research questions, this research relied on secondary sources such as climate change reports and predictions, Official Plans, water management plans and strategies.

4.0 Results and Discussion

4.1 Guelph

The City of Guelph is one of Canada's largest communities that is reliant on a finite groundwater source (City of Guelph, 2015). Guelph's water comes from a municipal supply system that includes 21 operational groundwater wells. The City also gets water from the Arkell Spring Grounds Glen collector system, which collects shallow groundwater through a series of underground-perforated pipes (City of Guelph, 2015). Guelph is working to reclaim its water capacity through various conservation strategies that have the ability to benefit the community and its local systems (Table 1).

City of Guelph's Official Plan

The City of Guelph's Official Plan values are "intended to promote long-term community sustainability" (City of Guelph, 2001, pg. 1). The plan is used to promote the Public's interest in future development. It has several goals, which consist of maintaining quality of life, stability and safety throughout the community. It is also promotes climate change protection and energy conservation through sustainable land use planning through development, approvals and other municipal initiatives (City of Guelph, 2001, pg. 4).

The City of Guelph's Official Plan focuses on water resource protection and conservation "through land use planning that maintains and enhances the aquatic ecosystems within and beyond the municipality (City of Guelph, 2001, pg. 59). The City is working with government agencies, municipalities and other interested parties in order to integrate and coordinate water resource management. This management system will allow for an enhancement of the existing water resources in and around the City for the communities water supply (City of Guelph, 2001, pg. 59).

The City is also implementing a Water Supply Master Plan (WSMP) that identifies how growth of lands designated for urban services will be implemented. In 2006, The City of Guelph endorsed the Water Supply Master Plan, which evaluated its water demand with its projected growth over a 50-year horizon (City of Guelph, 2015). The Master Plan evaluates alternative sources of water, if it is cost effective and also evaluates the immediate available sources of a new water supply. Population projections are required to determine future water supply requirements. The City of Guelph is committed to managing population growth and developing strategies for ensuring an

adequate water supply for now into the future. The WSMP is using the reduction targets and applying them to their growth target to accommodate population growth (City of Guelph, 2015).

The Water Supply Master Plan has three reduction targets based on the daily water production volumes in 2006. The reduction targets they created are:

- "Reduction of 10 percent (5,300 m3/day) in average day water use by 2010;
- Reduction of 15 percent (7,950 m3/day) in average day water use by 2017; and
- Reduction of 20 percent (10,600 m3/day) in average day water use by 2025."

(City of Guelph, 2015)

In order for the City of Guelph to achieve their reduction targets, they developed a Water Conservation and Efficiency Strategy Update. This was initiated in February 2008 and was an award winning ten-year strategy. The update "identified the preferred program, policy and resource recommendations to achieve a further reduction of water protection to 8,773 m3/day by 2019" (City of Guelph, 2015). The final reduction of water that the City of Guelph is aiming to reach is 9150 m3/day by 2038 (City of Guelph, 2015). The conservation initiatives that the City of Guelph has in place to conserve water are an outside water use program, grey water reuse system, PTTW and rainwater harvesting.

The outside water use program was created in 2002, as a response to the Ontario Low Water Response Plan. The objective of the program is to conserve the groundwater supply and to protect the City against the impact of drought during the dry, hot summer months (City of Guelph, 2015). The program allows for watering during the hours of 7:00

a.m. and 9:00 a.m. and 7:00 p.m. and 9:00 p.m. on alternative days (odd numbered address, odd numbered calendar day, even number address, even numbered calendar day). The program has "three levels that affect residential outside water use. These levels are triggered by dry weather and local watershed conditions" (City of Guelph, 2015).

Program level zero blue, calls for a careful use of water. There are no serious rainfall, stream flow or storage issues. The Level 0 Blue water use restrictions are enforced with a focus on education (City of Guelph, 2015).

Level 1 Yellow requires residents to reduce their water usage. A change to yellow can occur when one or more of the following low water response indicators are met: "precipitation (less than 80 per cent of historical average over one and/or three months; two weeks without rain); Eramosa River flow (less than 70 per cent of minimum low flow); water storage level (less than 75 per cent of average)" (City of Guelph, 2015). Once the conditions normalize, they return to Level 0 Blue. By-law officers enforce the Level 1 Yellow conditions and those who are in non-compliance of the water use restrictions can be issued a $130 ticket or summoned to court for each non-compliance event that is observed (City of Guelph, 2015).

Level 2 Red requires residents to reduce and stop nonessential use. A change to Level 2 Red can occur when one or more of the following low water response indicators are met: "precipitation (less than 60 per cent of historical average over one and/or three months; three weeks without rain); Eramosa River flow (less than 50 per cent of minimum low flow); water storage level (less than 65 per cent of average)" (City of

Guelph, 2015). The same enforcement by-laws are in place during the Level 2 Red conditions as they are in the Level 1 Yellow.

In response to the Outdoor Water Use Program, residents are able to obtain a lawn-watering permit, giving them the ability to water their lawns for a specified number of days outside the requirements of the Outside Water Use Program. There are two types of permits that can be purchased, which "differ based on the circumstances requiring special lawn watering: A Treated Lawn Permit and a New Lawn Permit" (City of Guelph, 2015). The Treated Lawn Permit allows for the permit holder the ability to water lawns treated with biopesticides on any day and at any period of 10 days following the treatment application date (City of Guelph, 2015). The other permit is a New Lawn permit, which allows the permit holder to water newly laid sod or a newly seeded lawn outside of the normal alternate day watering restrictions for a period of 30 days (City of Guelph, 2015).

The City of Guelph uses a greywater reuse system in order to conserve water. Greywater is "is gently used water from your bathroom sinks, showers, tubs, and washing machines. It is not water that has come into contact with feces, either from the toilet or from washing diapers" (Greywater Action, 2015). The greywater system collects water from household baths and showers, the water is then purified using chlorine and is then used to flush toilets within the home. "Toilet flushing represents about 30% of daily water use in the home" (City of Guelph, 2015). Using a greywater system eliminates the use of potable water for toilet flushing. The greywater system allows for a significant saving of both water and money for individual households.

In a standard home, water is fed to each appliance and fixture from the municipal water supply. The wastewater or greywater that is produced from each appliance or fixture is then sent directly to the sanitary sewer (City of Guelph, 2015).

Lastly, the City of Guelph encourages rainwater harvesting in order to conserve and reuse water. The rainwater harvesting system is used in order to collect large amounts of water from both rain and snow. This water is stored in tanks, which can then be used inside and outside of the home (City of Guelph, 2015). These systems have the ability to reduce the use of high-quality drinking water tasks that do not require it. This ultimately saves money for the residents by lowering their utility bills.

In the spring and summer, Guelph's water use increased by 30% due to various outdoor activities such as lawn watering, car washing and gardening (City of Guelph, 2015). By capturing free rainwater and using it for outdoor activities that do not require valuable drinking water, residents are able to conserve water and even save money. They are able to protect groundwater and the conservation of rainwater also works to reduce the demand on the municipal water system, especially during high use periods (City of Guelph, 2015).

Table 1: Guelph Water Management / Conservation Components and it's Implementing Agency

Components of Water Management/Conservation ***Implementing Agency***	**Purpose**
Water Supply Master Plan *City of Guelph*	To define how we will continue to access a sustainable supply of water—for residential and industrial use—over the next 25 years.

Government of Ontario	
Water Conservation and Efficiency Strategy *City of Guelph*	A strategic plan that aims to use less water per capita than the comparable Canadian City. Outlines the program, policy and resource requirements to achieve a reduction in water use of 8,773 m3/day by 2019
Ontario Low Water Response Program *Ontario Ministry of Natural Resources* *Ontario Ministry of the Environment* *Ontario Ministry of Municipal Affairs and Housing* *Ontario Ministry of Research and Innovation* *Association of Municipalities of Ontario* *Conservation Ontario* *City of Guelph*	Used to ensure provincial and local authorities are prepared in the event of low water conditions. There are three levels of low water conditions. First: potential water supply problem managed through conservation. Second: serious problem – restrict non-essential water uses. Third: if the water supply fails to meet demand than water is restricted and regulated.
Outside Water Use Program *City of Guelph*	The OWUP was created in 2002 in response to the Ontario Low Water Response Plan. The OWUP program objectives are to conserve Guelph's groundwater supply and protect against the impact of drought during the hot, dry summer months.
Greywater Reuse System *City of Guelph*	Gently used water from sinks, showers, tubs and washing machines. Not water that has come into contact with feces. This water is collected and purified using chlorine to flush toilets within the homes. Using reclaimed greywater from showers and baths eliminates the use of potable water for toilet flushing, resulting in significant annual water and wastewater cost savings.

Rainwater Harvesting *City of Guelph*	Collect water from rain or snow to be used both indoors and outside the home. These systems reduce the use of high-quality drinking water for tasks not requiring it (lawn watering, car washing), ultimately saving money by lowering utility bills.
Lawn Watering Permits *City of Guelph*	Lawn watering permits are issued by the City of Guelph to allow permit holders the ability to water their lawns for a specified number of days outside the requirements of the Outside Water Use Program. There is two types of lawn watering permits, which differ based on the circumstances requiring special lawn watering: a Treated Lawn Permit and a New Lawn Permit.
Official Plan *City of Guelph*	The City of Guelph's Official Plan is a statement of goals, objectives and policies for growth and development for the next 20 years. The Official Plan is developed based on input from the community and it promotes the public interest in the future development of the City. The Official Plan is focused on sustainability and establishes policies that have a positive effect on the social, economic, cultural and natural environment of the City (City of Guelph, 2015).

4.2 Waterloo Region

Similar to Guelph, Waterloo has a Water Conservation By-law, which is used to help limit outdoor water use during specific days and times. This By-law helps give the Region the power to regulate or prohibit activities within its jurisdiction over water storage, production and treatment (Region of Waterloo, 2014, pg. 1). The By-law comes into effect on the 31st day of May each year and ceases to be in effect on the 30th day of September each year. The watering times are between 5:30 am and 10 am and between the hours of 7:00 pm and 11:00 pm (Region of Waterloo, 2014, pg. 2). Their By-law also

has emergency water-use restrictions which restricts outdoor water use if a water storage capacity is less than 60% for urban water systems, pumping at greater than 90% capacity for settlement water systems only and an OLWR level III condition (Region of Waterloo, 2014, pg. 4).

The Region of Waterloo developed a Water Efficiency Master Plan for 2015 to 2025. Its vision is to "contribute to sustaining a clean and reliable drinking water supply for the future; a supply that draws primarily from out groundwater and river water sources" (Region of Waterloo, 2014). The Water Efficiency Master Plan has several goals, the first being to engage businesses, institutions, residents and municipalities in actions and behaviour that will promote water conservation and efficiency. It aims to positively impact the community's environment and economy through water conservation and efficiency. The Region wants to focus on a sustainable water supply with ground water and river sources by deferring large capital infrastructure projects into the future. They also want to effectively monitor and report on the measureable benefits of the water efficiency program (Region of Waterloo, 2014). The last goal the Region has is to be recognized as innovative leaders in water efficiency (Region of Waterloo, 2014). In order to achieve their goals, there are several objectives put into place. These consist of a reduction in outdoor and indoor water demand in the residential sector and reducing the total system demand for water. The Region is also working towards reducing summer peak demands and avoiding an increase to the water efficiency program budget and staff levels (Region of Waterloo, 2014).

The program has several expected benefits including:

- By 2025, saving 1370 million liters of water per year,
- Over the 10 years of the program, the cumulative savings will be 9023 million liters,
- By 2025 detached and semi-detached single family residential water consumption will decrease from 202 to 165 liters per capita per day,
- There will be a cumulative wastewater and water operating cost savings of $2.5 million by 2025,
- An estimated 7700 tonnes of carbon dioxide avoided from being released into the atmosphere.

(Region of Waterloo, 2014, pg. 1).

The Region of Waterloo has been actively engaged in water conservation since 1974 and is recognized as a leader in water efficiency and conservation (Region of Waterloo, 2014, pg. 1). The Region was 42% ahead of the target for 2011 and has exceeded its 2015 target of 8146 m3/day. This helped to reduce costs, decrease its greenhouse gas emissions and the deferral of large water infrastructure projects (Region of Waterloo, 2014, pg. 1). The tri-city uses an average of 202 litres of water per day per person.

There are various benefits that are associated with water savings. There is a reduction in operating costs that are associated with less energy and chemical usage and other variable cost savings (Region of Waterloo, 2014). There has been a reduction in seasonal peaking factors and greenhouse gas emissions from the lower demands for electricity and/or gas that are required to pump, treat and heat water. There is an estimated cumulative annual greenhouse gas savings from 2007 to 2011 of 496.7 tonnes (Region of Waterloo, 2014, pg. 6).

Some of the key findings, from the Water Efficiency Master Plan, were that were found are that the residents in the Region are supportive of water efficiency and conservation. “98% of residents consider water conservation ‘important’ or ‘very

important'. Just like Guelph the Region of Waterloo uses rainwater harvesting and rain barrels for the conservation and reuse of water.

Waterloo Official Plan

Region of Waterloo Official Plan is a "primary long-range, comprehensive municipal planning document that outlines a framework for land use decision-making for the City of Waterloo (City of Waterloo, 2014, pg. 2) (Table 2). One of the goals of the Official Plan is to maintain an adequate water supply. In order to maintain an adequate supply of potable water the Region will be using various conservation programs, drinking water protection measures and water infrastructure upgrades to meet future requirements (City of Waterloo, 2014, pg. 68). In order for the Region to maintain a network of local water mains to meet is obligations, it will conduct studies and evaluations on its water infrastructure. The assessments will assess the maintenance needs, service capacity and requirements for upgrades (City of Waterloo, 2014, pg. 68).

Water resources are a major concern for the Region of Waterloo and in order to protect them they are striving to:

a. Maintain, enhance, & restore water recourses,
b. Increase potable and non-potable water conservation and efficiency,
c. Enhance existing storm water management practices,
d. Maintain basic water infrastructure

(City of Waterloo, 2014, pg. 116).

The Region of Waterloo recognizes that it is vital that water be protected within the Region. "It is … necessary to safeguard both surface and groundwater, as they are intricately connected, from land uses and human activities that could impair their quality

or quantity. With continuing population growth and a finite supply of resources, the protection, conservation, and efficient use of water is imperative" (City of Waterloo, 2014, pg. 141).

The Region of Waterloo's Official Plan states that they are dedicated to maintaining, enhancing and restoring water quality and quantity. The Region plans to promote efficiency and sustainable use of water resources through water conservation. The Region is using education initiatives, incorporating storm water management, pursuing technological and other system improvements to address issues such as inflows and infiltration of sanitary sewers for water conservation (City of Waterloo, 2014, pg. 141).

The Grand River Conservation Authority (GRCA) plays a role in the responsible use of water within the Region and monitor the water quality and quantity (City of Waterloo, 2014, pg. 142). Not only does the Region encourage responsible and sustainable uses of water, they discourage land uses that have impacts on water resources. They discourage the use of large amounts of water or discharge and large amounts of water that will need to be treated (City of Waterloo, 2014, pg. 142). In order for new development to take place a hydrological assessment is done both pre and post development to ensure it is a sustainable system. Development is also not permitted near or on areas that have sensitive surface or ground water features (City of Waterloo, 2014, pg. 142). "Where feasible/appropriate development will maximize clean water recharge and conservation measures, including infiltration" (City of Waterloo, 2014, pg. 142).

The Region is working towards environmental sustainability by reducing ecological footprints. “Achieving environmental sustainability requires continuous effort, there is no end to the process” (City of Waterloo, 2014, pg. 165). Practices being promoted include energy and water efficient communities and infrastructure, reduction of greenhouse gases and elimination of point source and fugitive contaminants, efficient management of storm water, effective reduction and management of solid waste and protection of biodiversity (City of Waterloo, 2014, pg. 165).

The Region of Waterloo has a Water Resources Protection Master Plan (WRPMP) “to minimize the risk of historic, existing and future land uses on municipal water supplies (Region of Waterloo, 2008, pg. 1). Waterloos water supply comes from an integrated system of groundwater and surface to main urban areas and a series of smaller wells that service a variety of small communities bordering Waterloo (Region of Waterloo, 2008, pg. 1). The Region receives 75% of its water from ground water and the remaining 25% comes from surface water from the Grand River. The long-term sustainability of the Regions water supply system depends on the quantity and quality of recharge that is received by aquifers and the quantity and quality of flows in the Grand River (Region of Waterloo, 2008, pg. 1).

The Region has been implementing its WRPMP since 1993. In 2003, the Region partnered with GRCA and was rewarded funding from the Ministry of Environment (MOE) operation clean water municipal groundwater study initiative (Region of Waterloo, 2008, pg. 1). The WRPMP has been implementing numerous programs and source protection strategies have evolved both locally and internationally. The plan is

updated periodically when new information and technologies develop for water conservation and management.

The *Safe Drinking Water Act* has influenced source-water protection when it was introduced as a new category of water supply facility. It has mainly been a major influence for municipal wells that use groundwater under the direct influence of surface water. This is a result of source water being more prone to microbial and pathogenic contamination (Region of Waterloo, 2008, pg. 4).

Table 2: Components of Water Management/Conservation and its Implementing Agency

Components of Water Management/Conservation	**Role / Importance**
Water Conservation By-law *Region of Waterloo*	Used to limit outdoor water use to specific days and times in order to help reduce peak water use and limit the risk of an outdoor watering ban.
Water Efficiency Master Plan *Region of Waterloo*	This is used in order to contribute to sustaining a clean and reliable drinking water supply for the future; a supply that draws primarily from our ground water and river water sources. This plan engages municipalities, residents, business and institutions in actions and behaviors that will promote water conservation and efficiency.
Ontario Low Water Response Program *Ontario Ministry of Natural Resources* *Ontario Ministry of the Environment* *Ontario Ministry of Municipal Affairs*	Used to ensure provincial and local authorities are prepared in the event of low water conditions. There are three levels of low water conditions. First: potential water supply problem managed through conservation. Second: a serious problem – restrict non-essential water uses. Third: if the water supply fails to meet demand then water is restricted and regulated

and Housing *Ontario Ministry of Research and Innovation* *Association of Municipalities of Ontario* *Conservation Ontario*	
Water Resources Protection Master Plan *Region of Waterloo* *Ministry of the Environment* *Grand River Conservation Authority*	Provides the technical and policy or program initiatives needed to protect municipal drinking water. Uses risk-mitigation programs.
Safe Drinking Water Act *Region of Waterloo* *Government of Ontario*	Provide the protection of human health and the prevention of drinking water health hazards though the control and regulation of drinking water systems and drinking water testing.
Rainwater Barrel *Region of Waterloo*	Collect water from rain or snow to be used both indoors and outside the home. These systems reduce the use of high-quality drinking water for tasks not requiring it (lawn watering, car washing), ultimately saving money by lowering utility bills.
Greywater Reuse *Region of Waterloo*	Gently used water from sinks, showers, tubs and washing machines. Not water that has come into contact with feces. This water is collected and purified using chlorine to flush toilets within the homes. Using reclaimed greywater from showers and baths eliminates the use of potable water for toilet flushing, resulting in significant annual water and wastewater cost savings.

Official Plan *Region of Waterloo*	Road map for long-use range and development. It supports the overall goal of achieving a healthy community built on the principles of diversity and adaptability, accessibility and equity, connectivity, health and vitality.

4.3 SWOT Analysis

SWOT analysis, Strengths, Weaknesses, Opportunities and Threats – is a useful tool in planning. It helps to devise strategies to achieve the organization's overall purpose, within a specific bracket of targets. The purpose of a SWOT analysis is to enable organizations to identify internal and external influences. The primary objective is to help organizations develop a full awareness of all the factors, positive and negative, that may affect strategic planning and decision-making (Goodrich, 2015). A SWOT analysis is used to plan for future change but it can also be used to monitor existing programs (David, 1993).

SWOT analysis is meant to act primarily as an assessment technique. Therefore, for the purpose of this study, a SWOT analysis will allow for results to be drawn on the conservation techniques used in each study area to be able to compare and draw conclusions on which area is more prepared for the impacts of climate change and droughts. It will identify who has more water conservation strategies in place and whose goals are more obtainable. SWOT analysis is used for identifying possible areas of change in a program, exploring avenues for new initiatives and making decisions about execution strategies for a new policy.

The main principles for effectively climate change adaptation were outlined in section *2.7-climate change adaptation.* These principles are now used in a SWOT framework to evaluate the effectiveness of the climate change adaptation strategies of Guelph and Waterloo. To summarize, the principles are:

1. Avoid loss and unsustainable investment, and take advantage of new economic opportunities,
2. Take all reasonable and practical measures to increase climate resilience of ecosystems,
3. Create a share risk-management tools to support adaptation efforts across the province,
4. Achieve a better understanding of future climate change impacts across the province,
5. Seek opportunities to collaborate with others,
6. Anticipate the adverse effects of climate change and taking appropriate action to prevent or mitigate damage they can cause,
7. Collaboration with various stakeholders needed at all levels of administration - local and regional.

4.3.1 Guelph

Strengths

- Works towards achieving a better understanding of future climate change impacts across the Province,
  - Use provincial measures (Ontario Low Water Response Program) an incorporating them into their plans,
- Requires collaboration with various stakeholders – and all levels of administration – local and regional,
  - Ministry of Environment,
  - Local Government (City of Guelph),
  - Conservation Ontario,
  - Provincial Government,
  - Ontario Ministry of Natural Resources,
  - Ontario Ministry of Municipal Affairs and Housing,
  - Ontario Ministry of Research and Innovation,
  - Association of Municipalities of Ontario,
- Takes all reasonable and practical measures in order to increase climate resilience of ecosystems,

    - Greywater systems,
    - Toilet rebates,
    - Outdoor Water Use Program,
    - Water Supply Master Plan,
        - Reduce daily water use,
    - Water Conservation and Efficiency Strategy Update,
        - Identified preferred program, policy and resources recommendations to achieve a further reduction of water protection,
    - Rainwater harvesting,
    - Permit to take Water,
- Incorporates Climate Change adaptation strategies into Official Plans,
        - Promotion of long-term sustainability,
        - Water resource protection and conservation through land use planning that maintains and enhances the aquatic ecosystems,
- Anticipates environmental benefits of climate change adaptation,
    - Water conservation,
    - Decrease risk of drought,
    - Protect soil,
    - Increase water savings,
    - Increases energy savings,
- Reflects adaptation by resistance,
    - Increasing water supply,
    - Mitigating drought,
- Addresses the impacts that are a result of the warming which are already unavoidable due to past emissions,
    - Between 1948 and 2008, the average annual temperatures in Ontario increased by up to 1.4 degrees Celsius (Government of Ontario, 2014),
    - Decrease in ground water supplies,
    - Health issues: increase in disease, fresh water storages and worsened smog,
    - Land degradation,
        - Lower crop yields, increase in livestock death, crop failure.

Weaknesses

- Does not avoid loss and unsustainable investment and take advantage of new economic opportunities,
    - Guelph is not taking advantage of economic opportunities,
    - More water conservation strategies that could be incorporated or better enforced,
        - Monitor lawn watering,
- Does not apply risk management tools to support adaptation efforts
    - Risk management is not incorporated into Guelph's Official Plan or their Water Supply Master Plan,
        - Do not identify the drivers of risk management and their likely impacts.

Opportunities

- For incorporating more risk management into climate change adaptation strategies,
  - Science based tool that is used to help decision makers analyze risks,
  - Can be better utilized to mitigate the impacts of climate change and promote water conservation,
- For using adaptive management to learn from past mistakes,
  - Allows for improving resource management by learning from management outcomes,
    - Can allow for planners to learn about the ecological effects of climate change and can respond more appropriately,
- To build resilience,
  - Use drought resistant crops,
- To anticipate the adverse effects of climate change and takes appropriate action to prevent or minimize the damage they can cause, or taking advantage of the opportunities that may arise,
- To promote the public's interest in future development,
  - Maintain quality of life, stability and safety through community,
  - Improve and promote public transportation,
- To achieve a better understanding of future climate change impacts across the Province, by improving public awareness through education,
- Can further address the impacts that are a result of the warming which is already unavoidable due to past emissions,

Threats

- Change of government
  - Are the current strategies strong enough to withstand a change in government?
  - Will they disrupt the climate change strategies should a new leader?
  - How permanently institutionalized are the current strategies?
- Implementation measures and actions require time and government approval,
  - No guarantee strategies will be approved,
- Competition pressures from the tourism industry which lead to high standards of water quality,
  - Proliferation of golf course,
  - High water standards,
  - Water for splash pads,
  - Water parks,
- Lack of concern over effective water resource management by stakeholders, mainly farmers.

4.3.2 Waterloo

Strengths

- Requires collaboration of various stakeholders – and all levels of administration – local and regional,
  - Grand River Conservation Authority,
  - Local government (Region of Waterloo),
  - Provincial Government,
  - Ministry of Environment,
  - Ontario Ministry of Natural Resources,
  - Ontario Ministry of Municipal Affairs and Housing,
  - Ontario Ministry of Research and Innovation,
  - Association of Municipalities of Ontario,
  - Conservation Ontario,
- Takes all reasonable and practical measures in order to increase climate resilience of ecosystems,
  - Water Efficiency Master Plan,
    - Sustain clean and reliable water supply for future,
  - Water Conservation By-law,
  - Official Plan,
  - Water Resources Protection Master Plan,
  - Rain barrels,
  - Toilet rebates,
  - Lawn watering hours,
  - Safe Drinking Water Act,
- Reduce water demand during peak hours,
- Address the impacts that are a result of the warming which is already unavoidable due to past emissions,
  - Between 1948 and 2008, the average annual temperatures in Ontario increased by up to 1.4 degrees Celsius (Government of Ontario, 2014),
  - Extreme heat, frequency of heat waves,
  - Dry conditions,
  - Shortages of water,
  - Land degradation
    - Lower crop yields, increase in livestock death, crop failure,
- Incorporate Climate Change adaptation strategies into Official Plans,
  - Promotion of long-term sustainability,
  - Water resource protection and conservation through land use planning that maintains and enhances the aquatic ecosystems.

Weaknesses

- Urbanization,
  - Reduces impervious surfaces which allow for the recharge and refill of groundwater and aquifers,
  - Small amount of water available for a growing population,
  - Decrease water supplies and aquifers from rural farmers,
- Cannot monitor indoor water use effectively,
- Does not apply risk management not full incorporated into climate change adaptation plans,
- Climate change adaptation imperative is to avoid loss and unsustainable investment and take advantage of new economic opportunities,
  - Waterloo is not taking full advantage of the economic opportunities available.

Opportunities

- Use of grey water system in order to reuse waste or treated water,
  - Can be used for agriculture,
  - Car washing,
  - Lawn watering,
- For using resilience in climate change adaptation strategies,
- For incorporating adaptation management more effectively,
- Can use adaptation in order address the impacts that are a result of the warming which is already unavoidable due to past emissions,
  - Past emissions such as the burning of fossil fuels, clear cutting forests, methane gas from cattle and volcanic eruptions,
- Adoptability of recycled water,
- Create employment,
  - By-law monitoring Outdoor Water Use,
  - Infrastructure – waste water treatment plants, building rain barrels,
  - Engineers for lot grading and drainage plans to ensure groundwater refills,
- Reduce ecological footprint,
- To achieve a better understanding of future climate change impacts across the Province by improving public awareness through education.

Threats

- Change of government,
  - Are the current strategies strong enough to withstand a change in government,
  - Will they disrupt the climate change strategies should a new leader come into power,
  - How permanently instutionalized are the current strategies?
- Social resentment in the application of specific measures,
  - Grey water use or using treated water for household activities

- Lack of concern over effective water resource management by stakeholders, mainly farmers,
- Competition pressures from the tourism industry which lead to high standards of water quality,
    - Proliferation of golf course,
    - High water standards,
    - Water for splash pads,
    - Water parks.

4.3.3 Comparison

There are clear similarities and differences between the Climate change adaptation strategies of the two study areas. Seven principles of effective climate change adaptation were applied in a SWOT framework.; Neither location met all of the principles.

Both area's have strong collaboration between various stakeholders, not only is their local government working towards climate change adaptation, but they are working with regional governments as well. Not only that, but both area's have a strong focus on water conservation and climate change adaptation strategies, both of which are outlined in their Official Plans. Both area's are working towards long-term sustainability and promoting the conservation of resources.

In terms of water conservation, it is evident that Guelph has more water conservation programs established than Waterloo. Guelph has implemented greywater systems, toilet rebates, lawn watering permits and rain water harvesting. Whereas the Waterloo Region has only implemented rain barrels, toilet replacement programs and specific lawn watering days/times.

Nevertheless, both areas have water conservation goals and are working to decrease their current water usages. Both areas have a take on a water efficiency strategy, which outlines how they will achieve these goals, ways to implement water efficiency and cut down on water usages. After examining the water reduction goals between Guelph (Table 3 & 4) and Waterloo (Table 3), one is able to determine a strong difference between the two areas. The major difference is that Guelph has a higher reduction goal for water usage by 2019. Guelph has a target of 167 litres/person/day whereas Waterloo has a reduction target of 178 litres/person/day, which is higher than Guelph's 2015 target of 178 litres/person/day.

Table 3: Guelph and Waterloo Water Reduction Target 2019

	2007	2008	2009	2010	2011	2015	2017	2019	2025
Guelph	201	193	187	186	184	176		167	
Waterloo						188	184	178	168
* litres per person per day									

Table 4: Guelph Water Reduction Target 2025

Year	Water Usage (m3/d)	% Reduction
2010	5,300	10
2017	7,950	15
2025	10,600	20

In order to work towards meeting their water reduction targets Both Guelph and Waterloo have Outdoor Water Use Programs /By-laws in place that protect water usage within summer months. Guelph has an Outdoor Water Use Program, which is used in order to conserve the City's groundwater supply and protect them from a drought. Similar to this, Waterloo Region has a Water Conservation By-law, which is used to limit the outdoor use of water during peak periods. This will help to conserve and protect the City's water supply to also protect them from a drought.

Both areas have the opportunity to further increase the benefits of well-planned climate change adaptation strategies. Strengthening their current plans can save money and even lives in the long run. Climate change adaptation has the ability to decrease energy use, decrease greenhouse gas emissions and even increase the availability of fresh water supplies. Currently Guelph is incorporating adaptation by resistance, which is working towards increasing water supplies and mitigating drought. However, both areas have the opportunity to use resilience as an adaptation strategy by incorporating the use of drought resistant crops in to agricultural or personal uses.

Water conservation is a key area of interest for Guelph and Waterloo since both regions have a Water Efficiency Plan; outdoor water use programs/ by-laws and incorporate water management into their Official Plans. Both areas are striving to ensure they are prepared for climate change and the potential risk of a drought. They are both managing their water supplies efficiently and are on the right track to achieve their water conservation goals. However, Guelph as it currently stands has a more effective water conservation strategy in place than the Waterloo Region does. They are more successful at conserving water and reaching their water reduction targets.

5.0 Conclusion

Guelph and Waterloo Region have implemented several water conservation strategies, plans and programs in order to protect their water supplies and prepare for the future. Both of the areas are using similar water conservation practices such as toilet rebates and rain barrels, however, Guelph has more water conservation strategies in place such as lawn watering permits, rainwater harvesting and greywater reuse systems. These water conservation strategies are important due to the fact they reduce the amount of drinking water that is wasted and help to conserve the water supply of each area. Water is a finite resource and it is important to avoid being stuck in a drought without a backup supply of water available. However, with the increase in population and population targets for the future, the water that is being conserved today to mitigate drought, may not be sufficient for the future. With an increase in population, there will be an increase in the amount of water needed for the public and this may exceed the water that was conserved previously.

It is clear that both of the study areas are well on their way to effectively managing their water supplies and reaching their target reduction goals. After analyzing climate change adaptation strategies, it has become evident that the area's should incorporate risk management into their climate change adaptation strategies in order to more effectively mitigate the impacts of climate change on water resources to prevent them from going through a drought. Risk management allows for an assessment of all the risks and compares the magnitudes of each consequence and the likelihood that it will occur. This will be useful for these areas since they will be able to identify the likelihood of a drought occurring in order to help them prepare for it. They will be able to

implement new by-laws or monitor them more strictly should they become at an increased risk of a drought.

6.0 Recommendations

There are simple indoor and outdoor changes that can be used in order to conserve water. Not only that but implementing risk management or adaptive management into their climate change adaptation strategies can be an effective tool.

Indoor Changes

There are several simple and effective water conservation strategies that can be done around the house for individual household users. Many of the suggested water conservation strategies are simple changes that many individuals can do on a daily basis in order to protect this finite resource. Some of these daily changes that individuals can do is turning off the tap while they are brushing their teeth, this is a simple adjustment, however, can be easily forgotten leading to mass amounts of water being wasted. Individuals can also cut down on the length of the showers they take in order to reduce water usage. They can also use energy efficient toilets; Guelph and Waterloo have rebate systems for those who are switching out their old toilets for energy efficient ones. Lastly, ensuring that faucets and pipes are not leaking leading to unnecessary water usage.

Outdoor Changes

Some of the changes that individuals can do to increase water conservation outdoors is by planting drought resistant crops due to the fact they have the ability to survive during periods of low rainfall. Individuals can use mulch in their gardens since it

slows down the rate of evaporation that takes place, which will increase the ability for the soil to retain its moisture. This will then decrease the amount of water that is required for watering which will reduce the household's water intake.

The Region of Waterloo can incorporate the use of greywater systems in order to reduce the waste of fresh drinking water. Greywater systems use treated wastewater from showers, sinks and tubs to flush toilets to reduce the waste of fresh drinking water. This can then help the Region to meet their water reduction targets. Not only that, but the Region of Waterloo can use lawn-watering permits instead of or with their current lawn watering hours. This will help to monitor outdoor water usage more effectively since they will have the ability to say who can and cannot water their lawns.

Although, some of these changes can be hard to monitor, especially indoor water usages, they can lead to large savings in fresh drinking water. They will increase the chances of each area reaching its target water reduction targets.

Population Growth Management

It is evident that the populations within Guelph and Waterloo are increasing and will continue to do so. Both areas are working towards water conservation in order to be prepared for a drought. These conservation strategies are intended to be for long-term management; however, this may not be the case. These conservation strategies are more short-term since they are adaptation strategies and mainly deal with the current population. Guelph and Waterloo need to incorporate long-term conservation strategies that deal with the increasing population into their water management plans. This will then

allow for them to incorporate how much water is needed in the future and how much should be conserved in the present to be effective for the future.

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