

Indicators
of
Adaptive
Capacity

2013

This report is a list of potential indicators of adaptive capacity developed for Agriculture, and Hydrology.

Agriculture
and Hydrology

Ontario Centre for Climate Impacts and Adaptation Resources

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Sensitivity Mapping for Climate Change Impact on the Agricultural Sector in the Lake Simcoe Region¹

The following table (Table 1) provides a list of possible indicators developed to assess adaptive capacity of the agriculture sector in Lake Simcoe subwatersheds to respond to heat stress in livestock. Rationale for the selection of each indicator is also given.

Table 1: Possible indicators to assess adaptive capacity of the agriculture sector in Lake Simcoe subwatersheds to respond to heat stress in livestock

Number of Animals/Heat Stress			
Determinant of Adaptive Capacity	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Infrastructure ² (built and/or natural infrastructure)	<ul style="list-style-type: none"> Access to shade e.g. % tree canopy, or number of animals to size of farm (either land acreage, or size of barn/shade/shelter area) 	<ul style="list-style-type: none"> Shading, in the form of tree canopy can help reduce heat stress in livestock. A properly designed shelterbelt will provide shade and allow summer winds to circulate in the pasture or feedlot area further reducing stress to animals³ 	Access to shade = higher adaptive capacity
Infrastructure ⁴ (built and/or natural infrastructure)	Access to an adequate supply of cool, good quality water ⁵	<ul style="list-style-type: none"> Access to water can help reduce heat stress in livestock. Consuming water is the quickest and most efficient method to reduce body temperature. Water prevents dehydration and allows heat to be dissipated through evaporative cooling (sweating) and urination⁶ To prevent contamination of streams, rivers and lakes it is better to have another source of water for 	Access to water that does not come from river or stream = higher adaptive capacity

¹ (Jamieson, 2011)

² (Smit, Burton, Klein, & Wandel, 2000)

³ (PFRA Shelterbelt Centre, 2011)

⁴ (Smit, Burton, Klein, & Wandel, 2000)

⁵ (Nienaber & Hahn, 2007)

⁶ (Mader, Griffin, & Hahn, 2007)

Number of Animals/Heat Stress			
Determinant of Adaptive Capacity	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		animals. • Water should be protected from evaporation (?) e.g. is water trough sheltered?	
Infrastructure ⁷ (built and/or natural infrastructure) Technology ⁸	Evaporative cooling in barns ⁹	• Evaporative coolers, evaporative cooling pads (LPCV barns), low-pressure sprinkler systems or high-pressure mist systems can lower the temperature in barns by evaporating water ¹⁰ .	Access to some form of evaporative cooling = higher adaptive capacity
Infrastructure ¹¹ (built and/or natural infrastructure) Technology ¹²	Sprinkler system ¹³	• Sprinklers provide effective cooling for cows ¹⁴	Access to sprinklers = higher adaptive capacity
Infrastructure ¹⁵ (built and/or natural infrastructure) Technology ¹⁶	Ventilation in barn	• A well-designed ventilation system can reduce heat stress e.g. one or more options of natural ventilation, tunnel ventilation, basket fans and large-diameter, low-speed fans ¹⁷ • Tunnel ventilation provides a beneficial wind chill effect that cools the animals by convection. The net result is reduced heat stress, increased animal	Ventilated barns = higher adaptive capacity

⁷ (Smit, Burton, Klein, & Wandel, 2000)

⁸ (Smit, Burton, Klein, & Wandel, 2000)

⁹ (Nienaber & Hahn, 2007)

¹⁰ (House, 2010) (Janni, 2010)

¹¹ (Smit, Burton, Klein, & Wandel, 2000)

¹² (Smit, Burton, Klein, & Wandel, 2000)

¹³ (Nienaber & Hahn, 2007)

¹⁴ (Lang, 2011)

¹⁵ (Smit, Burton, Klein, & Wandel, 2000)

¹⁶ (Smit, Burton, Klein, & Wandel, 2000)

¹⁷ (Lang, 2011)

Number of Animals/Heat Stress			
Determinant of Adaptive Capacity	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		comfort, and the ability to maintain productivity in hot weather ¹⁸	
Information, skills * and management**	Aware of the impacts of heat on livestock	<ul style="list-style-type: none"> • Evaluation of the potential for heat stress on livestock¹⁹. • Look for clues to an impending heat stress crisis²⁰ 	Awareness = higher adaptive capacity
Information, skills and management ²¹	Heat Stress Management Plan ²²	<ul style="list-style-type: none"> • Proactive – identifies the triggers for heat stress, and sets out a plan to reduce heat stress among livestock 	Management Plan in place = higher adaptive capacity
Information, skills and management ²³ Technology ²⁴	Means to monitor weather	<ul style="list-style-type: none"> • Weather station on property • Access and use of internet • Access to/use of Smartphone <p>Helps anticipate potential heat stress in animals.</p>	Means to monitor weather = higher adaptive capacity
Information, skills and management ²⁵	Handling of animals ²⁶	<ul style="list-style-type: none"> • Handling animals during peak body temperature hours should be avoided during potential heat stress periods. Any forced animal activity will generate increased body temperature and additional heat stress. Handling includes weighing, shipping, or routine treatment of animals and should be scheduled for evening or early morning 	Handling at night or early in the morning = higher adaptive capacity

¹⁸ (Huffman, 2000)

¹⁹ (Mader, Griffin, & Hahn, 2007)

²⁰ (Mader, Griffin, & Hahn, 2007)

²¹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

²² (Mader, Griffin, & Hahn, 2007)

²³ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁴ (Smit, Burton, Klein, & Wandel, 2000)

²⁵ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁶ (Nienaber & Hahn, 2007)

Number of Animals/Heat Stress			
Determinant of Adaptive Capacity	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		hours, or at night to provide an opportunity for the animals to cool down after increased activity ²⁷	
Information, skills and management ²⁸	Feeding and nutritional strategies ²⁹	<ul style="list-style-type: none"> Feeding at dusk; highly digestible, high energy rations - produces less body heat³⁰ 	Feeding strategy to reduce body heat = higher adaptive capacity
Information, skills and management ³¹	Breeding practices ³²	<ul style="list-style-type: none"> Breeding in the spring to avoid hot weather³³ 	Breeding practices to avoid hot weather = higher adaptive capacity
Economics ³⁴	Revenue/Profit or Assets/Liabilities or access to financial products (loans, mortgages)	<ul style="list-style-type: none"> More profitable farms, or farms with access to financial products may have the capacity to make modifications to the farm in order to reduce heat stress among livestock 	Higher profits = higher adaptive capacity
Information, skills and management ³⁵	Municipal heat response plan	<ul style="list-style-type: none"> Municipal heat response plans/alerts could give the farmer notice of potential issues related to heat stress with his animals. 	Municipal heat response plan/alerts = higher adaptive capacity

²⁷ (Nienaber & Hahn, 2007) (Mader, Griffin, & Hahn, 2007)

²⁸ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁹ (Nienaber & Hahn, 2007)

³⁰ (Nienaber & Hahn, 2007)

³¹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

³² (Reid, Smit, Caldwell, & Belliveau, 2007)

³³ (Reid, Smit, Caldwell, & Belliveau, 2007)

³⁴ (Smit, Burton, Klein, & Wandel, 2000)

³⁵ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

Number of Irrigated Hectares³⁶

The following table (Table 2) provides a list of possible indicators to assess adaptive capacity of the agriculture sector in Lake Simcoe subwatersheds to respond the possible reduction in water availability due to extreme drought. Rationale for the selection of each indicator is also given.

Table 2: List of possible indicators to assess adaptive capacity of the agriculture sector in Lake Simcoe subwatersheds to respond the reduction in water availability

Number of Irrigated Hectares/Extreme droughts			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills and management ³⁷	Number of other industries / sectors with subwatershed with water permits	<ul style="list-style-type: none"> Greater number of industries/ sectors sharing the water could already mean the availability of water is low and become problematic during periods of drought. 	Low number of users = higher adaptive capacity
Information, skills and management ³⁸	Volume of water taken/allowed by other industries / sectors within the watershed	<ul style="list-style-type: none"> A higher demand for water within a subwatershed may place stress on the system 	Lower demand for water = higher adaptive capacity
Information, skills and management ³⁹	Responsiveness of the regulator to apply restrictions to water taking	<ul style="list-style-type: none"> Water restrictions can help conserve water in periods of drought 	Ability to respond quickly = higher adaptive capacity
Infrastructure ⁴⁰ (built and/or natural infrastructure) Technology ⁴¹	Type of irrigation used e.g. conventional versus water efficient ⁴²	<ul style="list-style-type: none"> Drip irrigation can save 30% to more than half of the amount of water used for furrow irrigation⁴³. Flood irrigation often results in water losses of up to 50%⁴⁴ 	Water efficient irrigation system = higher adaptive capacity

³⁶ (Jamieson, 2011)

³⁷ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

³⁸ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

³⁹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁴⁰ (Smit, Burton, Klein, & Wandel, 2000)

⁴¹ (Smit, Burton, Klein, & Wandel, 2000)

Number of Irrigated Hectares/Extreme droughts			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills and management ⁴⁵	Conduct regular maintenance on irrigation systems ⁴⁶	<ul style="list-style-type: none"> Water conservation practice – leak detection, loss prevention⁴⁷ 	Regular maintenance and testing = higher adaptive capacity
Information, skills and management ⁴⁸	Timing or scheduling of irrigation ⁴⁹	<ul style="list-style-type: none"> Scheduling irrigation for during the night, early morning, or on cloudy days for overhead irrigation; not using overhead irrigation on windy days⁵⁰ Schedule irrigation to maximize benefits to crops, taking into consideration rainfall and crop needs. Adjusting irrigation to fit the needs of the individual crops will ensure that water is not wasted and that crops will be of the highest possible quality and quantity. All crop irrigation should be scheduled⁵¹. 	Timing or scheduling irrigation to minimize loss through evaporation = higher adaptive capacity
Information, skills and management ⁵²	Readiness for low water conditions e.g. consideration about how to deal with potential periods of low water; contingency plan to	<ul style="list-style-type: none"> Ontario Low Water Response (OLWR) is a strategy for local water users and those with an interest in water use to have input into the well being of their community. Water Response Teams are established in areas experiencing low 	Being prepared to respond to low water conditions = higher adaptive capacity

⁴² (Shock, Shock, & Welch, 2013) (OMAFRA, 2004)

⁴³ (Shock, Shock, & Welch, 2013)

⁴⁴ (Environment Canada, 2004)

⁴⁵ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁴⁶ (Shock, Shock, & Welch, 2013) (Myslik, 1999)

⁴⁷ (Shock, Shock, & Welch, 2013) (OMAFRA, 2004)

⁴⁸ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁴⁹ (OMAFRA, 2004)

⁵⁰ (Shortt, Jamieson, & Brooke, 2012) (OMAFRA, 2004)

⁵¹ (OMAFRA, 2004)

⁵² (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

Number of Irrigated Hectares/Extreme droughts			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	deal with potential periods of low water ⁵³	water conditions so the local community can carry out actions to reduce and better manage water use. All water users are requested to share the limited water ⁵⁴ .	
Information, skills and management ⁵⁵	Participation of agriculture sector from subwatershed on Low Water Response Team	<ul style="list-style-type: none"> Water Response Teams are formed so that local water users, stakeholders and water managers can collectively make decisions about water use within their watershed during a time of shortage⁵⁶. 	Participation from subwatershed = higher adaptive capacity
Information, skills and management ⁵⁷	Availability of water in the watershed	<ul style="list-style-type: none"> Is the watershed already experiencing problems with water availability? Already stressed watersheds will only be more stressed in periods of drought. 	Lots of water = higher adaptive capacity
Information, skills and management ⁵⁸	Programs implemented to conserve wetlands ⁵⁹	<ul style="list-style-type: none"> Wetlands on the farm can help provide water e.g. through storage and slow release of water, wetlands can recharge groundwater, reduce peak flows during floods, and help maintain flow in rivers during dry periods⁶⁰ 	Program implemented to conserve wetlands = higher adaptive capacity
Infrastructure ⁶¹ (built and/or natural infrastructure)	Monitoring soil moisture	<ul style="list-style-type: none"> Monitoring soil moisture will help determine how much and when a crops need water resulting in more efficient use of irrigation. Adjusting irrigation to fit the needs of the 	Monitoring soil moisture = higher capacity to adapt

⁵³ (OMAFRA, 2004) (Myslik, 1999)

⁵⁴ (OMAFRA, 2004) (Myslik, 1999)

⁵⁵ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁵⁶ (Ontario Ministry of Natural Resources, 2010)

⁵⁷ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁵⁸ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁵⁹ (Tarnoczi & Berkes, 2010)

⁶⁰ (van der Kamp & Marsh, 2004)

⁶¹ (Smit, Burton, Klein, & Wandel, 2000)

Number of Irrigated Hectares/Extreme droughts			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		individual crops will ensure that water is not wasted and that crops will be of the highest possible quality and quantity. All crop irrigation should be scheduled ⁶² .	
Infrastructure ⁶³ (built and/or natural infrastructure) Information, skills and management ⁶⁴	Methods implemented to conserve or use less water e.g. avoid over-irrigating; schedule irrigation based on evapotranspiration; irrigate based on soil moisture; use deficit irrigation ⁶⁵ <ul style="list-style-type: none"> • Use water gauges to measure and log actual volume of water applied to crop and the evenness of application⁶⁶ • Water use audit⁶⁷ 	<ul style="list-style-type: none"> • When water is in short supply, farmers should rethink practices to obtain maximum benefit from available water. Even when water is more plentiful, there are good reasons to use less. Excessive water use can result in soil and fertilizer loss into water runoff. Excessive irrigation results in deep percolation and leaching of nitrates, nitrites, and other farm chemicals⁶⁸ 	Methods to conserve water = higher adaptive capacity
Information, skills and management ⁶⁹	Use of robust seed varieties ⁷⁰	Can withstand variable climatic conditions ⁷¹	Use of robust seeds = higher adaptive capacity
Information, skills and	Access to demonstration	Allowing farmers to interact with and observe new	Access to demonstration plots can

⁶² (OMAFRA, 2004)

⁶³ (Smit, Burton, Klein, & Wandel, 2000)

⁶⁴ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁶⁵ (Shock, Shock, & Welch, 2013)

⁶⁶ (OMAFRA, 2004)

⁶⁷ (Shortt, Jamieson, & Brooke, 2012)

⁶⁸ (Shock, Shock, & Welch, 2013)

⁶⁹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁷⁰ (Tarnoczi & Berkes, 2010)

⁷¹ (Tarnoczi & Berkes, 2010)

Number of Irrigated Hectares/Extreme droughts			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
management ⁷² Equity ⁷³	plots using new practices	practices seemed to limit the perceived financial risk of the investment, thus making the adoption of soil and water conservation farming practices more likely ⁷⁴	increase adaptive capacity

⁷² (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁷³ (Smit, Burton, Klein, & Wandel, 2000)

⁷⁴ (Tarnoczi & Berkes, 2010)

Soil Erosion⁷⁵

The following table (Table 3) provides a list of possible indicators to assess adaptive capacity of the agriculture sector to respond to soil erosion in the watershed. Rationale for the selection of each indicator is also given.

Table 3: List of possible indicators to assess adaptive capacity of the agriculture sector in Lake Simcoe subwatersheds to respond to soil erosion

Soil Erosion/Intense rainstorms = more soil loss			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills and management ⁷⁶	Stormwater management practices in place	<ul style="list-style-type: none"> Properly designed grass waterways, stormwater detention areas and outlets are essential components of a stormwater management plan if farmers are to prevent soil from being washed off their farms and into watercourses⁷⁷. 	Stormwater management practices = higher adaptive capacity
Information, skills and management ⁷⁸	Soil conservation and management practices in place to prevent erosion, e.g.: <ul style="list-style-type: none"> Reduced tillage Addition of organic materials Crop rotation Cover crops⁷⁹ 	Proper tillage practices employed separately or in combination with crop rotations can be very effective in reducing soil erosion losses. Fallow land has the highest erosion potential in any cropping system. Crop residues perform similar functions and, in addition, form small dams that help retain runoff water, thereby reducing erosion. <ul style="list-style-type: none"> Reduced tillage leaves residue on the soil surface, controlling erosion; loosens less soil Organic material leaves material on soil surface protecting it from erosion; promotes soil tilth (better water infiltration) and larger and more 	Soil conservation and management practices = higher adaptive capacity

⁷⁵ (Jamieson, 2011)

⁷⁶ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁷⁷ (MacRae, 2008)

⁷⁸ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁷⁹ (Ontario Ministry of Agriculture, Food and Rural Affairs, 2009) (Ritter, 2012)

Soil Erosion/Intense rainstorms = more soil loss			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		stable aggregates (less erosion) <ul style="list-style-type: none"> • Crop rotation keeps soil covered year round; helps hold soil in place with the extensive root systems • Cover crops protects soils by covering bare soil; holding soil in place by the roots⁸⁰ 	
Information, skills and management ⁸¹ Equity ⁸²	Access to agricultural associations that provide outreach; building awareness around good agricultural practices	Uptake of awareness programs allow farmers to learn about new agricultural practices	Awareness programs = high adaptive capacity
Institutions and networks ⁸³ Equity ⁸⁴	Access to demonstration plots using new practices	Allowing farmers to interact with and observe new practices seemed to limit the perceived financial risk of the investment, thus making the adoption of soil and water conservation farming practices more likely ⁸⁵	Access to demonstration plots = higher adaptive capacity
Institutions and networks ⁸⁶	Development / growth plans for the subwatershed	Planned, unrestricted development in already stressed areas may reduce adaptive capacity ...?	Restrictions on development in sensitive areas = higher adaptive capacity

⁸⁰ (Ontario Ministry of Agriculture, Food and Rural Affairs, 2009) (Stone & Moore, 1996) (Ritter, 2012)

⁸¹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

⁸² (Smit, Burton, Klein, & Wandel, 2000)

⁸³ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

⁸⁴ (Smit, Burton, Klein, & Wandel, 2000)

⁸⁵ (Tarnoczi & Berkes, 2010)

⁸⁶ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

Possible sources of Data

Best Management Practices⁸⁷
Cleaning up Lake Simcoe and South eastern Georgian Bay⁸⁸
Environmental Farm Plans⁸⁹
Lake Simcoe Basin Wide Report – 2008⁹⁰
Lake Simcoe Community Stewardship Program
Lake Simcoe Farm Stewardship Program
Lake Simcoe Protection Plan⁹¹
Lake Simcoe Region Conservation Authority⁹²
Lake Simcoe Region Conservation Authority Watershed Development Policies⁹³
Landowners Environmental Assistance Program⁹⁴
Municipalities
My Actions, Our Lake Simcoe⁹⁵
OMAFRA's Agricultural Resource Inventory⁹⁶
Ontario Ministry of Food and Rural Affairs⁹⁷
Ontario Ministry of Natural Resources⁹⁸
Source Water Protection⁹⁹
Statistics Canada¹⁰⁰

⁸⁷ <http://www.omafra.gov.on.ca/english/environment/bmp/series.htm>

⁸⁸ <http://ec.gc.ca/eau-water/default.asp?lang=En&n=BD6EB4CE-1>

⁸⁹ <http://www.omafra.gov.on.ca/english/environment/efp/efp.htm>

⁹⁰ http://www.lsrca.on.ca/pdf/reports/lsems/basin_wide_report.pdf

⁹¹ http://www.ene.gov.on.ca/environment/en/resources/STD01_076301.html

⁹² <http://www.lsrca.on.ca>

⁹³ http://www.lsrca.on.ca/pdf/watershed_development_policies.pdf

⁹⁴ <http://www.lsrca.on.ca/leap/>

⁹⁵ <http://www.ourlakesimcoe.com/projects.php>

⁹⁶ http://www.omafra.gov.on.ca/english/landuse/gis/ari_1983.htm

⁹⁷ <http://www.omafra.gov.on.ca>

⁹⁸ <http://www.mnr.gov.on.ca>

⁹⁹ <http://www.ourwatershed.ca/>

¹⁰⁰ <http://www.statcan.gc.ca/ca-ra2011/index-eng.htm>

Lake Simcoe Watershed Climate Change Vulnerability Assessment Water Quality and Quantity¹⁰¹

Water Use / Availability

The following table (Table 4) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to water use/availability. Rationale for the selection of each is also given.

Table 4: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to water use/availability

Water Use/Availability			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Institutions and networks ¹⁰²	Low Water Response plan in place	<i>Ontario Low Water Response</i> is intended to ensure provincial preparedness, to assist in coordination and to support local response in the event of a drought ¹⁰³ .	Low Water Response Plan in place = higher adaptive capacity
Institutions and networks ¹⁰⁴	Participation from subwatershed on Low Water Response Team	Water Response Teams are formed so that local water users, stakeholders and water managers can collectively make decisions about water use within their watershed during a time of shortage ¹⁰⁵ .	Participation on Low Water Response Team = higher adaptive capacity
Information, skills and management ¹⁰⁶	Frequency of water shortages in subwatershed (e.g. low water response)	Subwatersheds currently experiencing more frequent water shortages may be more vulnerable	Lower frequency = higher adaptive capacity
Institutions and networks ¹⁰⁷ Technology ¹⁰⁸	Water metering (water conservation)	Tied to price increases, metered households generally show reductions in water use, with the greatest savings occurring during the summer months, when water use	Water metering may increase adaptive capacity - it could also constrain adaptive capacity if

¹⁰¹ (MacRitchie & Stainsby, 2011)

¹⁰² (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁰³ (OMNR; OMOE; OMAFRA; OMMAH; OMRI; AMO; CO, 2010)

¹⁰⁴ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁰⁵ (Ontario Ministry of Natural Resources, 2010)

¹⁰⁶ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁰⁷ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

Water Use/Availability			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		is usually much higher due to frequency of lawn watering, car washing and other outdoor uses ¹⁰⁹ .	rates are too high....???
Information, skills and management ¹¹⁰ Technology ¹¹¹	Leak detection and repair program in place for water system ¹¹²	Up to 30% of the total water entering supply-line systems is lost to leaking pipes. In most cases, if unaccounted for water in a municipal system exceeds 10 to 15%, a leak detection and repair program is cost-effective ¹¹³ .	Maintenance of water system = higher adaptive capacity
Information, skills and management ¹¹⁴	Water conservation programs in place e.g. LWR, LWRT, rain barrel program, water use restrictions, programs to educate residents on water conservation, disconnect downspouts, rebate programs, etc	In some cases, more than half of municipal water is used by the residential sector. As a consequence, the residential sector represents a logical target for demand management activities. Depending on the nature of the water efficiency program developed, each household can reduce water use by 40% or more ¹¹⁵ .	Water conservation = higher adaptive capacity
Information, skills and management ¹¹⁶	Bylaws preventing new construction in areas with low water levels	Growing urban populations impose increasing demands on provision of water services, including water supply, drainage, wastewater collection and	Bylaws preventing new construction in areas with low water levels = higher adaptive

¹⁰⁸ (Smit, Burton, Klein, & Wandel, 2000)

¹⁰⁹ (Environment Canada, 2011)

¹¹⁰ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹¹¹ (Smit, Burton, Klein, & Wandel, 2000)

¹¹² (Environment Canada, 2011)

¹¹³ (Environment Canada, 2011)

¹¹⁴ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹¹⁵ (Environment Canada, 2011)

¹¹⁶ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

Water Use/Availability			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	Bylaws with minimum water efficiency standards for residential and non-residential construction. (e.g. LEED)	management, and beneficial uses of receiving waters ¹¹⁷ . Climate change may exacerbate this problem.	capacity
Infrastructure ¹¹⁸ (built and/or natural infrastructure) Technology ¹¹⁹	Mechanisms in place to monitor ground water levels and withdrawal	Groundwater level measurements from observation wells are the principal source of information on the effects of hydrologic stresses on groundwater systems. Data on groundwater withdrawal are similarly critical in assessments of the behaviour of water levels in aquifers ¹²⁰ .	Monitoring groundwater = higher adaptive capacity
Information, skills and management ¹²¹	Subwatershed Management Plan that includes climate change?	Proactive	Subwatershed plans that account for climate change = higher adaptive capacity
Information, skills and management ¹²²	Wetland preservation programs	Through storage and slow release of water, wetlands can recharge groundwater, reduce peak flows during floods, and help maintain flow in rivers during dry periods ¹²³	Programs to preserve wetlands = higher adaptive capacity

¹¹⁷ (Marsalek, Watt, Lefrancois, Boots, & Woods, 2004)

¹¹⁸ (Smit, Burton, Klein, & Wandel, 2000)

¹¹⁹ (Smit, Burton, Klein, & Wandel, 2000)

¹²⁰ (Marsalek, Watt, Lefrancois, Boots, & Woods, 2004)

¹²¹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹²² (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹²³ (van der Kamp & Marsh, 2004)

Baseflow index

The following table (Table 5) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond to possible issues around water quantity related to baseflow index. Rationale for the selection of each indicator is also given.

Table 5: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond to possible issues around water quantity related to baseflow index

Baseflow Index			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Infrastructure ¹²⁴ (built and/or natural infrastructure) Technology ¹²⁵	Mechanisms in place to monitor baseflow/ streamflow	Low water response: Streamflow and weather monitoring - when current conditions fall below the drought indicator levels the Low Water Response Program takes affect ¹²⁶ .	Monitoring streamflow = higher adaptive capacity
Infrastructure ¹²⁷ (built and/or natural infrastructure) Technology ¹²⁸	Ability to manage the flow of water (e.g. change operating procedures of dams and reservoirs, ability to divert water)	Ability to manage the flow could augment during low flow circumstances (e.g. flexible SoPs)	Ability to manage the flow of water = higher adaptive capacity
Institutions and networks ¹²⁹	Mechanisms in place to limit irrigation from rivers and streams to protect baseflow during low periods ¹³⁰ e.g. Low Water Response Plan	Limiting irrigation from rivers and streams would help preserve water during periods of low flow....	Limiting irrigation from rivers and streams = higher adaptive capacity

¹²⁴ (Smit, Burton, Klein, & Wandel, 2000)

¹²⁵ (Smit, Burton, Klein, & Wandel, 2000)

¹²⁶ (Ontario Ministry of Natural Resources, 2010)

¹²⁷ (Smit, Burton, Klein, & Wandel, 2000)

¹²⁸ (Smit, Burton, Klein, & Wandel, 2000)

¹²⁹ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹³⁰ (MacRae, 2008)

Wetland Cover

The following table (Table 6) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to wetland cover. Rationale for the selection of each indicator is also given.

Table 6: List of possible indicators to assess the adaptive capacity of the Lake Simcoe subwatersheds to respond issues around water quantity related to wetland cover

Wetland Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills and management ¹³¹	Wetland preservation or protection programs e.g. growing vegetation around its boundary, keeping livestock away and eliminate harmful activities like dredging, filling, large scale logging, dumping garbage, and harvesting peat ¹³²	A wetland is a groundwater discharge area if water enters it by moving upwards from the soils beneath the wetland or from the upland areas surrounding it. These "discharge wetlands" are ecologically important because they help control erosion and maintain water quality. Conversely, some wetlands act as recharge areas, collecting surface water and allowing it to percolate down through the soil and rock to the groundwater. This water recharge helps to maintain water quality and groundwater supplies, especially during dry periods ¹³³ .	Wetland preservation programs = higher adaptive capacity
Information, skills and management ¹³⁴	Wetland restoration programs	Restoring wetlands enhances surface and groundwater storage, and improves discharge and recharge functions ¹³⁵	Programs to restore wetlands = higher adaptive capacity
Information, skills and management ¹³⁶	Wetland monitoring programs	Monitoring data are essential to documenting the condition of the wetland	Programs to monitor wetlands = higher adaptive capacity

¹³¹ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹³² (LandOwner Resource Centre, 1999)

¹³³ (Ontario Ministry of Natural Resources, 2011)

¹³⁴ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹³⁵ (Ontario Ministry of Natural Resources, 2011)

¹³⁶ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

Wetland Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		resource, for determining the success of management actions such as restoration, and for understanding how wetland ecosystems change over time in the face of human-induced disturbances ¹³⁷ .	

¹³⁷ (Cole & Kentula, 2011)

Groundwater Vulnerability

The following table (Table 7) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to groundwater vulnerability. Rationale for the selection of each indicator is also given.

Table 7: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to groundwater vulnerability

Wetland Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Infrastructure ¹³⁸ (built and/or natural infrastructure) Technology ¹³⁹ Institutions ¹⁴⁰ and networks ¹⁴¹	Ground water monitoring programs	Maintaining and monitoring water levels promotes healthy habitat and sustainable water supply ¹⁴² .	A monitoring program may allow proactive action which = higher adaptive capacity
Information, skills ¹⁴³ and management ¹⁴⁴	Water conservation programs in place e.g. LWR, LWRT, rain barrel program, water use restrictions, programs to educate residents on water conservation, disconnect downspouts, rebate	In some cases, more than half of municipal water is used by the residential sector. As a consequence, the residential sector represents a logical target for demand management activities. Depending on the nature of the water efficiency program developed, each household can reduce water use by 40% or more ¹⁴⁵ .	Water conservation = higher adaptive capacity

¹³⁸ (Smit, Burton, Klein, & Wandel, 2000)

¹³⁹ (Smit, Burton, Klein, & Wandel, 2000)

¹⁴⁰ (Smit, Burton, Klein, & Wandel, 2000)

¹⁴¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁴² (Jatel, Curran, Geller, Everdene, & Garcia, 2009)

¹⁴³ (Smit, Burton, Klein, & Wandel, 2000)

¹⁴⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁴⁵ (Environment Canada, 2011)

Wetland Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	programs, etc		
Information, skills ¹⁴⁶ and management ¹⁴⁷	Programs in place to protect groundwater recharge areas e.g. zoning, maximizing infiltration by limited impervious surfaces (to 10%) and maintaining natural areas above recharge zone ¹⁴⁸	Retaining sufficient groundwater maintains the health of fish-bearing streams and the security of community water supplies. Zoning for groundwater protection directs development away from groundwater-sensitive or aquifer recharge areas. Rainwater and snowmelt infiltration is key to aquifer recharge ¹⁴⁹	Programs to protect groundwater = higher adaptive capacity

¹⁴⁶ (Smit, Burton, Klein, & Wandel, 2000)

¹⁴⁷ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁴⁸ (Jatel, Curran, Geller, Everdene, & Garcia, 2009)

¹⁴⁹ (Jatel, Curran, Geller, Everdene, & Garcia, 2009)

Forest Cover

The following table (Table 8) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to forest cover. Rationale for the selection of each indicator is also given.

Table 8: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to forest cover

Forest Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ¹⁵⁰ and management ¹⁵¹ Institutions ¹⁵² and networks ¹⁵³	Forest preservation programs in place e.g. tree cutting or forest conservation bylaws, invasive species programs, insects and disease monitoring, wildfire programs, forested headwaters, forest management plans, etc	Prevents the over-harvesting of forests, and can promote sustainable forestry practices ¹⁵⁴ . Forest cover decreases runoff ¹⁵⁵ Water reaching the forest floor is readily absorbed, and roots act as conduits to aquifers below ¹⁵⁶ Urban forests allow infiltration and the immediate absorption or retention of rainwater by tree root systems, keeping polluted storm water from directly entering sewer systems. This reduces flood risks and improves the quality of the water ¹⁵⁷	Programs to preserve forests in the watershed = higher adaptive capacity
Information, skills ¹⁵⁸ and management ¹⁵⁹	Afforestation and reforestation programs in	Forests provide various air and water benefits ¹⁶² .	Programs to add trees to the watershed = higher adaptive

¹⁵⁰ (Smit, Burton, Klein, & Wandel, 2000)

¹⁵¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁵² (Smit, Burton, Klein, & Wandel, 2000)

¹⁵³ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁵⁴ (LandOwner Resource Centre, 2005)

¹⁵⁵ (Environment Canada, 2004)

¹⁵⁶ (Gilpin)

¹⁵⁷ (Kenney & Rusak)

¹⁵⁸ (Smit, Burton, Klein, & Wandel, 2000)

Forest Cover			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Institutions ¹⁶⁰ and networks ¹⁶¹	place Tree planting programs		capacity
Information, skills ¹⁶³ and management ¹⁶⁴ Equity ¹⁶⁵	Forest education programs (e.g. school groups, extension programs)	Communities with higher levels of human capital have been shown to be more able to solve problems ¹⁶⁶	Forest education programs = higher adaptive capacity
Information, skills ¹⁶⁷ and management ¹⁶⁸	Arborist or forest manager in subwatershed ¹⁶⁹	Communities with higher levels of human capital have been shown to be more able to solve problems ¹⁷⁰	Access to skilled people = higher adaptive capacity
Information, skills ¹⁷¹ and management ¹⁷² Institutions ¹⁷³ and networks ¹⁷⁴	Forest management plan that includes climate change	Forest management plans usually assume a constant physical and policy environment. Climate may change dramatically within the rotation of existing forest stands (50-100 yr). These changes need to be considered and incorporated now into long-term planning ¹⁷⁵	Forest management plan that includes climate change = higher adaptive capacity

¹⁵⁹ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁶² (LandOwner Resource Centre, 2005)

¹⁶⁰ (Smit, Burton, Klein, & Wandel, 2000)

¹⁶¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁶³ (Smit, Burton, Klein, & Wandel, 2000)

¹⁶⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁶⁵ (Smit, Burton, Klein, & Wandel, 2000)

¹⁶⁶ (Joseph & Krishnaswamy, 2010) as cited in (Furness, 2012)

¹⁶⁷ (Smit, Burton, Klein, & Wandel, 2000)

¹⁶⁸ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁶⁹ (Furness, 2012)

¹⁷⁰ (Joseph & Krishnaswamy, 2010) as cited in (Furness, 2012)

¹⁷¹ (Smit, Burton, Klein, & Wandel, 2000)

¹⁷² (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁷³ (Smit, Burton, Klein, & Wandel, 2000)

¹⁷⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁷⁵ (Johnston, et al., 2010)

Variability of Streamflow

The following table (Table9) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quantity related to variability of streamflow. Rationale for the selection of each indicator is also given.

Table 9: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to variations in streamflow

Variability of Streamflow			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Technology ¹⁷⁶ Infrastructure ¹⁷⁷	Streamflow monitoring	Stream flow monitoring systems are indispensable to effectively management of floods ¹⁷⁸	Stream flow monitoring in place = higher adaptive capacity
Institutions and networks ¹⁷⁹	Low Water Response plan in place	<i>Ontario Low Water Response</i> is intended to ensure provincial preparedness, to assist in coordination and to support local response in the event of a drought ¹⁸⁰ .	Low Water Response Plan in place = higher adaptive capacity
Institutions and networks ¹⁸¹	Participation from subwatershed on Low Water Response Team	Water Response Teams are formed so that local water users, stakeholders and water managers can collectively make decisions about water use within their watershed during a time of shortage ¹⁸² .	Participation on Low Water Response Team = higher adaptive capacity
Information, skills and management ¹⁸³	Readiness for low water conditions • Consideration about how to deal with potential	• Ontario Low Water Response (OLWR) is a strategy for local water users and those with an interest in water use to have input into the well being of their community. Water Response Teams are established in	Being prepared to respond to low water conditions = higher adaptive capacity

¹⁷⁶ (Smit, Burton, Klein, & Wandel, 2000)

¹⁷⁷ (Smit, Burton, Klein, & Wandel, 2000)

¹⁷⁸ (Fortin, 2009)

¹⁷⁹ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁸⁰ (OMNR; OMOE; OMAFRA; OMMAH; OMRI; AMO; CO, 2010)

¹⁸¹ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁸² (Ontario Ministry of Natural Resources, 2010)

¹⁸³ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

Variability of Streamflow			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	periods of low water • Contingency plan to deal with potential periods of low water ¹⁸⁴	areas experiencing low water conditions so the local community can carry out actions to reduce and better manage water use. All water users are requested to share the limited water ¹⁸⁵ .	
Information, skills and management ¹⁸⁶	Availability of water in the watershed	<ul style="list-style-type: none"> Is the watershed already experiencing problems with water availability? 	Lots of water = higher adaptive capacity
Information, skills and management ¹⁸⁷	Water conservation programs in place e.g. LWR, LWRT, rain barrel program, water use restrictions, programs to educate residents on water conservation, disconnect downspouts, rebate programs, etc	In some cases, more than half of municipal water is used by the residential sector. As a consequence, the residential sector represents a logical target for demand management activities. Depending on the nature of the water efficiency program developed, each household can reduce water use by 40% or more ¹⁸⁸ .	Water conservation = higher adaptive capacity
Institutions and networks ¹⁸⁹	Mechanisms in place to limit irrigation from rivers and streams to protect baseflow during low periods ¹⁹⁰ e.g. Low Water Response Plan	Limiting irrigation from rivers and streams would help preserve water during periods of low flow....	Limiting irrigation from rivers and streams during low periods = higher capacity

¹⁸⁴ (OMAFRA, 2004) (Myslik, 1999)

¹⁸⁵ (OMAFRA, 2004) (Myslik, 1999)

¹⁸⁶ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁸⁷ (Smit, Burton, Klein, & Wandel, 2000) (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁸⁸ (Environment Canada, 2011)

¹⁸⁹ (Smit, Burton, Klein, & Wandel, 2000)(Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁹⁰ (MacRae, 2008)

Indicators for Water Quality¹⁹¹

Phosphorus loading

The following table (Table 10) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to phosphorus loading. Rationale for the selection of each indicator is also given.

Table 10: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to phosphorus loading

Phosphorus			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ¹⁹² and management ¹⁹³ Institutions ¹⁹⁴ and networks ¹⁹⁵ Technology ¹⁹⁶ Infrastructure ¹⁹⁷ Equity ¹⁹⁸	Number of projects underway to reduce phosphorus: <ul style="list-style-type: none"> Control runoff e.g. use grassed waterways, reduce numbers of acres in summerfallow Prevent livestock from entering water source (on agricultural land) Maintain healthy riparian 	<ul style="list-style-type: none"> In Lake Simcoe, aside from STP discharge, agricultural and rural runoff, and polder water present the greatest opportunity for phosphorus reduction since they are reasonably well understood from the perspective of control, and the magnitude of their phosphorus loadings offers opportunities for reduction. There may be other potential sources of phosphorus loading that could be reduced. However, they are either individually small such as on-site systems and would require aggregation, or pose significant uncertainties in estimating load reduction 	Projects underway to reduce P = higher adaptive capacity

¹⁹¹ (MacRitchie & Stainsby, 2011)

¹⁹² (Smit, Burton, Klein, & Wandel, 2000)

¹⁹³ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁹⁴ (Smit, Burton, Klein, & Wandel, 2000)

¹⁹⁵ (Swanson, Hiley, Venema, & Grosshans, 2007)

¹⁹⁶ (Smit, Burton, Klein, & Wandel, 2000)

¹⁹⁷ (Smit, Burton, Klein, & Wandel, 2000)

¹⁹⁸ (Smit, Burton, Klein, & Wandel, 2000)

Phosphorus			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	zones <ul style="list-style-type: none"> rain barrel programs Stormwater management plans Subwatersheds with existing or planned Stormwater Management Facilities (SMF): <ul style="list-style-type: none"> Stormwater management ponds (Wet Ponds, Dry Ponds) Wetlands 	such as atmospheric deposition ¹⁹⁹ . <ul style="list-style-type: none"> Uncontrolled, stormwater can negatively affect water quality, stream form and function, the biologic capacity of a stream, and increase flooding potential. Interception of stormwater runoff through the use of Stormwater Management Facilities (SMF) at the outlet of urban catchments can reduce the severity of these impacts²⁰⁰. Wetlands are effective waste treatment systems, including phosphorus²⁰¹. 	
Information, skills ²⁰² and management ²⁰³	Phosphorus reduction strategies that consider future population growth	Rapidly increasing population growth, urban development, and fewer but larger farms with more crops and livestock has resulted in higher than normal phosphorus levels in Lake Simcoe ²⁰⁴ .	Reduction strategies that consider population growth = higher adaptive capacity
Infrastructure ²⁰⁵ (built and/or natural infrastructure) Technology ²⁰⁶	Watershed with Tertiary water treatment	Tertiary treatment is enhanced treatment to remove constituents, such as phosphorus and nitrogen, which may not be satisfactorily reduced through conventional secondary treatment ²⁰⁷	Tertiary treatment releases less P into water – having tertiary treatment = higher adaptive capacity

¹⁹⁹ (XCG Consultants Ltd, 2010)

²⁰⁰ (Lake Simcoe Region Conservation Authority, 2007)

²⁰¹ (Wilson, 2008)

²⁰² (Smit, Burton, Klein, & Wandel, 2000)

²⁰³ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁰⁴ (Environment Canada, 2013)

²⁰⁵ (Smit, Burton, Klein, & Wandel, 2000)

²⁰⁶ (Smit, Burton, Klein, & Wandel, 2000)

²⁰⁷ (Environment Canada, 2011)

Phosphorus			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ²⁰⁸ and management ²⁰⁹ Institutions ²¹⁰ and networks ²¹¹	Nutrient management plans (e.g. Apply phosphorus to crop needs; control runoff from manure stockpile)	Fertilizer, manure and other nutrient management techniques through appropriate storage and land application methods has been identified as a practice that helps reduce phosphorus loads into Lake Simcoe ²¹²	Nutrient management plans in place = higher adaptive capacity
Information, skills ²¹³ and management ²¹⁴ Institutions ²¹⁵ and networks ²¹⁶	Shoreline management plans (e.g. increased buffer zones)	Ecologically healthy shoreline and natural heritage system will improve water quality and better equip the watershed to respond to ongoing and future challenges. Natural shoreline areas filters contaminants and retain nutrients and sediment ²¹⁷	Shoreline management plans in place = higher adaptive capacity
Information, skills ²¹⁸ and management ²¹⁹ Institutions ²²⁰ and networks ²²¹	Stream management plans (e.g. increased buffer zones)	Watershed streams or tributaries that include the runoff from urban, rural and agricultural areas in the watershed were identified as major sources of phosphorus loading in Lake Simcoe ²²²	Stream management plans in place = higher adaptive capacity

²⁰⁸ (Smit, Burton, Klein, & Wandel, 2000)

²⁰⁹ (Swanson, Hiley, Venema, & Grosshans, 2007)

²¹⁰ (Smit, Burton, Klein, & Wandel, 2000)

²¹¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

²¹² (Ontario Ministry of the Environment, 2010)

²¹³ (Smit, Burton, Klein, & Wandel, 2000)

²¹⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

²¹⁵ (Smit, Burton, Klein, & Wandel, 2000)

²¹⁶ (Swanson, Hiley, Venema, & Grosshans, 2007)

²¹⁷ (Funnell, 2012) – presentation at the A.D. Latornell Conservation Symposium, November 2012

²¹⁸ (Smit, Burton, Klein, & Wandel, 2000)

²¹⁹ (Swanson, Hiley, Venema, & Grosshans, 2007)

²²⁰ (Smit, Burton, Klein, & Wandel, 2000)

²²¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

²²² (Ontario Ministry of the Environment, 2010)

Phosphorus			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ²²³ and management ²²⁴ Institutions ²²⁵ and networks ²²⁶	Programs to educate the public on phosphorus reduction	...the development of a Community Stewardship Program, will contribute to an increased awareness of phosphorus sources and encourage rural and urban residents, and land managers to protect natural features and engage in activities and behavioural changes that can further reduce phosphorus inputs into urban and rural stormwater ²²⁷ .	Education programs in place = higher adaptive capacity
Infrastructure ²²⁸ (built and/or natural infrastructure) Technology ²²⁹	Phosphorus monitoring	Long term monitoring is a critical part of the overall effort to restore the health of Lake Simcoe. Monitoring is needed to measure the success of the phosphorus reduction actions, as well as progress towards achieving the target of 7 mg/L for dissolved oxygen ²³⁰ .	P monitoring program in place = higher adaptive capacity
Institutions ²³¹ and networks ²³²	Inventory of septic systems	Septic systems were identified as one of the major sources of phosphorus loading in Lake Simcoe ²³³	Inventory = higher adaptive capacity

²²³ (Smit, Burton, Klein, & Wandel, 2000)

²²⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

²²⁵ (Smit, Burton, Klein, & Wandel, 2000)

²²⁶ (Swanson, Hiley, Venema, & Grosshans, 2007)

²²⁷ (Ontario Ministry of the Environment, 2010)

²²⁸ (Smit, Burton, Klein, & Wandel, 2000)

²²⁹ (Smit, Burton, Klein, & Wandel, 2000)

²³⁰ (Ontario Ministry of the Environment, 2010)

²³¹ (Smit, Burton, Klein, & Wandel, 2000)

²³² (Swanson, Hiley, Venema, & Grosshans, 2007)

²³³ (Ontario Ministry of the Environment, 2010)

Floodplain Area

The following table (Table 11) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to variability of streamflow. Rationale for the selection of each indicator is also given.

Table 11: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to variations in streamflow

Floodplain area			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ²³⁴ and management ²³⁵	Up-to-date floodplain maps	Flood plain maps maintained by the Conservation Authorities are now on average 22 years old; 39 per cent are more than 30 years old. Old maps are of limited value and complicate the task of administering and enforcing the flood plain regulations since they are difficult to defend on technical grounds ²³⁶ .	Up-to-date floodplain maps = higher adaptive capacity
Information, skills ²³⁷ and management ²³⁸	Flood Management Plan for subwatershed <ul style="list-style-type: none"> • Includes regular maintenance of flood control structures 	Hard assets include the dams, dykes, and channels that harness flood flows. These structures require ongoing maintenance, repair and replacement to function effectively and safely ²³⁹ .	Flood management plans = higher adaptive capacity
Information, skills ²⁴⁰ and management ²⁴¹	Flood Management Plan for subwatershed <ul style="list-style-type: none"> • Considers climate change 	Flood managers with higher levels of knowledge could proactively take steps to protect water quality in the event of flooding	Subwatersheds with plans that considers climate change = higher adaptive

²³⁴ (Smit, Burton, Klein, & Wandel, 2000)

²³⁵ (Swanson, Hiley, Venema, & Grosshans, 2007)

²³⁶ (Fortin, 2009)

²³⁷ (Smit, Burton, Klein, & Wandel, 2000)

²³⁸ (Swanson, Hiley, Venema, & Grosshans, 2007)

²³⁹ (Fortin, 2009)

²⁴⁰ (Smit, Burton, Klein, & Wandel, 2000)

²⁴¹ (Swanson, Hiley, Venema, & Grosshans, 2007)

Floodplain area			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
			capacity
Information, skills ²⁴² and management ²⁴³	Programs in place to inform the public of the risks of flooding	Informing planners and the general public about the risks of flooding will promote proper land use planning and regulation of development on flood plains thus preventing people from living and/or working on flood plains ²⁴⁴ .	Programs to inform the public = higher adaptive capacity
	Emergency Preparedness Plan in place to respond to flooding	It is imperative that floods are forecasted to the extent possible as well as that plans are in place to respond quickly to emergency flooding situations ²⁴⁵ .	Emergency Preparedness Plan = higher adaptive capacity
Information, skills ²⁴⁶ and management ²⁴⁷	Programs to reduce transport of nutrients, and contaminants into streams and rivers from floodplains e.g. buffer zones, preserving wetlands, stormwater management, nutrient management, etc	Reducing the transport of nutrients and contaminants into streams and rivers to and from floodplains could help preserve water quality	Programs to reduce the transport of contaminants to the floodplain = higher adaptive capacity
Information, skills ²⁴⁸ and management ²⁴⁹	Regulations to restrict new development on floodplain	Developing on a floodplain could increase flooding in that area by reducing the natural function of the floodplain. Municipalities may prohibit the use of land or erecting buildings and structures within areas that are significant features, hazard lands and areas prone to flooding (e.g.,	Laws to restrict development on floodplain = higher adaptive capacity

²⁴² (Smit, Burton, Klein, & Wandel, 2000)

²⁴³ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁴⁴ (Conservation Ontario, 2003)

²⁴⁵ (Conservation Ontario, 2003)

²⁴⁶ (Smit, Burton, Klein, & Wandel, 2000)

²⁴⁷ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁴⁸ (Smit, Burton, Klein, & Wandel, 2000)

²⁴⁹ (Swanson, Hiley, Venema, & Grosshans, 2007)

Floodplain area			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
		floodplains or valleylands). Prohibiting development in natural areas and hazard lands promotes ecological services that address climate change mitigation and adaptation (e.g., carbon sequestration and storm water retention and infiltration, while reducing economic, health and safety costs and risks) ²⁵⁰ .	

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<http://archive.riversymposium.com/index.php?element=PAYNE>

²⁵⁰ (Ontario Ministry of Municipal Affairs and Housing, 2009)

Sewage Bypass

The following table (Table 12) provides a list of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related sewage bypass. Rationale for the selection of each indicator is also given.

Table 12: List of possible indicators to assess adaptive capacity of the Lake Simcoe subwatersheds to respond the possible issues around water quality related to sewage bypass

Sewage Bypass			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Information, skills ²⁵¹ and management ²⁵²	Age of sewage plant	Older plants may have a higher risk of sewage by pass than newer treatment plants??	Younger STP's = higher capacity
Information, skills ²⁵³ and management ²⁵⁴	Participates in a Wastewater Treatment Plant Optimization Program	Wastewater treatment plants (WWTPs) have traditionally been designed to conservative design guidelines and standards that were developed based on historic design practices. Procedures are often passed from operator to operator without consideration for new approaches that might improve performance or reduce costs. Generally, experience has shown that WWTPs often have considerable additional capacity beyond the rated capacity that was assigned at design. Furthermore, improvements in performance and reductions in operating costs can often be achieved through optimization approaches ²⁵⁵ .	Participation in WWTP = higher adaptive capacity

²⁵¹ (Smit, Burton, Klein, & Wandel, 2000)

²⁵² (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁵³ (Smit, Burton, Klein, & Wandel, 2000)

²⁵⁴ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁵⁵ (Federation of Canadian Municipalities and National Research Council, 2003) (XCG Consultants Ltd., 2010)

Sewage Bypass			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
Infrastructure ²⁵⁶ (built and/or natural infrastructure) Technology ²⁵⁷	Plans to reduce the need for bypass in event of heavy precipitation (e.g. increase size of STP, build storage tanks for use during high flow periods, etc)	Reducing the amount of bypasses helps protect water quality	Plans for reduction in amount of bypasses = higher adaptive capacity
Information, skills ²⁵⁸ and management ²⁵⁹	Water conservation programs in place to reduce the volume of sewage (e.g. watering bans, reduced flow showerheads, low flow toilets, etc)	Water conservation: <ul style="list-style-type: none"> • Water conservation can play an important role by reducing the amount of sewage that needs to be treated, making the treatment process more efficient and can potentially delay the need to expand an STP. • Sewage volumes can be reduced by implementing water conservation measures and taking action to reduce inflow and infiltration into the sewer system²⁶⁰. 	Water conservation programs in place = higher adaptive capacity – communities are already aware of the need to conserve water.
Information, skills ²⁶¹ and management ²⁶²	Laws requiring mandatory disconnection of downspouts	Disconnect any eaves trough downspouts connected to the storm sewer and redirect to the lawn or garden. Include “rain gardens” or areas where water is used in your landscaping to handle water from your downspouts ²⁶³ .	Mandatory disconnection of downspouts = higher adaptive capacity – community is already aware of the need to reduce water into the system.
Information, skills ²⁶⁴ and management ²⁶⁵	Water harvesting programs in place (e.g. rain barrels,	Rain barrels can collect rain water for gardening purposes ²⁶⁶	Water harvesting programs = higher adaptive capacity –

²⁵⁶ (Smit, Burton, Klein, & Wandel, 2000)

²⁵⁷ (Smit, Burton, Klein, & Wandel, 2000)

²⁵⁸ (Smit, Burton, Klein, & Wandel, 2000)

²⁵⁹ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁶⁰ (Ontario Ministry of the Environment, 2010)

²⁶¹ (Smit, Burton, Klein, & Wandel, 2000)

²⁶² (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁶³ (The CLEAR Network, 2006)

²⁶⁴ (Smit, Burton, Klein, & Wandel, 2000)

Sewage Bypass			
Determinant	Indicator of Adaptive Capacity	Rationale for the selection of the indicator	Score
	water reuse)		community is already aware of the need to reuse water, keeping it out of the sewage system

²⁶⁵ (Swanson, Hiley, Venema, & Grosshans, 2007)

²⁶⁶ (The CLEAR Network, 2006)

Possible Sources of Data

Best Management Practices
Environmental Farm Plans²⁶⁷
Forestry and Geographic Information Systems
Lake Simcoe Basin Wide Report - 2008²⁶⁸
Cleaning up Lake Simcoe and South eastern Georgian Bay²⁶⁹
Lake Simcoe Farm Stewardship Program
Lake Simcoe Region Conservation Authority²⁷⁰
Landowners Environmental Assistance Program²⁷¹
Managed Forest Tax Incentive Program (MNR)
Municipal Water and Wastewater Survey
Municipalities
My Actions, Our Lake Simcoe²⁷²
Ontario Ministry of Food and Rural Affairs²⁷³
Ontario Ministry of Natural Resources²⁷⁴
OurLakeSimcoe.com²⁷⁵
PTTW – Permits to take water
PWQMN
Showcasing Water Innovation
Source Water Protection²⁷⁶
Statistics Canada²⁷⁷

²⁶⁷ <http://www.omafra.gov.on.ca/english/environment/efp/efp.htm>
²⁶⁸ http://www.lsrca.on.ca/pdf/reports/lsems/basin_wide_report.pdf
²⁶⁹ <http://ec.gc.ca/eau-water/default.asp?lang=En&n=BD6EB4CE-1>
²⁷⁰ <http://www.lsrca.on.ca>
²⁷¹ <http://www.lsrca.on.ca/leap/>
²⁷² <http://www.ourlakesimcoe.com/projects.php>
²⁷³ <http://www.omafra.gov.on.ca>
²⁷⁴ <http://www.mnr.gov.on.ca>
²⁷⁵ <http://www.ourlakesimcoe.com/>
²⁷⁶ <http://www.ourwatershed.ca/>
²⁷⁷ <http://www.statcan.gc.ca/ca-ra2011/index-eng.htm>

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