POLICY RECOMMENDATIONS FOR REDUCING URBAN HEAT ISLAND EFFECT IN HAMILTON

by

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Abstract

Urban areas have always been a pulling factor for many in the rural areas due to the quality of material life they provide. However, the development of these urban areas to sustain such quality has brought with it undesirable effects among which in the urban heat island effect to the detriment of the residents. The effect has been amplified by the climate change phenomenon which makes action to mitigate the urban heat island effect critical. Some cities have acted to different levels of success and it is hoped that the recommendations provided here will chart Hamilton on the path toward following such exemplary cities in the ways particular to it. Hamilton needs to establish green development guidelines for areas prone to high heat intensities, overhaul the exiting storm water management plan and encourage adoption of green technologies by individuals and private developers. Continuing education of the public about necessity of such municipal action is welcome to voluntary adoption of the recommended sustainable technologies.

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INTRODUCTION TO THE STUDY

The global phenomenon of climate change has brought with it multiple dangers to the human population especially the most vulnerable. The increasing world population has meant more people exposed to such dangerous effects (IPCC, 2014). Most of the increase in population has been registered in urban centers. Urban centers are been the major recipients of urban heat islands (USEPA, 2008) with higher temperatures due to developments that use materials that do not reflect solar radiation or allow water to infiltrate after storm events.

Canada is a highly urbanized country with over 80% of its population living in urban centers while Ontario in which Hamilton is situated had 86% of its population in urban centers (Statistics Canada, 2011). The population will be adversely affected by increased heat waves exacerbated by climate change in future unless remedial measures are undertaken (IPCC, 2014).

Hamilton has experienced increasingly hot summers with repeated heat warnings increasing in number and intensity. Increased heat levels consequently lead to high energy use and increased mortality risks for vulnerable members of the population (ICLEI, 2016; Public health services Alert 2007).

The study aims at establishing the best practices forward in remedying the effects of Urban Heat Islands in Hamilton.

Area of study (scope)

This thesis is limited to the geographical boundary of Hamilton Municipality, Ontario, Canada. The municipality has a regional land area of 1,117.23 Sq.Km and lies in the southwestern corner of Lake Ontario (Montgomery, 2013).

Thesis objectives

The main objectives were to

- Ascertain the status quo in combating Urban Heat Islands in Hamilton
- Compare best practices in remediating Urban Heat Islands
- Recommend way forward for Hamilton

METHODOLOGY

The approach used in this study was use of informal interviews, site visits and document review of relevant documentation.

Interviews

Individuals from the following cities were interviewed informally. Three modes of communication were used namely face to face, phone and email depending on the distance from the interviewee based on the template in Appendix 1. The questions were adapted to the responses given.

- City of Hamilton (face to face)
- City of Toronto (e-mail communication and phone conversation)
- City of Mississauga (e-mail communication)

The interviews improved my knowledge the existence of programs targeting reducing Urban Heat Islands, the scientific basis of the programs, the level of coordination of the different government agencies and departments.

Site visits

Site visits were made to selected surface parking lots in the center of Hamilton, Municipal Parks as well as the Main Street.

Document review

I reviewed existing literature on Urban Heat Islands mitigation, legislation, policies, and guidelines in use by the different cities and municipalities in North America.

LITERATURE REVIEW

Theory of Urban Heat Islands

The urban heat island effect is a phenomenon in developed and developing cities that results in greater surface temperatures in urban centers than surrounding rural areas (Taha, 1997). Within the cities or urban centers themselves, there exist different surface temperatures depending on the different surface characteristics. In addition, urban areas have darker areas and less vegetation than rural areas (Akbari et al, 2001). Figure 1 below shows the differentiation of temperature in different neighborhoods.

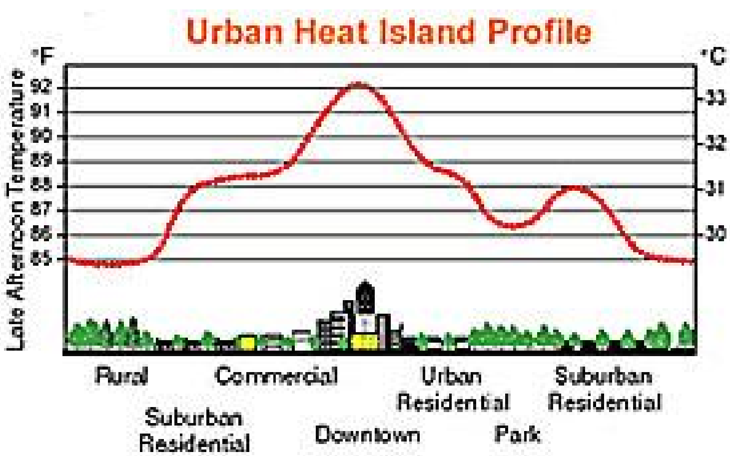

Figure 1: Source New York State Department of Environmental Conservation

Three types of urban heat islands are grouped as surface, canopy and boundary layer. Surface heat islands are contributed by the mineralogical materials constituting the surfaces, canopy islands exist between the surface and the tree tops or roof tops while the rest are grouped as boundary layer islands (BNQ 3019-190/2013).

Reviewed studies regarding urban heat islands

The following studies were reviewed for their relevance to the study. They highlight the scope in thinking and progress in our understanding of urban heat islands to form the foundation for successful mitigation.

Wang et al, (2017) opine that the mitigation measures against heat islands have been unsuccessful because of regional rather than local emphasis where application is more realistic. However, climate research is on a regional/global scale. Previous studies treated cities as uniform without considering the variability of locations within which might require different interventions. They proposed mitigation measures such as vegetation cover and high albedo materials at zonal or local area level.

Antonyova et al, (2017) suggest that buildings benefit from energy savings from use of vegetation outside of houses which reduces their need for air conditioning. The authors achieved the temperature reduction with the use of vines as species.

Park et al, (2017) found that small green spaces have a reduction potential of temperature on building blocks with mixed spaces fairing highly compared to monolithic spaces. Any green space has a reducing effect on the temperature of air with polygonal and mixed SGs reducing more than the linear and single types. Mixed type spaces had the best reduction performance

Shiflett et al, (2017) considered the vegetation, Land Surface Temperature (LST) and air temperature (T_a) connection as not definite as some other studies show. Vegetation had a positive relationship to the two but no correlation was seen between Land Surface Temperature (LST) and air temperature (T_a). They added that

- Vegetation reduces air temperature (T_a) on a localized level but this is not translated to a regional level.
- Energy consumption increased during heat waves. The impact of vegetation in reducing (T_a) was higher where the heat waves were significant
- At a micro level, Vegetation may reduce air temperature (T_a) close to the land surface. Vegetation cooled air temperature ($T_{a)}$ at night and Land Surface Temperature (LST) during the day on a regional level.
- There is therefore need to have big areas of vegetation to be impactful towards temperature reduction

In their consideration of mitigation strategies currently used in Toronto, Wang et al, (2016) found that; Cool pavements impacted middle rise buildings; cool roofs impacted the detached buildings more while urban vegetation impacted all areas in more or less the same magnitude.

- All the mitigation measures are impactful with the combination yielding more air temperature reduction in high rise areas
- Urban Heat Island Mitigation measures are impactful in the summer, no losses during the other seasons
- The only mitigation measures considered in the study were cool pavements, cool roofs and vegetation. The greatest effect was caused by vegetation

Feng et al, 2016 in studying the impact of vegetation on temperature of central building objects found that

- Vegetation has much more impact on low rise buildings than middle or high rise buildings
- The closer the vegetation is to low rise buildings, the greater the reduction in its Land Surface Temperature.

- The impact of vegetation on high rise buildings is not pronounced in the first 200m but is observable from 300 to 500m. High rise buildings have ‘their own shade’ and get little impact from vegetation.
- With increase in areas, the impact of neighboring land cover features on low rise buildings on Land Surface Temperature was low while the impact increased with mid-rise and high rise buildings.

Zölch et al, (2016) emphasize the need for urban areas need to plan for effects caused by climate change. They found that

- Cool roofs had no appreciable reduction in air temperature or Physiological Equivalent Temperature (PET) compared to the others. The green facades reduce the effects close to themselves and the impact vanishes as distance increases
- Greening facades contribute to Physiological Equivalent Temperature (PET) reduction and should be considered in locations where tree planting may not be possible to fully meet temperature reduction proportion.
- Physiological Equivalent Temperature (PET) reduction of 13% is achieved by a 34% increase in tree coverage, while 22% PET reduction is achieved by 22% tree coverage “provided hotspots are prioritized”.
- The study did not consider other purposes of green infrastructure such as ‘storm water mitigation, carbon sequestration, and enhancement of bio diversity to study the synergies and trade-offs between the different Urban Green Infrastructure scenarios.

Rafael et al, (2016) propose adaptation of cities to effects of climate change through

- White roofs as a cheap resilience option, applicable to high density areas
- White roofs as a supplement to green urban areas reduce the heat

Benrazavi, et al, (2016) compared open space, near water and under shade differences on materials. They found that

- Surface temperature under shade was lower than the temperature in open space or near water.
- Surface temperature of asphalt was higher than air temperature

Bokaie et al, (2016) realized that different areas within the cities have different temperatures due to different causes; industrial, construction, use of previously green areas.

Morabito et al., (2016) addressed the data gap between the proportions of built up areas and their influence on land surface temperature in cities (Rome, Florence, Milan and Bologna) over a 13 year period. They found that

- Increase in built up area is associated with increase in land surface temperature (for all cities) with higher increase in warm seasons compared to cold seasons
- Highest night time Land Surface Temperature variation between highly built up areas and low density areas
- Findings show need for action regarding the impact of imperviousness
- $0.4 km^2/km^2$ yields an increase between 1.8^0C warm temperatures

Monteiro et al, (2016) in their understanding of how the vegetation cover effects cooling in the area of location found that

- Cooling varies according to space size from very small green spaces that do not extend temperature reduction beyond the boundaries of the areas covered to medium sized spaces affecting a distance over 100m beyond their boundaries.
- Green space must be at least 72 m for the extend of cooling to extend beyond the boundary

- Green spaces with trees cool further than those without, while intensity of cooling depended on extent of grass
- 3-5ha could reduce temperature by 0.7^{0}C close to 100-150m

Gratani et al, (2016) estimated carbon sequestration capabilities of the different plant species and quantified the economic benefits to form a basis for selection of plants in future parks. The found that

- The amount sequestered was dependent on the leaf area index (LAI) and estimated the carbon sequestered by different tree species and groups.
- Economic savings were made from sequestration

Liu et al, (2016) found that

- Urban Heat Islands had temporal and spatial variation depending on the season and morphology
- The noon variation higher than night probably because of human activities

Yang, et al, (2016) opine that

- The Urban Heat Island effect is felt in the urban centers than outskirts
- Urban Heat Islands are caused by 'change in the underlying surface and less ventilation'. Improvement in ventilation reduces the Urban Heat Island effect.

Park et al, (2016) in a study aimed to provide parking space to residents while reducing the effect of urban heat islands found

- Mean radiant temperature of elements in a green parking street lower than conventional Parking Street during the day. No major difference were observed during the night though both levels reduced

Fallmann et al, (2016) however warn that

- Mitigation measures such as vegetation in parks and higher albedo can have negative secondary effects such as increased concentrations of NO, CO and O3 due to reduced surface temperatures

Krafft et al, (2016) in addressing income differences and urban heat island effect noted that

- Wealthier neighborhoods had more urban cover and educated neighborhoods increased in green cover

Skelhorn et al, (2016) found that in relating buildings and vegetation

- Vegetation reduces the Urban Heat Island through temperature reduction by shading. However, the vegetation needs to be oriented in such a way as not to reduce wind speed since it is inversely proportional to the intensity.

Davis, et la, (2016) also found that

- Vegetation reduces the surface temperature but the reduction varies depending on the extent of tree size with bigger and mature trees reducing more than young trees and grass.

Touchaei et al, (2016) realised

- Reduced costs for heating, ventilation, air condition in buildings as a result of urban heat island reduction strategies increasing the albedo.

Emmanuel et al, (2015) found that an

- increase in urban green cover by 20% of current level can reduce the air temperature by 2^0C through green parks, street trees, green roofs, or combinations thereof.

Santamouris et al, (2015) agreed that

- Increase in temperature leads to increase in peak electricity demand

Page et al, (2015) noted that

- Suspended pavements with a soil root matrix underneath provide an avenue for storm water treatment as an alternative to bio retention areas.

Peron et al, (2015) observed that

- Cooling roofs can utilize new materials; pavements may not use new materials but transform existing ones through increasing their reflectance and permeability.
- Night summer temperatures in high density urban areas experience higher temperatures than sub urban areas (4 or 7^0C)

Fernández et al, (2015) noted that

- Optimization of green space location can minimize the Urban Heat Island effect and help in locating the sites for green areas and their area.

Middel et al, (2015) observed that

- The presence of climate change compounds the detrimental effects of Urban Heat Islands
- An increase in green cover from 10 to 25% will lead to a 2^0C reduction in temperature
- Impact of cool roofs lower than expected

Taha, (2015) found that

- Urban Heat Island mitigation measures help reduce air emissions, reduce energy demand, and cooling of environment though they have side effects like increased ozone concentrations.

Depietri et al, (2013) conclude that

- Urbanization leads to urban heat island effect
- Increased risk of death due to temperature rise
- Risk was reduced by green cover
- Vulnerable population exist in the peripheries (the poor, elderly, single or widowed) and are heavily affected by the urban heat island effect

Taleghani et al, (2014) found

- Temperature difference between green areas and non-green areas
- Temperature reduction from application of vegetation and water pools

Taleghani et al, (2014) in their study on thermal performance of courtyard dwellings found that

- Increased air conditioning leads to more waste heat from mechanical elements. This is going to increase with global warming
- Green roofs increased in door thermal comfort

Maimaitiyiming et al., (2014) emphasized that

- Urban Heat Island is a phenomenon of higher temperatures (surface and air) in urban areas than surrounding rural areas
- The link between green spaces and land surface temperature reduction. However, Land Surface Temperature is affected by patch density (PD) and edge density(ED) which call for their optimization
- Space restrictions and water shortages make this model imperative
- Green spaces are an adaptation method

Erell et al, (2014) in analyzing the relationship between material choice and pedestrian comfort realized that

- Asphalt heats up more quickly than concrete
- Surfaces are warmer than the air and dark surfaces significantly warmer than light surfaces
- East facing walls are warmer in the morning while west facing surfaces warmer in the evening
- The effect on air temperature is not significant between the different surfaces. However, the nature of surroundings features might affect the result

Skelhorn et al, (2014) found that

- Increase in vegetation can reduce surface temperature with no major reduction in air temperature
- However, replacement of vegetation by asphalt increased both surface temperature and air temperature by significant amounts

Zhang et al, (2014) found that

- The cooling effect of vegetation reduces the energy demand for air conditioning. This translates to reduced carbon emissions from energy production
- Energy savings have been associated with the cooling effect of trees

Roy et al, (2012) realized that

- Increased urbanization leads to deterioration of natural systems and the environment
- Trees can ameliorate some of the devastating effects

Zhang et al, (2011) agree that

- Impervious surfaces lead to increased surface temperature

Lin et al, (2011) found that

- Trees doubly help by reduce CO_2 concentrations through photosynthesis and cooling reducing need for more energy which reduces carbon emissions

Millward et al, (2011) found that

- There is demonstrable benefit of trees in an urban center
- The cost-benefit from tree planting resulted from storm water savings, air pollutant removal among others
- There are improved property values from the aesthetics
- It is important to plant a diversity of trees

Onishi et al, (2010) found that

- Land use land cover and impervious surfaces affected the surface temperature of parking lots in opposite ways with the latter increasing and the former cooling.

Akbari et al, (2001) found that

- Urban areas have darker materials and less vegetation than rural areas
- Use of high albedo materials and planting vegetation reduce summertime temperatures
- Cool roofs, urban trees and cool pavements

Approaches to combating Urban Heat Islands

Approaches towards addressing UHI have considered remedying causes (mitigation), its effects (adaptation) or a combination of both.

The mitigation approaches are aimed at reducing temperatures. High albedo materials and vegetation are the likely candidates to achieve the direct reduction (Akbari et al, 2001) since loss of vegetation and use of mineral materials of low albedo are the major contributing factors of Urban Heat Islands (USEPA, 2008). Indirectly, the reduced energy required for meeting cooling needs leads to carbon emissions which have been a contributing factor to global warming (Zhang et al, 2014).

Cool roofs and green roofs have been identified as potential areas for reducing urban heat islands. Green roofs have been modelled to reduce energy cooling needs but have had no great effect on air temperature. Cool pavements aim at reducing the surface temperatures of the surface or air above them (USEPA, 2008).

Reducing the heat emissions from vehicles can alleviate the street temperatures and adapting the urban lay out of tall buildings to reduce the amount of heat trapped during the time of intense solar radiation. Encouraging limited use of private transport and promotion of public transit reduces emissions.

ACTION ON URBAN HEAT ISLANDS BY OTHER SELECTED NORTH AMERICAN MUNICIPALITIES/CITIES

North American cities have been at the forefront of remedying urban heat islands for a multiplicity of reasons.

City of Burlington, Ontario, Canada

In order to reduce the urban heat island effect among other benefits, the city adopted a forest management master plan to among other things to preserve, maintain and promote trees that are privately owned and in public trust (City of Burlington, 2010). Previous planted trees were non-native and invasive while the predominant native species was vulnerable to diseases.

City of Toronto, Ontario, Canada

The city adopted a green development plan and proposed guidelines for developing green parking lots. Having identified surface parking lots as sources of high surface temperature and potential areas for pollution of storm water, the guidelines for greening surface parking lots were developed mainly to minimize storm water and reduce the urban heat island effect (Design guidelines, 2013). These guidelines amplified the effect of the Toronto green standard which seeks to reduce the greenhouse gas emissions in the city through pursuing a clean development approach (Toronto Green Standard Version 2.0, 2015).

The municipality also has a tree planting program with a target for increasing the canopy which has a significant impact on reduced temperatures (Strategic forest management plan 2012-2022).

Quebec, Canada

Quebec has measures for mitigating urban heat islands in its climate change policy 2013-2030. (These measures were enacted before the Paris climate change conference). In addition, the BNQ (standards institution) has designed guidelines to combat the Urban Heat Islands effect through proposing an integration of storm water management with selection of materials to improve the thermal performance of surface parking lots (BNQ 3019-190/2013, 2016).

Mississauga, Ontario, Canada

The city has no direct policies addressing urban heat island effect. However, it has green development standards that aim towards environmental friendly development practices (Green development standards, 2012) with an emphasis on storm water management. Recently, a storm water management policy became effective in 2016 where properties are charged fees depending on the amount of impervious surface and size (BY- LAW 135-15, 2015). The recommended practices in the by-law that reduce storm water quantities on site have an indirect effect of lowering surface temperature.

Windsor, Ontario, Canada

The city of Windsor has developed an index for determining the heat intensities for warning the public. It also provides cooling places for the affected persons (Carolis, 2012).

Louisville, Kentucky, USA

Louisville has experienced increasing differences in urban and rural temperatures over 0.6F per decade since the 1970s (Kenward et al, 2014).The city's sustainability plan has measures that will help reduce the urban heat island effect (Louisville, 2013). The city has been losing its urban tree canopy (Urban tree canopy, 2015) which will diminish any temperature reduction gains unless the reduction is arrested.

Seattle, Washington, USA

The climate action plan, (2013), on its direct adaptation methods for combatting climate change, will have a remedial effect on reducing urban heat islands. Forested areas are planned for areas with a propensity to experience heat waves. In addition, the encouraged features under the GSI strategy (GSI, 2015) could reduce the heat island effect.

Phoenix, Arizona, USA

The city adopted a tree and shade master plan with intention of among others cooling the land area. The plan emphasizes the use of trees in remedying the effects of excessive heat (Tree and shade master plan, 2010).

City of Portland and Multnomah County, Oregon, USA

The Climate action plan, (2015) accepts that climate change has been a cause of intense heat waves and deaths in cities. It proposes actions that reduce global emissions and protect the natural forests as strong remedial measures to combat climate change and its consequent effects.

Burlington, Vermont, USA

The city with a desire to ameliorate the health impacts from heat waves among other effects of climate change adopted the (Climate action plan, 2010) that incentivizes compact mix use development, promotes energy efficiency of buildings through the green roof program and increases the tree canopy. The green roof policy has not been implemented yet (Progress report, 2014)

In summary few of the cities and municipalities have specifically acted on reducing urban heat islands directly while most of the others deal with the challenge as indirectly by acting to remedy climate change effects as a form of adaptation. However, heat islands will always be generated irrespective of the global climate levels which only intensify the intensity. On a local level, action must be undertaken to reduce the micro temperatures which are generated from any development that distorts the existing ground conditions.

HAMILTON ACTION ON URBAN HEAT ISLANDS

Hamilton municipality has had no specific action targeting the reduction of urban heat islands but policies targeting other challenges as mentioned below have a secondary effect of the same purpose to a degree. The list following describes the current action as obtained from reviewed legislation, by-laws, community actions and plans.

The Hamilton community climate change action plan (LURA, 2014) proposes sustainable storm water management (low impact development) and provides initiatives which would reduce urban heat islands at the proposed while primarily reducing the burden on storm water infrastructure.

The city has notifications that are issued by the health department in cases of extreme heat events in three levels with free availability of public designated facilities for cooling (Public health services Alert 2007). Action is intended to improve the thermal comfort of city dwellers as shown by the alert and response system below. The response stages correspond to a day, two or more with day time temperatures higher than $31^{0}C$[1] as represented in figure 2 following.

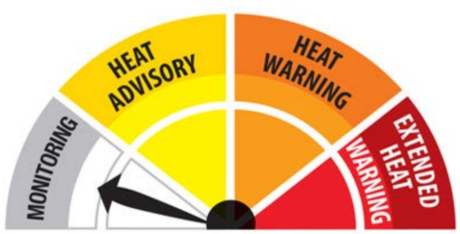

Figure 2: Hamilton's alert and response system levels (source: Hamilton city)

There exist mechanisms to protect, preserve and maintain tree vegetation (BY-LAW NO. 06-151, 2006) in public places. However, they do not accord the same protection to those on private property which are necessary for maintaining the common public good. The tree planting

[1]https://www.hamilton.ca/public-health/health-topics/heat-alerts-heat-related-illness

program[2] is not robust enough (in terms of wide scope, measureable target and extent necessary) to encourage significant increase in green area as a measureable form of the urban tree canopy needed to avert the secondary effects of climate change like intensity of heat waves. The program also does not address any targets for increasing the canopy level in the municipality

The storm water policy of Hamilton (Storm drainage policy, 2004) and the Comprehensive development and guidelines and financial policies manual (2016) recommend adoption of sustainable storm water management practices which have a secondary effect of reducing urban heat island effect. These well intentioned policies can be amplified with more to induce private developers to adopt such well-intended measures.

Indirectly, promotion of public transit reduces the number of emissions from more people using private vehicles. The Hamilton cycling masterplan (Shifting gears, 2009) encourages adoption of cycling which reduces any emissions from possible vehicles with their detrimental effects on air temperature.

[2]https://www.hamilton.ca/home-property-and-development/property-gardens-trees/street-tree-planting-program

INFORMAL INTERVIEW NOTES

The informal interviews which were carried out in three municipalities involved the use of face-to face and e-mail communication.

City of Hamilton

Interviewee works with the public health services which is spearheading action on urban heat islands as a public health issue. Other departments including (especially public works) need to adopt a proactive stance and partner to reduce the danger from growing heat islands.

City of Toronto

There is commitment from the city planning team (environmental planning and urban design) which involves coordination of the different specialties to ensure compliance with the guidelines that will help reduce the urban heat islands.

City of Mississauga

The city has no direct strategy adopted for urban heat islands but credits available through the storm water management charge enable adoption of green infrastructure necessary to assuage many causes of urban heat islands.

POLICY RECOMMENDATIONS FOR HAMILTON AND SIMILAR SIZED MUNICIPALITIES IN THE SAME CLIMATIC ZONE

It is well established that cities experience urban heat island effects (Oke, 1973) and therefore imperative that action is done to mitigate their negative effects or at the minimum adapt to overcome the effects. Though temperatures have been rising in Hamilton since the 1970s by 0.90C on average and the projected increase of 1.5^0C is expected in the next three years unless drastic action is taken to mitigate climate change (ICLEI, 2016), the status quo does not address the current challenge.

The most urgent situation needs the creation and adoption of guidelines for green development specific to the city of Hamilton addressing urban heat islands. None of the existing municipal surface parking lots have any sustainable/green paradigm which would be a source of savings in case of redevelopment. New ones would have to be development according to the guidelines. The setback to such an option would be the time it would take the city council to approve such guidelines. On the other hand, developers can still adopt the practices with incentives in form of reduced development fees.

There needs to be a revamping of the existing storm water management policies to reduce the quantities and impact on the existing old sewer system. A credit system that rewards residents that reduce their storm water while financing the revamping of the old infrastructure through levies on non-compliant ones should be started. The advantage of such a policy is that it can be designed to reward techniques that combine thermal performance and storm water management which is already considered in the existing regulations.

There is need for an increase in green roofs and green walls in down town Hamilton. The heat maps show that the intensity of heat is highest in downtown Hamilton with vegetation areas minimal with less room for expansion. On the other hand, there's an abundance of high walls which are a potential for growing walls.

The existing tree planting program/initiative[3] needs to be widened beyond its current mandate to include the protection of vegetation on private property and encourage wide spread addition of vegetation in public places to set targets. The existing forested area in the urban areas has limited capacity in size and density to reduce the surface and air temperature by significant levels that are helpful to the greater public. The challenge with this approach would be the hesitancy of the private owners to cooperate but an extensive education and sensitization program highlighting the benefits would be useful. On the other hand, Hamilton has a parkland area of 3480[4] acres which has a potential of reducing air temperature with increased intensity of trees.

There is need for education and sensitization of the public for all groups in Hamilton. The existing standard for green buildings adopted emphasizes energy efficiency of the buildings and reducing footprint of the users and low impact development that only emphasizes reduced run off (LEED grant program, 2016). These procedures while admirable in energy efficiency and environmental design, are silent on the reducing the urban heat island effect. Educated developers would voluntarily adopt better materials and other techniques to alleviate Urban Heat Island at the micro level especially for old developments that are not in immediate need of refurbishment.

Asphalt parking and driveways in Hamilton should be replaced by higher reflectance based materials or an equivalent where possible. The surface parking lots visited that are in use are asphalt surfaced with no provision of shading whatsoever for the parked vehicles.

[3]https://www.hamilton.ca/home-property-and-development/property-gardens-trees/street-tree-planting-program
[4]https://www.hamilton.ca/parks-recreation/parks-trails-and-beaches/parks-listing

Figure 3: Municipal Surface parking lot (Pictures by Bruno R)

Figure 4: Private parking lot at 1280 Main street west, Hamilton (Pictures by Bruno R)

The municipality needs to take a lead in providing higher thermal performing surface asphalt parking spaces while subsidizing private developers and home owners to adopt similar attitudes.

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Appendix 1: Interview template

A few questions for your consideration and kind response

1. How was the Municipal council receptive to your recommendations for combating UHI? Were there any objections to your suggestions? How did you overcome them (if any)?
2. How have the developers been receptive to the initiative?
3. What have been the results of the mitigation strategies thus far?
4. How helpful were other departments in driving through the initiative?
5. Was there a need for specialists other than those employed by the municipality? How helpful were they?
6. What challenges have you faced in implementing the UHI mitigation strategies?
7. What in your opinion is the hierarchy of use of urban green infrastructure in tackling UHI?
8. Which is the better approach, mitigation vs adaptation?
9. Any other helpful remarks