Toronto's Green Roof Bylaw

A Water Governance Assessment

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Abstract

Green roofs are an increasingly popular measure to address shortcomings of urban water systems as for example the inability to cope adequately with excessive rainfall. Toronto in Canada was the first city in North America to enact a bylaw which obliges specific building projects to have a green roof implemented. This report applied the “Assessment of Water Management and Governance” method by Rijswick et al. (2014) in order to identify strengths and weaknesses of Toronto's green roof policy. In general, the city of Toronto has a sound green roof policy in place which resulted from a consultative policy making progress. Still, the policy should be subjected to constant review and enhancements. The latter one may be encouraged by findings of this reports and the formulated recommendations for policy improvements such as as a more diverse green roof incentive program, incorporation of photovoltaic technologies within green roof construction, stimulation of economy of scale processes for green roof construction units and materials as well as advanced monitoring to quantify benefits of green roofs for the city of Toronto and green roof performance maximization in consideration of local peculiarities.

Introduction

Green Roofs

During the last decade, green roofs have become a prominent tool to address problems in urban areas as for instance stormwater management, air quality, energy consumption and the urban heat island effects (Greenroofs.org, 2007). Many cities all around the world have devised green roof incentive programs or even oblige owners of (new) buildings to construct green roofs.

In Portland in the United States, green roofs are promoted as a measure to decrease stormwater runoff during precipitation events. In order to facilitate the construction of green roofs, landowners have to pay a monthly fee per 1000 square feet impermeable surface area. In addition, all new buildings which are owned by the city are obliged to have a green roof coverage of at least 70%. The city of Chicago promotes the implementation of green roofs in order to decrease the urban heat island effect. Similarly to Oregon, green roofs are not a mandatory measure in Chicago but suitable projects can qualify for financial support by the city's green roof incentive program. Stuttgart in Germany facilitated green roof construction as a measure to enhance air quality and introduced a subsidy program for private house owners (White, 2010).

Based on the depth of the vegetation layer, two categories of green roofs are to be distinguished: Extensive and intensive green roofs. The former one has a vegetation layer of up to 15 cm depth while the latter one can have a vegetation layer of up to 65 cm depth (Currie, 2010). Even though, both types of green roofs perform the same function, their efficiency and costs vary depending on the underlying construction standards and ecological characteristics.

In Toronto green roofs have been established as early as during the 1990s. The city mainly facilitates the construction of green roofs as a measure for stormwater management and in order to mitigate the urban heat island effect. Green roofs as a means for stormwater management gained attention after the city was affected by sever flooding in 2005 (Mees and Driessen, 2011). Both, excessive stormwater runoff and the urban heat island effect, are expected to worsen with the advance of climate change in the future (Mees, 2010).

The municipality of Toronto was the first in North America to enact a bylaw that mandates the construction of green roofs for specific building projects. The city's bylaw resulted from a long-term consultation and implementation process which consisted of several phases (White, 2010). First, the city commissioned a report which was conducted by the Ryerson University and assessed the potential large-scale economic benefits of green roofs for the city of Toronto in consideration of various scenarios. The main aspects under consideration were combined sewer overflows, air quality, the urban heat island effect and energy use of buildings (Banting, 2005). The findings were supportive for the plan of widespread green roof implementation and drafts of a bylaw were devised through workshops and stakeholder participation. In 2006, the implementation strategies were presented to the city council and finally lead to a bylaw which required green roof construction on eligible building projects. The bylaw was enacted on January 31st 2010 and affects commercial, institutional and residential buildings.

Objective

The objective of this report is to use the "Assessment of Water Management and Governance" method by van Rijswick et al. (2014) in order to evaluate the green roof policy of the city of Toronto. Based on this assessment, a conclusion about the policy's strengths and deficiencies will be drawn and used to identify leverage points for future policy improvement.

Methodology

Water systems often exist within a framework of multiple administrative levels, have implications on different temporal and spatial scales and affect various actors ("multilevel, multi-scale and multi-actor"). In order to address their governance and management in a correspondingly comprehensive and intricate way, a multidisciplinary approach of assessment is required.

The ten building blocks assessment method (figure 1) by Rijswick et al. (2014) tries to address this requirement and integrates various disciplines such as water system knowledge; stakeholder analysis and conflict prevention; social objectives; law and public administration; economics and engineering within a theoretical framework of assessment, organisation and implementation of water governance measures.

This report is based on systematic literature research. The underlying information were either published by the city of Toronto or third parties.

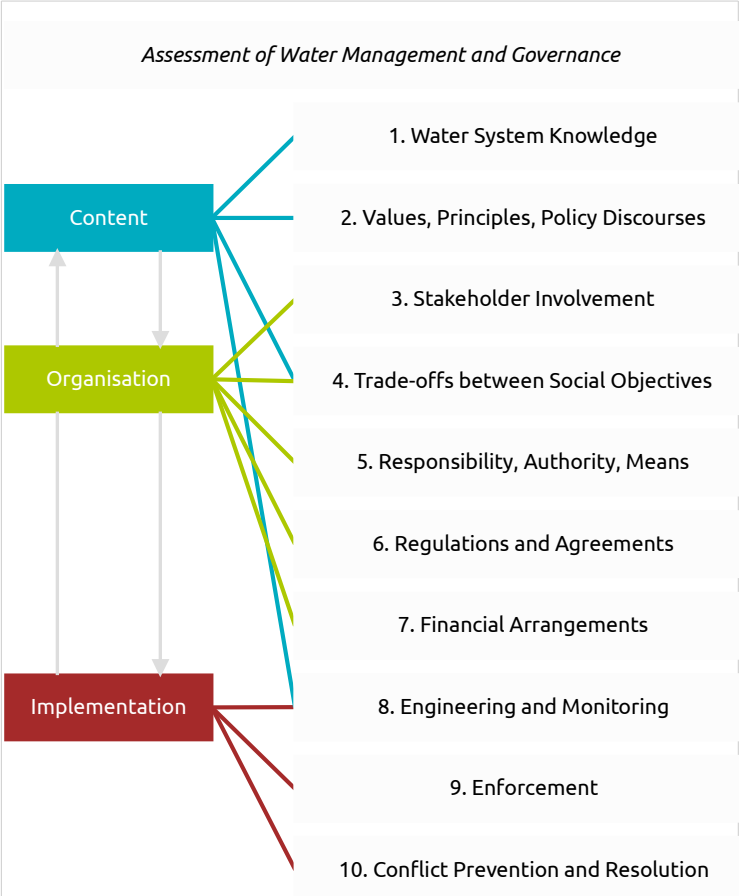

Figure 1: The ten building blocks of the Assessment of the Water Management and Governance Method by van Rijswick et al. (2014)

A precise overview of all used sources can be found in the Bibliography on page 17.

Water System Knowledge

Assessment Criteria

Assessment criteria: Is there sufficient knowledge of the existing water system in order to deliver the required service level of societal functions? If not, what are the gaps; is sufficient knowledge available to assess the impact on the water system because of changes in environment and societal functions? (van Rijswick, 2014)

Green roofs potentially support a variety of societal, economical and environmental functions. Most notable reduction of energy costs, mitigation of the urban heat island effect, stormwater flow reduction, lowering of peak discharges, less instances of combined sewage overflows (CSO), improvement of air quality, increase in biodiversity as well as aesthetic improvements (Banting, 2005).

Green roofs are widely used as a measure to influence the urban water cycle. The urban water cycle consists of natural physical components such as precipitation, evapotranspiration, runoff and unnatural components such as man-made infrastructure which is disruptive to natural water flows. Within the context of water governance assessment and Toronto's urban water system, the most relevant function of green roofs is reduction of stormwater runoff after extreme precipitation events.

In order to assess the potential impact of green roofs on the city of Toronto, the Toronto and Region Conservation Authority (TRCA) initiated a green roof pilot site at Toronto's York University. Additionally, a comprehensive study was commissioned and conducted by the Ryerson University to quantify economic effects of green roofs.

According to the study, green roofs are likely to have a positive impact on the city's stormwater management, air quality, energy use of buildings and will reduce the urban heat island effect (Banting, 2005). Excessive stormwater runoff in urban areas is critical because of the high share of impermeable surface in overall area. Much water is channelled into drainage infrastructure instead of infiltrating into the ground (as it would be the case in most natural ecosystems). Drainage systems carry water towards wastewater treatment plans which only have a limited capacity to deal with water inflow. Several negative aspects are attached to this practice: In case of combined sewer overflows (CSO; inflow exceeds the plants capacity), sewage water and (possibly with pollutants contaminated) runoff are released into the environment and may cause negative effects. Furthermore, intensive water flows can cause erosion of infrastructure which increases recurrent costs for maintenance.

The construction of green roofs addresses these problems in several ways. First of all, stormwater runoff is reduced in quantity which results in less urban flood risk and effects of erosion. Additionally, green roofs absorb water. This reduces the overall amount of discharge and causes a delay of peak discharge as water is released from green roofs in relatively slow rates. Depending on the depth and properties of the applied growing substrate, green roofs have proven to absorb or delay as much as 60 to 100% of all stormwater discharge (Banting, 2005). Less intense stormwater discharge in drainage systems also reduces the risk of combined sewage overflows. In addition, the quality of stormwater runoff increases because much of the contaminants are absorbed by plant growth or growing substrate where certain pollutants might even dissolve.

The "Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto" quantified initial and annual savings of widespread green roof implementation under the assumption that green roofs are constructed on 100% of the suitable area (an area equal to 5,000 ha). The results (compare table 1, p.6) suggest high economic value of green roofs for the city of Toronto. This is even more the case with respect to climate change as Toronto is expected to receive less snow and higher amounts of rainfall during the winter months (City of Toronto, 2012).

Table 1: Quantification of the expected environmental benefits due to widespread construction of green roofs in the city of Toronto. Based on (Banting, 2005).

Category of benefit	*Initial cost savings*	*Annual cost savings*
Stormwater		
Alternate best practice cost avoidance	$ 79,000,000	
Pollutant control cost avoidance	$ 14,000,000	
Erosion control cost avoidance	$ 25,000,000	
Combined Sewer Overflow (CSO)		
Storage Cost Avoidance	$ 46,000,000	
Reduced beach closures		$ 750,000
Air Quality		
Impacts of reduction in GHG[1]		$ 2,500,000
Building energy		
Annual energy use		$ 21,000,000
Peak demand reduction	$ 68,700,000	
CO_2 reduction		$ 563,000
Urban Heat Island		
Annual energy use		$ 12,000,000
Peak demand reduction	$ 79,800,000	
CO_2 reduction		$ 322,000

Green roofs also being regarded as a “no-regret” measure since no major drawbacks are known to be attached to the construction of green roofs. Much theoretical knowledge about the benefits of green roofs is available to support the decision of policy-makers. The knowledge results from real-world application in many other cities and (for some instances) also within the city of Toronto.

Theoretical knowledge is based on the Ryerson University's report which suggests initial cost savings (capital costs) of $313,100,000 and annual cost savings of $37,000,000 (Banting, 2005).

The study assumes that green roofs are implemented on 100% of all area which is suitable for green roofs (flat roofs with an area above 350 square metres). In total, this results on an area of 50,000,000 square metres. Furthermore, it was assumed that all green roofs have a minimum depth of 150 mm and a runoff coefficient of 50%.

The study suggest very promising economic benefits. However, it is questionable whether the assumed conditions will ever be fulfilled. Even in the long-term a covering of 100% suitable roof area under the above-mentioned conditions seems unlikely because the bylaw is only valid for new construction projects and many buildings will remain without green roofs. To address this issue, the city of Toronto should commission a study which focuses on the benefits of green roof implementation on a smaller scale.

1 Greenhouse gases

Values, Principles, Policy Discourses

Assessment Criteria

Assessment criteria: Is there sufficient knowledge of shared or conflicting values, viewpoints and principles (represented by different policy discourse coalitions) for water issues and their consequences for facing water management issues? (van Rijswick, 2014)

Several stakeholders are affected by Toronto's green roof policy and represent various environmental, economic and societal value Some values are characteristic for single stakeholders, others for a group of stakeholders and again others converge among stakeholders.

Stakeholders representing rather economic aspects look at the financial benefits attached to green roofs (e.g. construction contracts, energy savings, savings because of less infrastructure damage because of erosion, ecosystem recovery, etc.). Environmentalists, conservationist as well as the public see green roofs as a measure to enhance the urban ecology and decrease air pollution and thus share values of aesthetics, environmental conservation and human well-being. These values mainly converge with public values. However, the public additionally emphasises flood safety as an important benefit of green roofs. Many stakeholders which are in favour of green roofs work in close collaboration with Toronto's public authorities to maximise the performance of green roofs (Mees and Driessen, 2011).

For the municipality, green roofs were most importantly regarded as a tool to improve the city's stormwater management.

Within the context of urban water management, this can be regarded as a precautionary measure to prevent flood hazards and damages as well as combined sewer overflows. The following part "Stakeholder Involvement" will elaborate on the involvement and consideration of various stakeholders.

No major drawbacks are known to accompany the installation of green roofs ("no regret measure") and the potential for conflicting values is relatively low as they comply with the current cultural mindset of the public.

No policy-discourses accompany the implementation of green roofs in Toronto. The green roofs bylaw converges with the city's long-term planning manifested in the "Green Standard", Wet Weather Flow Master Plan, the policy to double tree canopy and the Clean Air Partnership (Mees and Driessen, 2011).

Overall, sufficient knowledge exists about the values of all involved stakeholders and does not suggest a major potential for conflict. The only noteworthy complain arises from the economic burden of green roof construction for businesses and will be discussed in the following paragraph.

Stakeholder Involvement

Assessment Criteria

Assessment criteria: Are all relevant stakeholders involved? Are their interests, concerns and values sufficiently balanced considered in the problem analysis, solution search process and decision-making? (van Rijswick, 2014)

As discussed in the previous section, stakeholders can mainly be categorised in three groups representing environmental, economic and societal values. Hereby, it is important to notice that the boundaries between groups and interests are not always sharp but may converge or overlap in certain cases.

Important and influential public stakeholders are for instance the city of Toronto and the Toronto

and Region Conservation Authorities (TRCA). Typically, public authorities are very influential because they are responsible for spatial planning through municipal and planning acts. The city of Toronto can be regarded as highly influential because of devising the green roof policy and the passing of the green roof bylaw. The TRCA plays an important role in adopting the strategic plan of the city of Toronto as it is the TRCA's responsibility to ensure environmental conservation and to address climate change issues. Both were involved in several round table sessions which were initiated to communicate values of different stakeholders. These public consultation meetings involved for example owners and developers of industrial use buildings, stakeholders representing commercial development, the Ontario Industrial Roofing Association and members of the public (City of Toronto, 2009). Accordingly, the process of participation can be regarded as wide because public consultation processes were open to any interested person.

The depth of stakeholder involvement however, is rather limited. While some of the stakeholder suggestions have been implemented in the green roof bylaw, it becomes obvious that governmental bodies are still dominant in the process of decision making (van Rijswick et al., 2014). However, since Torontonians are mainly in favour of the green roof bylaw, there is no extensive evidence of conflicting values between the government and the public (City of Toronto, 2006). It is noteworthy that most stakeholders benefit from green roofs and the municipality has granted exemptions for green roofs as urban gardens to some of the stakeholders (Adelmann, 2014). Owners and developers of industrial use buildings expressed concern that green roofs were impractical from an economic and technical viewpoint and threatened that green roofs pose a burden to employment (City of Toronto, 2009). The municipality defied this argument but still offers eligible projects subsidies to decrease the financial burden.

Trade-offs between Social Objectives

Assessment Criteria

Assessment criteria: Are agreed service-level decisions based on trade-offs of costs, benefits and distributional effects of various alternatives? (van Rijswick, 2014)

Allocation: The leading principle of green roof implementation is to enhance the city's urban water system especially with respect to stormwater management. This can have impacts on aspects of the water use system such as combined sewer overflows, water quality and damages due to flooding but also on non-water-use-system-related aspects such as the urban heat island effect, energy savings, etc. (compare “Water System Knowledge“ p.5).

Conflict may arise among house owners who are obliged to install a green roof against their own will on basis of the bylaw if they would prefer to utilize the roof area for other purposes such as solar power or urban agriculture. In general, trade-offs of green roofs are likely to be similar in different cities.

With respect to the urban water system, alternatives for green roofs potentially comprise permeable paving or extensive drainage infrastructure. With regard to other benefits such as the reduction of energy costs and the urban heat island effect, measures such as brown roofs, cool roofs or sophisticated insulation may pose an alternative.

Reallocation: Whether there is a major reallocation of costs or benefits depends on how well green roofs perform on an economic perspective. The “Eco-Incentive” program that subsidises the construction of green roofs (compare “Financial Agreements“ p.10) is financed by public money. Accordingly, the benefits of widespread green roof implementation are hoped to outweigh the costs for subsidies.

Whether green roofs are a burden to eligible

construction projects depends on long-term benefits such as recurrent savings of energy expenditures.

Allocation mechanism: The mechanism to facilitate green roof constructions is a mixture between mandatory implementation and financial incentives for voluntary implementation (compare "Enforcement" p.12). The investments in subsidies for eligible projects are regarded as a long time investment in order to improve the city's stormwater management, energy use, air quality, etc. (compare "Water System Knowledge" p.5). It is distinguished between installations enforced by the bylaw and installations promoted by incentive programs. The former one represents 50 to 60 installations per year and the latter one 10 to 12 installations (Mees and Driessen, 2011).

Responsibility, Authority and Means

Assessment Criteria

Assessment criteria: What are the responsibilities and authorities related to water? What are the property rights? How are they restricted? What is the participative capacity of the public domain? What is the integrative capacity of the public domain? (Rijswijck et al, 2014)

Green roofs are by definition part of buildings which are in many cases private property of house owners, businesses or public institutions. Property rights in Toronto are defined in the Bill 190 of the Property Rights and Responsibilities Act (Barrett, 2009). In Canada property rights are the responsibility of the province. Toronto lies within the province of Ontario and hence is subject to Ontario's property legislation. Property is legally seen as the combination of legal individual rights with respect to objects and the obligations owed them by other parties and guaranteed and protected by the government (Bale, 2014). According to the property rights and responsibilities act amended in 2009, everyone has a right to own the real and personal property that they have acquired in line with the law to the extent provided by the law. However, the law can still restrict how responsibilities for properties are managed. This is because owners are morally responsible to ensure their property is maintained to a standard in accordance with the legal uses of the property and the character of the community where the property is situated (Barrett, 2009). This means property owners are still obliged to comply with the legal requirements and are not completely free to do as whatever they want. This gives the respective authorities enough power to enforce measures such as the green roof bylaw.

Allocating authority and responsibilities: In Canada, provinces delegate planning authorities to the municipalities through municipal and planning acts and supervise them. Municipalities devise detailed spatial plans to adopt by-laws, regulate zoning, environmental regulations, building regulations, etc. and enforce their implementation (Mees, 2010).

Participative capacity of the public domain: The city of Toronto established an Adaptation Steering Group to facilitate cooperation among the public domain. The group consisted of directors from all the major city divisions and was coordinated by a staff member of the Environment Office. After successfully leading the adaptation strategy for green roofs, the group became less important (Mees, 2010).

The creation of multi-stakeholder working groups consisting of governmental, academic and environmental organisations was aimed to assist decision makers with the policy development and promote stakeholder participation (Mees, 2010).

Integrative capacity of the public domain: The internal policy coordination is supported by external knowledge exchange networks such as the Toronto Urban Climate Network which promotes the exchange of green roof knowledge between its members and the public (TUCCN, 2009). In addition, Toronto is part of the C40 cities network that organises activities to share knowledge and practices of measures to counter climate change (Mees, 2010).

Regulations and Agreements

Assessment Criteria

Assessment criteria: Are regulations and agreements legitimate and adaptive, and if not, what are the main problems with regard to the above mentioned legitimacy aspects? (van Rijswick, 2014)

Appropriateness: No information suggest that the green roof policy conflicts with cultural, political or religious values or institutional circumstances prevalent in the city of Toronto. Financial empowerment by means of a subsidy program (compare "Financial Agreements" p.10) established appropriate economic conditions for green roof implementation. Since green roofs are regarded as a no-regret measure, they comply with governmental regulations to protect and develop public works, protect ecosystems and to enhance the performance of the urban water system. Round tables involved non-governmental actors and the public during the policy development process.

Legal capacity and adaptiveness: The green roof bylaw was devised by the Planning and Growth Management Committee and adopted by the Toronto City Council based on authorisation through section 108 of the City of Toronto Act (City of Toronto, 2015a; City of Toronto Council, 2011) which defines the structure and responsibilities of the municipality. The municipality of Toronto is governed by multiple councils with elected councillors. A new council is elected every four years and has a head of council also referred to as mayor (AMO, 2013).

The rules accompanying the construction of green roofs are formulated in the city of Toronto's by-law No. 583-2009 §492-1 (compare "Engineering and Monitoring" p.11 and "Enforcement" p.12).

The green roof bylaw can be amended and in fact, the municipal code states that the chief building official should periodically review the Toronto green roof construction standards and consult a "Technical Advisory Group" (compare "Engineering and Monitoring" p.11 in order to assess possible enhancements. Still, flexibility is limited as green roofs are an inherent technical aspect for the construction of new houses. Once a green roof has been built, flexibility is rather limited. The strictness of green roof implementation is discussed under "Enforcement" (p.12).

Financial Agreements

Assessment Criteria

Assessment criteria: Are SLAs sufficiently available (implicit or explicit) in order to redesign the existing infrastructure? Are the design and consequences of different alternatives sufficiently available? Is there sufficient monitoring of the system and are the data analysed? (Rijswijck et al, 2014)

Funding of green roofs is aided by an "Eco-Roof Incentive Program" which financially supports existing residential, industrial, commercial and institutional buildings as well as newly constructed buildings that are not subject to the green roof bylaw. Whether a building project is subject to the by-law depends on its gross floor area (compare "Engineering and Monitoring" p.11). Eligible projects receive $75 per square meter up to a maximum of $100,000 (City of Toronto, 2015b). Owners of existing buildings with a gross floor area lower than 2000m² are exempted from the by-law. Also other parties are equally able to receive funding by the "Eco-Roof Incentive Program" to become financially empowered. An exemption from the green roof by-law has to be approved by the Toronto Chief Planner and, if accepted, costs $200 per square meter (City of Toronto, 2015a; Viola, 2013).

The actual costs of green roofs vary for most

projects. According to Acks (2003) and Wong et al. (2003) the costs for standard roofs are 50 to 90$ while green roof cost 90 to 240$. However, in practice some green roof projects in Toronto even cost up to 400$ per square meter (Esri Canada, n.d.; Harvey, 2009). The costs for green roofs are not fixed and depend on every green roof's individual design. Most decisive for the costs of the green roof is whether it is intensive or extensive (compare "Green Roofs" p.3). Additional costs may arise due to maintenance or replacements if a long period of time is considered. Possibly, widespread implementation of green roofs will stimulate the green roof construction market and cause an economy of scale effect that results in lower per unit prices.

The subsidy program which is financed by the municipality (a decentralised authority) from public money (solidarity principle) under the assumption that the construction of green roofs will benefit the public. Whether the subsidy program is financially empowering is different for every single green roof project. Therefore, it is difficult to judge whether the Eco-Incentive program is powerful enough or not. This aspect will further be discussed under "Conclusion and Recommendations" (p.14).

Engineering and Monitoring

Assessment Criteria

Assessment criteria: Are SLAs (service level agreements) sufficiently available (implicit or explicit) in order to redesign the existing infrastructure? Are the design and consequences of different alternatives sufficient available? Is there sufficient monitoring of the system and are the data analysed? (van Rijswick, 2014)

The city of Toronto's by-law No. 583-2009 §492-1 defines a green roof as "an extension of an above grade roof, built on top of a human made structure, that allows vegetation to grow in a growing medium and which is designed, constructed and maintained in accordance with the Toronto Green Roof Construction Standard" (Toronto Municipal Code, 2015). Comprehensive information about the service level agreements which govern the required standards for engineering and monitoring of green roofs in Toronto can be found in article IV of Chapter 491 of the Toronto Municipal code which is freely accessible to any interested party (Toronto Municipal Code, 2015).

The city of Toronto published several brochures such as the "Toronto Green Roof Construction Standard Supplementary Guidelines" and the "City of Toronto Guidelines for Biodiverse Green Roofs" with the aim to sufficiently supply prospective users with advice on the construction of green roofs. The former addresses engineering aspects such as vegetation, growing media, drainage panel and filter fabric, insulation, membrane protection and root barrier, roofing membrane and structural support (Hitesh, n.d.). The latter one contains recommendations for prospective users on how to maximise ecological benefits of green roofs for the city of Toronto (Torrance, 2013). In addition prospective users can consult a green roofs technical advisory group.

For safety reasons planning of green roofs has to comply with the Ontario Building Code (OBC) part 4.1 *Structural Loads and Procedures*. If this is not the case, amendments in a buildings structure may be considered. The OBC is easily accessible and contains all required information for prospective owners of green roofs and involved parties to fulfil the standards for green roofs in Toronto.

In addition, a maintenance plan is stipulated by the Toronto Municipal Code in order to monitor the performance of green roof components and identify locations for replanting if necessary (Toronto Municipal Code, 2015). Compulsory monitoring is meant to serve the assessment and maintenance of individual green roof performances, rather than for large-scale research purposes about the performance of green roofs in Toronto. This issue should be addressed by monitoring and studies about the overall performance and impact of green roofs on intended issues such as stormwater management, urban heat island effect, etc.

(compare "Water System Knowledge" p.5).

However, the application of green roofs is usually limited to roofs which are either flat or only slightly inclined. Many traditional pitched roofs are not suited for the construction of green roofs. The construction of green roof alternatives will be addressed under "Conflict Prevention and Resolution" p.13).

Enforcement

Assessment Criteria

Assessment criteria: Are regulations and agreements enforceable by public and/or private parties, and are there appropriate remedies available? (van Rijswick, 2014)

The implementation of green roofs in Toronto is enforced by law and the corresponding juridical framework. In 2010 Toronto became the first city in North America to enact a new by-law which requires newly built commercial, institutional and multifamily residential building with a gross floor area of at least 2,000m² to partially be covered by a green roof (Benfield, 2010). Non-compliance with the bylaw can be fined with up to 100,000$ (City of Toronto, 2009). The city's target is to double its tree canopy by 2050 which can partly be achieved by creation of green roofs (Mees and Driessen, 2011). Currently, the proportion of the total area of the roof which needs to fulfil the requirements of a green roof, ranges from 20 to 60% depending on the gross size of the buildings floor area (compare table 2; Toronto Municipal Code, 2015).

However, many private households are not affected by the law because their houses do not exceed a gross floor area of at least 2000m² and thus do not require a green roof. In order to achieve an implementation of green roofs on a broad scale Toronto started an "Eco Roof Incentive" programme which is part of the city's wider climate change action plan. The programme subsidies eligible projects for residential, industrial, commercial and institutional buildings with 75$ per square metre green roof (City of Toronto, 2015b). Accordingly, green roof projects with an projected area of up to 1333 square metre green roof are supported[2].

Overall, the measures taken by the city of Toronto to enforce the implementation of green roofs are good but can still be enhances (compare "Recommendations for Policy Improvement" p.16). During the last five years, 260 new green roofs were built (City of Toronto, 2015a). Still, in order to further facilitate the creation of green roofs, the city of Toronto should carry out research in order to quantify social , economic and environmental benefits and communicate them among stakeholders. Furthermore, logistical, financial and technical support may persuade prospective users to transform their roof into a green roof (Banting, 2005).

Table 2: Required Size of green roof according to "Toronto Municipal Code, Chapter 492, Green Roofs" (City of Toronto, 2015a)

Size of Building/ Gross Floor Area	***Coverage of Available Roof Space***
≤ 2,000 m²	Not mandatory
2,000 – 4,999 m²	20%
5,000 – 9,999 m²	30%
10,000 – 14,999 m²	40%
15,000 – 19,999 m²	50%
≥ 20,000 m²	60%

2 100,000$ / 75$/m² = 1333 m²

Conflict Prevention and Resolution

Assessment Criteria

Assessment criteria: Are there sufficient conflict prevention and resolution mechanisms in place? (van Rijswick, 2014)

The most controversial subjects attached to green roofs are aesthetic concerns by residents, costs, attraction of non-native wildlife, plant selection (if non-native), use of fertilizer and with pesticides contaminated runoff (Getter and Rowe, 2006). In some cases green roofs may compete for space with other purposes such as photovoltaic systems.

In the case of Toronto, literature research did not provide evidence about widespread public complaints about the city's bylaw to facilitate the installation of green roofs except of financial costs (compare "Stakeholder Involvement" p.7). This might be the result of clear communication of economic, social and political benefits for the community.

However, to decrease the potential for the most common conflicts attached to green roofs, the city offers information and advice on green roofs to prospective users and the affected community as for example suggestions about native plant species for green roofs (City of Toronto, 2015a).

In 2011 another bylaw was issued which amends the City of Toronto Municipal Code Chapter 492 on green roofs by providing an alternative to the Green Roof requirement for industrial buildings. It enables industrial buildings to avoid installation of a green roof if a "cooling roof" is installed instead (City of Toronto Council, 2011). Private house owners can apply for an exemption from the green roof bylaw which is most commonly coupled with the payment of a fee which amounts to 200$/m² and can go up to 100,000$ (City of Toronto, 2015a). Overall, there is no evidence that major conflicts are attached to the construction of green roofs. This might be the result of clear communication of public and private benefits such as saving of energy costs as well the general notion of green roofs as a "no-regret measure".

Conclusion and Recommendations

Discussion

This report set out with the aim to assess the current green roof policy of the municipality of the city of Toronto in Ontario, Canada, and identify its deficiencies and weaknesses in order to formulate appropriate recommendation for future policy improvement. The assessment was based on a multidisciplinary approach including aspects of water system knowledge, societal benefits and demerits, authority, responsibility and law, economics as well as technical enforcement and feasibility. The "ten building blocks for sustainable water governance" assessment method provided a strong framework as a guidance through the most relevant aspects for policy assessment.

In summary, the city of Toronto has a comprehensive policy in place to facilitate widespread implementation of green roofs. The city's decision to facilitate green roof implementation was based on empirical assessments about potential benefits for Toronto (Banting, 2005) and with respect to the expected impact of climate change in the future (City of Toronto, 2012).

The city of Toronto successfully communicated the benefits of green roofs among stakeholders and thus minimised conflict. Most likely it was favourable that green roofs are commonly regarded as a "no-regret" measure as no significant negative aspects, except of higher construction costs compared to normal buildings, are known. This facilitated the creation of a shared vision of green roofs as a positive measure to improve the urban environment.

Since costs were the only major source of potential conflict, the city started a comprehensive subsidy program for mandatory green roof projects as well as an "Eco-Incentive" program for voluntary implementation of green roofs. Most likely, the relatively effortless reconciliation of stakeholders can additionally be linked to shared values among citizens, as Toronto is known as a rather "green" city with a supposedly high rate of acceptance for green roofs.

Toronto is also part of the "C40 Cities Climate Leadership Group", a fact that reflects, that public awareness about environmental issues is comparably high. It is also worth mentioning that the city of Toronto is relatively prosperous and can financially afford the wide-spread subsidy of green roofs.

Since 2010, green roofs are mandatory for newly constructed buildings with a floor size of 2000 m^2 or more. Mandatory implementation by law is an appropriate measure because the property rights of the objects where green roofs are implemented, often exclusively belong to house-owners. In order to avoid conflict, the installation of cooling roofs offers an alternative and serves as conflict prevention if stakeholders cannot or do not want to install a green roof. Non-compliance with the bylaw (either green roof or cool roof if mandatory) is penalised with a fee. The engineering and monitoring of green roofs is clearly regulated by the "Toronto Green Roof Construction Standard" and must comply with the "Ontario Building Code". Both documents are freely accessible to any involved party.

Policy Effectiveness

No official measurements about the effectiveness of Toronto's green roof policy are publicly available. In fact, it is difficult to assess whether the green roof policy has proven to be successful or not. One approach would be to look at the economic benefits that are presently being generated by the implementation of green roofs.

The city of Toronto disclosed that during a period of roughly five years since the inception of the policy, 260 green roofs have been built. The area of newly built green roofs amounts to 196,560 sq metres and the total number of green roofs within the municipality of Toronto is 444 (City of Toronto, 2015a). Assuming that the 260 newly built roofs are representative for the average green roof in Toronto, the average size of all 444 green roofs would be 756 square metres. Multiplying the assumed average green roof size with the total number of green roofs results in a total area of 335,532 square metres that are covered with a green roof as of March 2015.

The "Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto" by the Ryerson University suggests that green roofs hold potential for 313 million dollars initial- and 37 million dollars of annual cost savings. The underlying assumption of the report was that 50 million square metres of Toronto's area were covered with a green roof. If the cost savings are broken down to per square metre savings of green roofs, initial savings are 6.26$ per square metre and annual savings amount to 0.74$ per square metre. Scaling these values up with respect to the area of green roofs covering the city today, the initial cost savings would be 2,101,682$ and annual cost saving amount to 248,441$.

The numbers are presentable assuming that the green roof initiative is still in its infancy and intended as a rather long-term measure for city development. They might even indicate that the green roof policy proofs to be effective.

However, it is arguable if the underlying assumptions and values of the calculations are sufficiently based on empirical knowledge. In addition they assume that economic benefits follow a linear development which is most likely not the case because of non-linear development and threshold levels within the water system.

Conclusion

Whether the green roof policy of the city of Toronto is a success or not is difficult to assess and depends on which indicator is consulted. The total number of green roofs has almost doubled since the enacting of the green roof bylaw. Still, the economic benefit of green roofs is (at least partly) difficult to measure and no detailed information about the number, size and performance of green roofs is publicly available.

Overall the city of Toronto devised a comprehensive policy to facilitate the creation of green roofs. All relevant aspects, such as knowledge availability, stakeholder reconciliation, administrative organisation, legal arrangements, technical obligations and possibilities for alternatives seem to have been sufficiently addressed during the policy-making process.

Still, in order to further improve the policy, research must be conducted in order to assess the performance of green roofs in Toronto and quantify their social, environmental and economic benefits. Based on this knowledge the green roof policy must be regularly subjected to enhancements.

Recommendations for Policy Improvement

Recommendations for Policy Improvement

• Currently the implementation of green roofs is enforced by a rather simple set of mandatory implementations and a subsidy program for green roof construction. A more sophisticated set of financial measures could involve reduction of taxes for example on wastewater treatment and/or energy prices for heating/air conditioning. A similar concept is already being applied in Basel (Switzerland) and in Stuttgart, Germany (Mees et al., 2013). Reduction of taxes implies recurrent cost savings for green roof owners instead of a one time subsidy and might pose an additional incentive for the construction of a green roof.

• Joint efforts between private and public stakeholders of green roofs. This should include public authorities, public and private research institutes and roofing contractors in order to maximise the performance of green roofs. Gained knowledge should be communicated with external partners such as C40 cities or other cities which have a large-scale green roof policy in place. Toronto will also be able to benefit from their experiences and knowledge.

• Green roofs potentially compete for space with solar energy. The city of Toronto should support construction of green roofs with solar panel integration for interested stakeholders. This would reduce the potential for conflict and may even increase the water retention capacity of green roof (GRT, 2015).

• Large scale subsidy programs can stimulate economy of scale processes and thus decrease the costs of construction units and materials for green roofs. This would reduce the price margin between conventional roofs and green roofs and be supportive for the overall share in installations. Additionally, the need for economic incentives will decrease if the initial costs of green roof construction is reduced.

• More effort should be undertaken to quantify benefits of green roofs by monitoring and research. Reliable information about practical benefits of green roofs would help to improve their performance and to make policy adjustments. Development of urban temperatures for instance or combined sewage overflows might serve as appropriate indicators.

Bibliography

Acks, 2003. A framework for cost-benefit analysis of green roofs: initial estimates.

Adelmann, M., 2014. City Failing to Harvest Potential of Green Roofs.

AMO, 2013. How Municipal Government Works.

Bale, G., 2014. Property Law [WWW Document]. Can. Encycl. URL http://www.thecanadianencyclopedia.ca/en/article/property-law/ (accessed 6.23.15).

Banting, D., 2005. Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto.

Barrett, T., 2009. 39:1 Bill 190, Property Rights and Responsibilities Act.

Benfield, K., 2010. Toronto's leadership for green roofs | Kaid Benfield's Blog | Switchboard, from NRDC [WWW Document]. URL http://switchboard.nrdc.org/blogs/kbenfield/torontos_leadership_for_green.html (accessed 5.18.15).

City of Toronto, 2015a. Green Roofs - Environment - City Planning | City of Toronto [WWW Document]. URL http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=3a7a036318061410VgnVCM10000071d60f89RCRD (accessed 5.18.15).

City of Toronto, 2015b. Eco-Roof Incentive Program - Grants, Incentives & Tips - Programs for Residents | City of Toronto [WWW Document]. URL http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=3a0b506ec20f7410VgnVCM10000071d60f89RCRD (accessed 5.26.15).

City of Toronto, 2012. TORONTO'S FUTURE WEATHER & CLIMATE DRIVER STUDY: OUTCOMES REPORT.

City of Toronto, 2009. STAFF REPORT ACTION REQUIRED By - law to Require and Govern the Construction of Green Roofs in Toronto.

City of Toronto, 2006. Making Green Roofs Happen.

City of Toronto Council, 2011. By-Law No. 1381-2011 - To amend City of Toronto Municipal Code Chapter 492, Green Roofs, by providing a cool roof alternative to the Green Roof requirement for industrial buildings.

Currie, 2010. Using Green Roofs to Enhance Biodiversity in the City of Toronto.

Esri Canada, n.d. EcoRoof Case Study.

Getter, K.L., Rowe, D.B., 2006. The Role of Extensive Green Roofs in Sustainable Development. HortScience 41, 1276–1285.

Greenroofs.org, 2007. How Your Community Will Benefit from Adopting.

GRT, 2015. Solar Energy and Green Roofs.

Harvey, I., 2009. When it comes to green roofs, there's green and then there's green. Tor. Star.

Hitesh, D., n.d. Toronto Green Roof Construction Standard - Supplementary Guidelines.

Mees, H.L.P., 2010. Climate Greening London, Rotterdam and Toronto A comparative analysis of the governance capacity of adaptation to climate change in urban areas.

Mees, H.L.P., Driessen, P.P.J., 2011. Adaptation to climate change in urban areas: climate-greening London, Rotterdam, and Toronto. Clim. Law 2, 251–280.

Mees, H.L.P., Driessen, P.P.J., Runhaar, H.A.C., Stamatelos, J., 2013. Who governs climate adaptation? Getting green roofs

for stormwater retention off the ground. J. Environ. Plan. Manag. 56, 802–825. doi:10.1080/09640568.2012.706600

Toronto Municipal Code, 2015. TORONTO MUNICIPAL CODE CHAPTER 492, GREEN ROOFS.

Torrance, S., 2013. City of Toronto - Guidelines for Biodiverse Green Roofs.

TUCCN, 2009. TUCCN's Mandate.

Van Rijswick, E., 2014. Ten building blocks for sustainable water governance: an integrated method to assess the governance of water. Water Int. 39. doi:10.1080/02508060.2014.951828

Van Rijswick, M., Edelenbos, J., Hellegers, P., Kok, M., Kuks, S., 2014. Ten building blocks for sustainable water governance: an integrated method to assess the governance of water. Water Int. 39, 725–742. doi:10.1080/02508060.2014.951828

Viola, D., 2013. Toronto a leader in green roof industry. REMINET.

White, T., 2010. Toronto's Green Roof Policy - A Review of the Process and Product.

Wong, N.H., Tay, S.F., Wong, R., Ong, C.L., Sia, A., 2003. Life cycle cost analysis of rooftop gardens in Singapore. Build. Environ. 38, 499–509. doi:10.1016/S0360-1323(02)00131-2