Interactive GIS and Public Engagement of the St. George Rainway

Nathan Eastman, Wayne Jong, William Lusk, Bobbianne Riches, Brian Tai
EVCS 400 Environmental Science Capstone
Simon Fraser University
April 15th, 2021
Dr. Tara Holland
Julie McManus, City of Vancouver Green Infrastructure Implementation
Kelly Gardner, CityStudio

Table of Contents

1. Executive Summary

Background

St. George Creek, also known as *te Statlew*, was once located on the St. George Street, stretching from Great Northern Way to Kingsway. Due to the infrastructural development back in the early 1900s, the Creek was covered and buried. The idea of St. George Rainway was revitalized and reimagined to create a cost-effective solution to combat climate change related consequences . Problems, like flooding and overflow of combined sewage systems, can be alleviated. Other co-benefits of the rainway, including pollutant treatment and biodiversity enhancement, can also be facilitated in the process of implementing the rainway.

The St. George Rainway Project has been advocated for by the nearby community for more than a decade, involving residents, students, and other local stakeholders. Recently, with the 2013 Mount Pleasant Community Plan Implementation Documents and 2019 Rain City Strategy by the City of Vancouver, the actualization of this project is closer to reality than ever. The City launched and has just ended Phase 1 Engagement to consult citizens about the values and visions for the project. The survey has received significant amounts of interest and concern over different aspects of the project, such as excitement for more greenery space, and other cost-and-benefit factors. Our project will be focused on addressing the varying views of the public and taking into account constructive feedback to improve.

Our goal for this project is to develop an online resource for ongoing public engagement and education on the community about environmental co-benefits of the St. George Rainway implemented through the Rain City Strategy by the City of Vancouver. As we develop this resource, our goals, objectives, and targets will be closely aligned to those set in the Rain City Strategy.

Objectives

With our educational resource we want to educate the public on the importance of green rainwater infrastructure (GRI) and increase support for the St. George Rainway Project. Scientific understanding of GRI's benefits is not currently well understood by the public. Through our interactive map tool we hope citizens will be able to learn about what GRI and specifically the Rainway Project can bring to the Mount Pleasant area. We also want to see our educational tool be used not just for learning but as a source of engagement between the City of Vancouver and it's citizens. More broadly we want to foster an interest in learning about the effects of GRI and a desire within the public to communicate and collaborate in the shaping of their city.

Introduction

The City of Vancouver has adopted the Rain City Strategy, with goals on improving how the city interacts and deals with rainwater and other environmental factors. Some of the City's goals include capturing and cleaning 90% of Vancouver's rainwater before disposal, increasing the city's livability, increasing urban biodiversity in Vancouver and decreasing the city's urban heat island effect. In order to achieve these goals, the City has implemented and will continue to implement Green Rainwater Infrastructure (GRI) throughout the city. GRI is a part of Green Infrastructure (GI) which uses natural systems in combination with urban infrastructure to promote ecosystem services. GRI focuses on specifically ecosystem services that involve the management and retention of rainwater in the City. Our goal is to aid in public relations and education for a specific GRI project, the St. George Rainway Project. There currently exists a disconnect between the scientific communities' understanding of the importance of GI and the public's feelings of its importance. We hope that by educating the public on the GRI benefits the Rainway brings in an accessible and engaging manner, we will see increased support and interest for the project's implementation. We are proposing the development of an interactive mapping tool to achieve this goal. The mapping tool will be able to disseminate information in a visually interesting and simply to understand manner to help grow public support for the St. George Rainway.

Literature Review

Intro

Vancouver has long been a pioneer in combining urban and natural environments. The City has a long history of green space implementation. Green infrastructure is an extension of these greenspaces that uses natural functions of ecosystems to provide services in urban environments. GRI specifically focuses on rainwater management and converting or stormwater management from grey to green (man-made to incorporating natural elements). In this Literature Review we focused on several aspects of GRI. GRI benefits to the community are discussed as well as how we can best educate these benefits to the general population. We also review the literature on factors that can prevent the implementation of GRI and how we can determine our projects level of success.

History and Evolution of the Concept of Green Infrastructure

Green infrastructure first appeared in the academic literature around the year 2000 but its origins can be traced back to the 19th century. Fredrick Olmsted is considered the forefather of green infrastructure with his emphasis on building urban parks and sewer infrastructure in a time well before the benefits of green spaces had been fully realized. Since then, similar green space concepts have been developed and carried out, but the modern idea of GI did not gain popularity until around 2008. In our current day and age, GI is the standard framework used by urban planners in cites to produce ecosystem benefits in urban areas.

GRI Benefits

Green rainwater infrastructure has been shown to bring many benefits in urban environments. Grey infrastructure like asphalt roads and concrete buildings and sidewalks absorb heat from the sun and re-emit that heat over time leading to an effect in cities known as the urban heat island (UHI) effect. The UHI effect causes cities to have significant increases in temperature in comparison to non-urbanized areas. Water can reflect the sun's heat and vegetation absorb less heat than grey infrastructure. Therefore, GRI can help to reduce the urban heat island effect. Soil and vegetation are also much more absorbent than concrete and asphalt, this means that GRI can slow down and reduce rain flow into the sewer system. With a slower flow of water into the sewer system (especially during storms), water can be more easily managed in the stormwater system allowing for more to be captured and cleaned before reaching the ocean. GRI has also been shown to decrease the amount of pollutants reaching waterways, increase recreation activities and enhance community bonds and human health.

Implementation Barriers

Despite the benefits of GI being clear amongst the scientific community, GI faces barriers in being actualized in many cities. Some of the major barriers to GI implementation are lack of funding and lack of public understanding and/or support for GI. There are many ways we can act to remove these barriers. Educating and engaging the public on GI's benefits can help to show the importance functions of GI to citizens. As part of this education and engagement, being able to quantify GI benefits can be useful. Public support can also be garnered through increased collaboration between the city and the public; working to make sure the interests of different citizen groups can be met as best as possible. Increasing the authority of municipal governments can also help them to make decisions around GI in the communities they serve.

Education

Research has shown that simply relaying scientific information to the public is insufficient in changing dissenting opinions. People tend to interpret information in context of previous experiences and their personal viewpoint. Individuals will twist information to fit their narrative of the situation and will even reject information if it is significantly contradictory to their world view. This can make education and public support very difficult especially when considering polarizing topics like environmental science. Thankfully, we are seeing a shift in how scientific information is presented to the public to better engage and educate people. Presenting information in a narrative can help to get people engaged but can also increase potential polarization. Focusing on a local narrative has been shown to decrease to rejection of environmental information amongst conservative audiences. Simplifying complex topics in environmental science can increase engagement and understanding but also runs the risk of creating misinformation. Because simplified information is more general and therefore more open to individual interpretation it can more easily be misinterpreted.

Public Engagement and Other Cities' Strategies

Cities took many different approaches when attempting to engage their citizens with green infrastructure initiatives. However, a common theme among these cities was that education programs were tailored to specific demographics in comparison to our more broad engagement plan. For example, several cities had programs targeted specifically at youth, with student education programs and tours of GI throughout their city. Other cities' engagement/ education programs still used print to communicate, such as brochures and booklets. We hope to utilize the same simplified language and visual communication seen in these brochures but in a more modern, online format.

Metrics of Success

It is vital that when creating a project u develop, alongside the project, ways to measure its success. Having metrics of success allows the project developers to have an understanding of what worked and what can be improved in their work. There are many ways to measure the success of an educational tool such as the one we are proposing. Having measurement tools that are tailored to the specific projects goals and target audience is critical in ensuring that the chosen metrics of success are representative of what one wishes to achieve. For our education resources we hope to use randomly assigned polls of users when combined with site visitation statistics to determine where we have succeeded and what can be improved.

Conclusion

This Literature Review is helpful in determining how to best educate the public and gain their support. We believe that by telling the story of the history and future of the rainway we will create a narrative around the positive outcomes from the St. George Rainway's construction. And our online method can achieve our goals in an exciting yet, COVID safe manner.

Proposed Plan

Rationale

We chose to create an online, interactive mapping system to educate and engage the public. We felt this would work well because it can be used safely, even during covid restrictions. Using signage along with the map resource brings a balance between virtual and real world learning.

The map's format also allows for easy visual communication and builds a narrative around the history and future of the St. George Street Area.

Plan and Prototype

Signage around St. George Street and at specific locations of GRI implementation will give citizens information about what is being (our has been built). Those who are interested in learning more can use the link or QR code on the sign to access the website containing the mapping tool. The website will have an interactive map of the St. George street area, showing information such as the location of historic shores lines and streams as well the sites where GRI is (our has been built). By clicking on icons associated with each GRI installation, users can then learn more about the specific piece of GRI and its benefits. The map will also include a historical timeline showing changes in the area as GRI is built.

Next Steps

As the Rainway is constructed we will continue to update the map resource to reflect the state of construction progress. We can also use data collected on the completed Rainway to add information on exactly how the St. George Rainway is benefiting the community. This could include a decrease in the UHI effect, an increase in biodiversity and more depending on what is monitored. The map can also be updated with GRI exploration challenges or citizen experience surveys. This will help to keep people engaged and learning about GRI in Vancouver and can give people an opportunity to share their opinion on the City's green future.

2. Report Authors

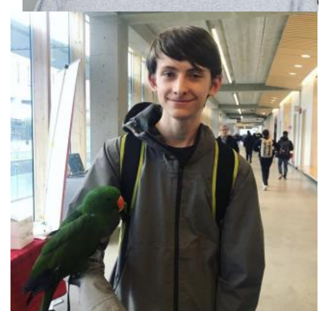
Nathan Eastman:

Nathan is in his final year of studies at SFU in environmental sciences in the applied biology stream. He is passionate about preserving ecosystem health and biodiversity both locally and on a global scale. Nathan is excited to enact positive change through the St. George Rainway project and other projects throughout metro vancouver.

Wayne Jong;

An Environmental Science student at SFU with a concentration in applied biology. He enjoys learning about the environment and the natural processes that tie everything in the world together. Wayne is in his final year of study and hopes to leave a positive impact on the world.

William Lusk:



William Lusk is graduating from the SFU Faculty of Environmental Science this year with a specific concentration in environmental earth systems. He has always had an interest in the natural environment and ecosystems and plans to continue studies in environmental science after graduation. William is a strong supporter of progressive environmental policy and has eagerly studied a variety of green infrastructure projects and types during his studies.

Bobbianne Riches:

In her last year of studies of Environmental Sciences at SFU in the applied biology stream. She enjoys being in nature and learning about the environment. She is enthusiastic on green initiatives for climate change and the future.

Brian Tai:

Brian is also graduating this year with an Environmental Science major in environmental earth systems concentration. Moving forwards, he plans to move to Interior BC and pursue a small business idea with food security and sustainability in mind.

3. Introduction

The purpose of our project is to create an educational tool for people to use for learning about green rainwater infrastructure within Vancouver. The hope is that this tool will help bridge the knowledge gap between city planners, governments, and the public. Many stakeholders must cooperate for green rainwater implementation to be successful therefore having a platform where feedback can be made is key for the success of green rainwater projects. Our project focuses on creating an engaging tool to help people connect to and understand the St. George Rainway in the Mount Pleasant area of Vancouver. The primary reasons for the Rainway's construction are to better manage rainwater and drainage capacity. The Rain City Strategy of Vancouver outlines the target to capture and clean 90% of rainwater within the city. Building new green rainwater infrastructure and converting gray infrastructure throughout the city will be key in meeting these targets. Other Rain City goals include increasing Vancouver's resilience through water management; increasing livability of natural and urban ecosystems; removing pollutants from air and water; mitigating urban heat island effect; and increasing total green surfaces. The goal of this project is to push for the acceptance of green rainwater infrastructure implementation within Vancouver. Further, this project seeks to educate the public on the benefits of green rainwater infrastructure through engagement with our proposed resource. To achieve this we propose the creation of an online mapping tool where users can be educated on green rainwater infrastructure within Vancouver by seeing visual timelines of projects. This tool will be an interactive experience and will allow users to give input on the St. George Rainway and possibly other green infrastructure projects within Vancouver. To give our proposal a strong scientific basis, a literature review was conducted to examine the history, benefits and barriers of GRI and optimal methods of education and engagement.

4. Literature Review

4.1 - Introduction

Vancouver has been famous for its greenways program in the past, and now its transition into green infrastructure (GI) or green rainwater infrastructure (GRI). The Ridgeway Greenway adopted in 1995 was the first pioneering implementation in the city, accredited by many as it actualized the idea of greenways and successfully contributed into betterment of the landscape, sense of community and aesthetic experience (Erickson, 2006). Greenways were further implemented as waterfront promenades, urban walks, environmental demonstration trails, heritage walks, and nature trails as they provide urban reaction, alternative mobility, better experience with nature, community, and city life (Erickson, 2006). A planning initiative called *Green Infrastructure* in *Metro Vancouver - Facts in Focus*, 2015, directed the development of the *Rain City Strategy* by the City of Vancouver in 2019, whereas GRI focused to improve water resource management, reduce flood risks, and support diverse ecosystems (City of Vancouver, 2019). GI is defined as “an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict & McMahon, 2002) while GRI emphasizes on both engineered and ecosystem-based methods to protect, restore and mimic the natural water cycle (City of Vancouver, 2019). GI has been implemented successfully in many metropolitan cities, like Chicago Wilderness Biodiversity Conservation Plan, Portland, Oregon Metro Greenspace Program, with specific focuses on different ecological or natural resources (Benedict & McMahon, 2002). Vancouver’s implementation of GRI undoubtedly focuses on water resources and includes types of GI such as bioswales, rain gardens, permeable pavements, and others (City of Vancouver, 2019).

In this literature review, we explore the topics of history and evolution of GI, its benefits, implementation barriers, education, engagement methods, and lastly metrics of success while education and engagement methods are our prime focus here for this project. We have to communicate science effectively with the public by avoiding rejection and polarization since environmental science can be a subject of political controversy and often information perception is dependent on political affiliation or ideology (Hart et al., 2012; Rigutto, 2017). Visual media online, however, can draw in audiences when communicating complex processes and straying away from deficit-model education (Rigutto, 2017). There is still potential, nevertheless, creating sources of misinformation since individual interpretation varies. Therefore, an understanding of the public's knowledge and perception of GRI both before and after using the educational tools should be evaluated as to provide the metrics of success (Bonney et al., 2009). These are all important factors we have to include in decision making while designing and planning our public education and engagement tool.

4.2 - History and Evolution of Green Infrastructure

GI has been an emerging concept and terminology used in urban planning and social sustainability development for the last decade to play a "pivotal role in urban renaissance", and to combat the consequences from climate change effects and cities' tighter livable spaces (Mell, 2009). It is, however, claimed to be 'old wine in new bottles', and can be categorized into old antecedents and ideas before 2000 including urban forestry, greenways and green corridors, community forests, ecological networks (Davies et al., 2006). Eisenman (2013) attempted to trace back the origin of the idea of GI back to 19th century landscape architecture, Frederick Law Olmsted. Olmsted was involved in many urban park and sewage developments, like the

Back Bay, Boston and Muddy River restoration projects, where Olmsted demonstrated "an intuitive understanding of the link between nature and human well-being that is the underpinning of what we today know as ecosystem services" (Eisenman, 2013). Fast forward to the 2010s, GI completely replaced the political initiative of green belt in England as the concept gives planners and politicians a comprehensively better understanding of economic costs and benefits, as well as spatial planning and soft governance (Thomas & Littlewood, 2010). Mell (2017) framed GI development into three eras: Exploration (1998–2008), Expansion (post-2008–2011) and Consolidation (2010–2012 onwards); wherein the concept and discussion of GI and its benefits were advocated for and evolved from older terminologies in *Exploration*; an incline in the amount of academic, government working on GI, and more discussions, policy guidance and research projects looking at its benefits happened in *Expansion*; lastly, "common consensus relating to what GI is and how it should be developed" (Mell, 2017) have reached in the current *Consolidation* state. These phases are similarly demonstrated in Vancouver's city planning on the transition of GI developments.

4.3 - GRI Benefits

GRI has been a popular concept among sustainable land use planners mainly due to its multifunctionality as opposed to its conventional grey infrastructure counterpart. There are many benefits to GRI including the monetary, community, ecological, and environmental values. In this section, we highlight some of the benefits of GRI which can be grouped into two broad categories: (1) environmental benefits and (2) socioecological and human benefits.

(1) Environmental Benefits

The two main issues that GRI can help address in cities is the urban heat island (UHI) effect and flooding (Derkzen et al., 2017). Grey infrastructure such as buildings and impermeable pavements cause negative impacts such as increased anthropogenic heat, altered natural ventilation, and modified urban heat balance (Bartesaghi-Koc et al., 2020). One of the benefits of GRI is its cooling capacity and ability to mitigate UHI (Zardo et al., 2017; Bartesaghi-Koc et al., 2020). Studies have found that water bodies and tree canopy coverage were most efficient in reducing land surface temperatures (Zardo et al., 2017; Bartesaghi-Koc et al., 2020). Surface wetness and vegetated irrigation also play a significant role in providing effective cooling (Bartesaghi-Koc et al., 2020). The use of impermeable pavements for roads and sidewalks has also resulted in decreased stormwater infiltration and increased surface runoff, which leaves urban areas susceptible to flooding (Jackson, 2003). A desirable benefit of GRI especially in urban landscapes is its ability to provide vegetated drainage ditches and retain stormwater (Derkzen et al., 2017). Due to the infiltration capacities of GI, they can absorb excess storm water and reduce flooding. Additionally, GRI has stormwater filtration capabilities that can remove contaminants or excess nutrients picked up along grey infrastructure and prevent them from entering and polluting waterways (Prudencio & Null, 2017; Hobbie et al., 2017). Implementing GRI can help restore valued ecosystem services such as improved water quality, groundwater replenishment, diverse habitats to increase biodiversity, and recreation (Prudencio & Null, 2017). GRI can also reduce carbon emissions and sequester carbon from the atmosphere to help mitigate the effects of climate change.

(2) Sociocultural and Human Benefits

Aside from providing the ecosystem services mentioned above, GRI can also provide sociocultural benefits. This includes educational opportunities, improvements to the built environment, an increase in social capital, and improved landscape aesthetics (Kim & Song, 2019). For example, the St. George Rainway has the potential to increase recreational opportunities along the street and increase contact with nature. This can be used as an educational opportunity to increase public awareness on environmental issues. GRI can also promote community development and is associated with the formation of strong social ties among neighbours, creating a sense of place among residents (Song & Kim, 2019; Kuo et al. 1998). Other sociocultural benefits include an increase in social gathering spaces, cultural expression, and increased physical/mental health (Song & Kim, 2019). Mental health is becoming an increasingly important aspect in today's society, and there is a growing body of evidence that links the design of living space to human health. Inhabitants that are exposed to natural light and ventilation, views of greenery, and have close proximity to outdoor green spaces experience reduced stress and therapeutic effects on their mental and physical state (Jackson, 2003). Additionally, being around nature is linked with other positive effects, such as happiness and subjective well-being, and positive social interactions, while decreasing negative effects such as mental distress (Bratman et al. 2019). The current state of the COVID-19 pandemic lockdown has significantly affected mental health, increasing symptoms of anxiety and depression among the general public (Pouso et al., 2020). This has led to an increased realization of the importance of green infrastructure and the mental health benefits that it can offer (Pouso et al., 2020).

4.4 - Implementation Barriers

The literature highlights the many barriers to GI implementation. The top GI implementation barriers as outlined by Tolsma and Hunter (2020) include funding, knowledge gaps, policy, resources, maintenance, coordination, and collaboration. These barriers represent flaws in the planning and outreach stages of GI implementation. Studies recommend bridging the gap between science and policy so GI can be incorporated into law. It is suggested that municipalities create more environmental authority through their bylaws for stormwater management, landscaping, development, and soil management (Tolsma & Hunter, 2020)**.** The papers agree that there are a variety of ways to improve GI implementation including educating the public, including the public in planning stages, and creating more policies for legal implementation. Poor partnerships and incentives are outlined as a barrier to implementing stormwater management in several frameworks (Prudencio & Null, 2017). These studies suggest quantifying the ecosystem services that come along with GI to better inform governments and people of the monetary and ecosystem benefits of GI (Prudencio & Null, 2017). When people are better informed about the value of GI, then they can make a clearer choice on implementing it (Derkzen et al., 2017). If people are more knowledgeable about the positive impacts of GI, then they would be more willing to pay for and support GI implementation projects. A study by Batiste et al. (2015) showed that people are more willing to want GI if the projects were free. This finding shows the need for government authority to step in for GI implementation, so it is not as expensive for taxpayers. The government should make more bylaws to enforce the use of GI for most development projects so that the developers must pay. Another focus of the literature was emphasizing the need for more collaboration and bridging the gaps between competing interests. Making the public feeling included and heard is a major theme among the literature and more community involvement could help to overall better GI implementation. A major way to both include and connect with the public while bridging knowledge gaps is through education. However, education has its own set of issues and any education plan needs to be carefully planned and implemented in order to positively engage the public.

4.5 - Education

It is a commonly held belief in scientific communities that the simple dissemination of information will produce a change in behaviour of less scientifically literate audiences. More commonly referred to as the deficit-model, this model of science communication assumes that scientific literacy and consensus is increased by increasing communication of science (Hart et al., 2012). The use of this model has become less common recently as mounting evidence proves it untrue (Crowell et al., 2016; Gregory, 2020; Hart et al., 2012). Particularly, the deficit-model fails to account for the strong effect of individual values that people use to interpret information and commonly results in polarizing audiences. When information is presented directly to an audience, its members will use previous experiences, values and ideology to view it through a unique lens. As a result, people interpret the same information in various ways that support their own beliefs (Hart et al., 2012). Especially in politically controversial fields like environmental science the presentation of such information without significant context and explanation leads to the spread of misinformation, backed by political affiliation (Hart et al., 2012; Rigutto, 2017). This often leads to the polarization of an audience as members reject or attach to information based on their ideologies (Hart et al., 2012). In order to communicate science effectively with the public, strategic and novel efforts needed in order to avoid rejection and polarization.

Environmental science and environmental education have fortunately been moving away from standard communication practices and instead has begun focusing on the behaviour of people and how their understanding affects decision making (Wals et al., 2014). Engaging people in a narrative is one way that environmental science can improve its dissemination and reception. Particularly, tying a scientific issue to a community in a human narrative improves its reception (Crowell et al., 2016; Rigutto, 2017; Wals et al., 2014) though it also can increase the risk of polarization as various ideologies clash. Conservative audiences often respond negatively to the presentation of environmental information, even more so with certain narratives attached to them (Hart et al., 2012). While this can be reduced by framing the narrative locally, there will always be portions of audiences that react negatively to science communication, and a targeted approach to moderate and supportive demographics will be more successful and produce less backlash (Hart et al., 2012). Online mediums provide a unique ability to engage audiences, improving their involvement and understanding (Rigutto, 2017; Wals et al., 2014). Visual media in online platforms especially can integrate with platforms and draw in audiences while communicating complex processes (Rigutto, 2017). Moreover, images can emotionally engage people and with more advanced software can be interacted with, straying from deficit-model education. While online platforms can reach previously unprecedented audiences, the simplification of contextual information, as is often necessary for education, can create sources of misinformation as individual interpretation varies (Rigutto, 2017). Online visual media provides an excellent opportunity to engage narratively and emotionally with audiences but must be careful to do so with consideration and context to not result in the spread of misinformation and backlash.

4.6 - Public Engagement and Other Cities' Strategies

Getting people interested in civic projects, especially concerning the environment is not an easy task. Our goal is to educate the public and gain support in the community for the St. George Rainway Project. To achieve this, it's important that we understand not only how to educate people and encourage support of the project but that we also know how to attract people to our educational resources. One way to discover what strategies are effective in achieving our goal is to look towards other cities and their education and support programs for GI. A key theme among different municipal programmes was to tailor education and engagement strategies to a specific demographic of interest (City of Surrey, 2019; The City of Portland, 2019; US EPA, 2017). However, regardless of demographic it is important that our educational resource be accessible and digestible to many if we want public engagement. City GI programs have utilized educational tools such as handbooks or brochures as well as mapping. Using plain direct language and visual aids can be useful in describing complex topics like GI (City of Philadelphia, 2018; City of Surrey, 2019). Cities also used GI tours and youth education programs to garner engagement (City of Philadelphia, 2018; The City of Portland, 2019). However, considering costs and time factors; using signage around the St. George area (especially during planning and construction) which leads people to our resource, may be the best option (US EPA, 2017).

4.7 - Metrics of Success

When creating a project or resource it is important to be able to evaluate its level of success, in order to make future improvements. Prior to our resource's creation, it is important to establish a clear aim and objectives to reach. Setting clear goals is what will help to guide us in determining how successful our education resource is and what methods will be optimal for measuring that success (UCL, 2017). Just as in our methods to garner engagement, it is important that we design our goals and metrics of success around our specific audience (Spicer, 2017). If we want to most effectively measure the success of our education resource it is important we have an understanding of the public's knowledge and perception of GI both before and after they use our resource (Bonney et al., 2009). Unfortunately, again like with our choice of methods to engage the public; metrics of success that can be measured will be limited by cost and time constraints. Considering our goals for our engagement resource and our target audience we suggest using two methods to measure success. Random polling of Vancouver residents on their opinions regarding the St. George Rainway Project and perceived GRI knowledge before and after use of our educational resource. When combined with site statistics measuring visitation count, we should be able to accurately judge the success of our project (Bonney et al., 2009; UCL, 2017).

4.8 - Conclusion

With the St. George Rainway project soon approaching its implementation phase, this literature review synthesizes our research thus far to aid in the development of our public engagement and education resource. Since our resource will take the form of an online webpage, is it vital that the public is made aware of our resource, and that the information contained within it is presented in a way that can be easily understood by the public. Educating the public about the benefits of GRI is one of our main goals for this resource. These benefits include reducing urban heat island effects, stormwater retention and filtration, flood mitigation, sociocultural benefits, and mental health benefits (Zardo et al., 2017; Bartesaghi-Koc et al., 2020; Derkzen et al., 2017; Prudencio and Null 2017; Song & Kim, 2019; Jackson, 2003). To enhance information retention among audiences, we will utilize methods such as constructing a narrative that the public can easily relate to, and using visual media to help explain complex processes, as these methods can improve engagement and emotional connection. However, not all individuals will have a positive reaction, and it is important that we set a target demographic for our resource.

Previous GRI projects have utilized brochures, tours, and youth education to promote public engagement, however due to current circumstances, this might not be a feasible option. As an alternative, using signage around St. George street to direct people to our resource is a more suitable and cost-effective solution. Lastly, measuring the success of our resource will depend heavily on our target demographic. We will utilize both qualitative and quantitative measures to gauge the success of our resource.

5. Proposed Plan

5.1 - Rationale

While our main focus is bridging the knowledge gap in terms of green rainwater infrastructure between the public and the scientific community, other potential risks and challenges are also needed to be addressed or avoided. Thus, our team came up with the idea of using a geographic information system (GIS) interactive mapping system to map out the entirety of the St. George Rainway GRI project and its development timeline as our primary outreach and educational resource. This way, not just COVID-19 restrictions and concerns can be eliminated; information bias can also be avoided as much as possible since geographical locations and features are based on scientific research and physical counterparts to convey accurate information to the public. The GIS interactive mapping system can create an engaging and participatory form of learning and strike a balance between virtual and real world involvement, no matter if there are restrictions and inconvenience brought about by the pandemic. Additionally, this visual and interactive medium of learning avoids the previously discussed deficit-model of learning by creating a temporal narrative and taking advantage of the benefits of visual media.

5.2 - Proposed Plan and Prototype

GIS is defined as a framework for gathering, managing, and analyzing data (esri GIS definition). For our preliminary demonstration and prototype, we utilize the open and free access platform, MapHub, to give us a sense of how this interactive mapping system can be implemented and actualized in real world settings (link to the prototype mapping program in the appendix). Despite this being a one-way communication method, there are many options for us to adopt interactive options to make the tool appealing and interesting. Users would firstly walk physically around the St. George Rainway and come across preexisting and newly-established signages. Those signages would provide a link or QR code to directly on the map with additional information such as a simple user guide. Throughout the interactive map, users can explore geographical information and features in different component layers:

- Historical water features, such as historic shoreline and historic creeks of Vancouver
- Related major infrastructure, like combined sewage systems
- Visualized timeline of the St. George Rainway Project with pictures for each project stage
    - Pre-construction/ existing look of St. George Street
    - Completed GRI items
    - Projected changes with embedded mockup/rendered pictures

Importantly, when users click on an individual map feature, a pop-up window will show pictures, text information, embedded links related to the feature. This will provide both visuals of the GRI developments and the informational context to understand the developments. Beyond just infographics, real location photos, GRI rendered pictures, educational videos, archives and information packages can be linked with each individual map feature. To foster further engagement, users will be able to communicate with representatives from the City of Vancouver working under the St. George Rainway GRI project through our resource. However, this feature is not available on our preliminary prototype as Mabhub does not support this function, however it is common among other GIS mapping software such as ArcGIS Online.

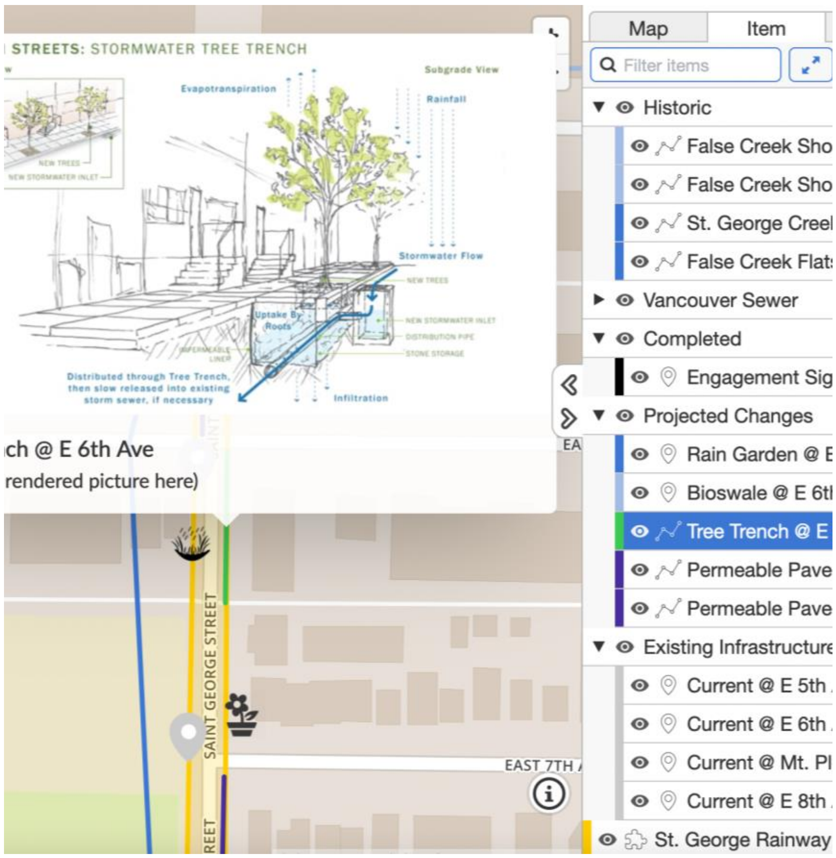


Figure 1. Screenshot of our St. George Rainway Interactive Mapping prototype

5.3 - Next Steps

As the construction of the St. George Rainway takes place, information on the development of the Rainway will be continuously updated to mirror the real-time progress. In addition to physical data, collaboration with data monitoring proposals can enrich the variety of information available to the public. Particularly, biodiversity changes could be framed as a narrative progression for the public's enjoyment as the project is implemented. To maintain constant engagement in the future, other interactive experiences, challenges, and surveys can also be embedded into the map. This allows residents to take up an active role in shaping their living environment and would help garner further support on the implementation of the Rainway. With our St. George Rainway Interactive Mapping Campaign, we hope to shift the perception and remedy the misconceptions of GRI. Collaboration among multiple parties, public acknowledgement and approval, as well as, long-term monitoring can be achieved with further expansion of this project if it is adopted. Lastly, we also present our three-phases implementation plan for the interactive mapping campaign:

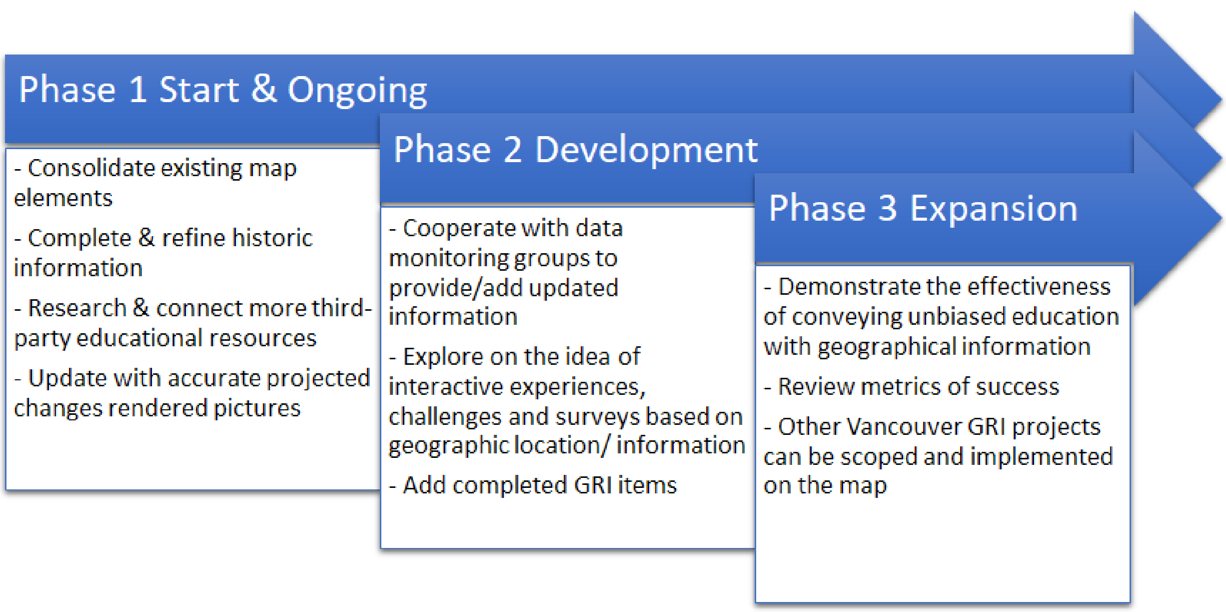


Figure 2.Three-phases implementation strategy for the interactive mapping campaign

5.4 - Limitations

With everything else being said, the interactive mapping campaign would still have flaws and limitations. Firstly, it requires sizable time and effort to create and constantly update geographic features and data. While some of the data can be imported from existing geographical databases onto the platform, it would still need dedicated staff to update and make sure the map is accurate and has real world connectivity. Secondly, despite large portions of the populus possessing computers and smartphones to interact with the mapping tool, the complexity of interactive maps restricts full engagement to those that are technologically literate. Thirdly, our resource is based on the internet, and thus cannot be accessed without a working internet connection. Compounding these issues is that, as a tool requiring self driven and voluntary interaction, the tool will be interacted with by only those passionate or interested in the St. George Rainway. This can be partially addressed by an effective use of signage and possibly a physical kiosk that hosts the program located at the completed Rainway to expand the tool's reach. In the future to help mitigate issues of becoming obsolete, further reviews and measurements of metrics of success should be done after each phase in our implementation strategy while this tool still has its potential to be upscaled and expanded upon in the near future. Despite these limitations, we are hopeful and confident that our proposed mapping tool will assist in public engagement and acceptance of the St. George Rainway.

Acknowledgements

This project was made possible by Julie McManus from the City of Vancouver Green Infrastructure Implementation and supervised by Dr. Tara Holland from the Faculty of Environment at Simon Fraser University.

References

Baptiste, A. K., Foley, C., & Smardon, R. (2015). Understanding urban neighborhood differences in willingness to implement green infrastructure measures: a case study of Syracuse, NY. *Landscape and Urban Planning*, *136*, 1–12. https://doi.org/10.1016/j.landurbplan.2014.11.012

Bartesaghi-Koc, C., Osmond, P., & Peters, A. (2020). Quantifying the seasonal cooling capacity of 'green infrastructure types' (GITs): An approach to assess and mitigate surface urban heat island in Sydney, Australia. *Landscape and Urban Planning*, *203*, 103893. https://doi.org/10.1016/j.landurbplan.2020.103893

Benedict, M. A., & McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable resources journal*, *20*(3), 12-17.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience*, *59*(11), 977–984. https://doi.org/10.1525/bio.2009.59.11.9

City of Philadelphia. (2018, December 12). *City of Philadelphia: Public Education*. https://www.phila.gov/water/educationoutreach/publiceducation/Pages/default.aspx

City of Surrey. (2019, December 11). *Biodiversity Conservation in Surrey | City of Surrey*. https://www.surrey.ca/vision-goals/biodiversity-conservation-strategy

City of Vancouver. (2019). *Rain City Strategy: A green rainwater infrastructure and rainwater management initiative.* Retrieved from: https://vancouver.ca/files/cov/rain-city-strategy.pdf

Crowell, A., & Schunn, C. (2016). Unpacking the relationship between science education and applied scientific literacy. *Research in Science Education, 64*, 129-140.

Davies, C., MacFarlane, R., McGloin, C., & Roe, M. (2006). Green infrastructure planning guide. Project: Final Report. Retrieved from https://www.researchgate.net/profile/Maggie_Roe/publication/265012095_GREEN_INFRASTRUCTURE_PLANNING_GUIDE_Authors/links/54f087a70cf24eb87940c8c1.pdf

Derkzen, M. L., van Teeffelen, A. J. A., & Verburg, P. H. (2017). Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? *Landscape and Urban Planning*, 157, 106–130. https://doi.org/10.1016/j.landurbplan.2016.05.027

Eisenman, T. S. (2013). Frederick Law Olmsted, green infrastructure, and the evolving city. *Journal of Planning History*, 12(4), 287-311.

Gregory J. (2020). Engaging with 'activists' and 'alternatives' in science communication. *Journal of Science Communication, 19*(6), 1-7.

Hart, P. S., & Nisbet, E. C. (2012). Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Communication Research, 39*(6), 701-723.

Hobbie, S. E., Finlay, J. C., Janke, B. D., Nidzgorski, D. A., Millet, D. B., & Baker, L. A. (2017). Contrasting nitrogen and phosphorus budgets in urban watersheds and implications for managing urban water pollution. *Proceedings of the National Academy of Sciences*, *114*(16), 4177–4182. https://doi.org/10.1073/pnas.1618536114

Jackson, L. E. (2003). The relationship of urban design to human health and condition. *Landscape and Urban Planning*, *64*(4), 191–200. https://doi.org/10.1016/S0169-2046(02)00230-X

Kim, D., & Song, S.-K. (2019). The Multifunctional Benefits of Green Infrastructure in Community Development: An Analytical Review Based on 447 Cases. *Sustainability*, *11*(14), 3917. https://doi.org/10.3390/su11143917

Kuo, F.E., Sullivan, W.C., Coley, R.L., & Brunson, L. (1998). Fertile ground for community: inner-city neighborhood common spaces. *American Journal of Community Psychology*, 26 (6), 823–851.

Mell, I. C. (2009, March). Can green infrastructure promote urban sustainability?. *In Proceedings of the institution of civil engineers-engineering sustainability* (Vol. 162, No. 1, pp. 23-34). Thomas Telford Ltd.

Mell, I. C. (2017). Green infrastructure: reflections on past, present and future praxis. *Landscape Research*, 42(2), 135-145.

Metro Vancouver. (2015). *Metro Facts in Focus | Policy Backgrounder - Green Infrastructure.* Retrieved from: http://www.metrovancouver.org/services/regional-planning/PlanningPublications/PolicyBackgrounder-GreenInfrastructure.pdf

Prudencio, L., & Null, S. E. (2017). Stormwater management and ecosystem services: A review. *Environmental Research Letters, 13*(3), 33002. https://doi.org/10.1088/1748-9326/aaa81a

Rigutto, C. (2017). The landscape of online visual communication of science. *Journal of Science Communication, 16*(2), 1-9.

Spicer, S. (2017). The nuts and bolts of evaluating science communication activities. *Seminars in Cell & Developmental Biology*, *70*, 17–25. https://doi.org/10.1016/j.semcdb.2017.08.026

The City of Portland. (2019, December 1). *Community Watershed Stewardship Program (CWSP) | The City of Portland, Oregon*. https://www.portlandoregon.gov/bes/43077

Thomas, K., & Littlewood, S. (2010). From green belts to green infrastructure? The evolution of a new concept in the emerging soft governance of spatial strategies. *Planning Practice & Research*, 25(2), 203-222.

Tolsma, K., & Hunter, P. (2020). Advancing a regional green infrastructure network in Metro Vancouver: Summary report. Adaptation to Climate Change Team, Simon Fraser University.

UCL. (2017, October 23). *Evaluation Toolkits and Guides*. UCL CULTURE. https://www.ucl.ac.uk/culture/projects/evaluation-toolkits-and-guides

US EPA, O. (2017, May 30). *Green Infrastructure in Parks Guide* [Reports and Assessments]. US EPA. https://www.epa.gov/nps/green-infrastructure-parks-guide

Wals, A. E. J., Brody, M., Dillon, J., & Stevenson R. B. (2014). Convergence between science and environmental education. *Science, 344*(6184), 583-584.

Zardo, L., Geneletti, D., Pérez-Soba, M., & Van Eupen, M. (2017). Estimating the cooling capacity of green infrastructures to support urban planning. *Ecosystem Services*, *26*, 225–235. https://doi.org/10.1016/j.ecoser.2017.06.016

Appendix A

Link to preliminary prototype: https://maphub.net/BrianTai/St.-George-GI/