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Green walls for sustainability: Challenges and opportunities for urban infrastructure development

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ABSTRACT OF THESIS submitted by:

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Increasing urbanization spurs a unique set of issues to the human being and their surrounding environment. Urban development attracts more population which creates congested cities with unsustainable land-use strategies. A balanced relation between the urban architecture and the natural environment is the key to sustainable city development (S. M. Sheweka and Mohamed 2012). In the quest of the exact solution, researchers developed the concept of green infrastructure (GI). One of the attractive features of the GI is its multifunctionality which provides benefits in several dimensions including the environmental, social, and economic (European Commission 2012). Among many GIs, green walls (GW) have gained the attention of the city planners and the stakeholders in recent years as a very attractive way of sustainable urban designing. Because of its vertical structure, GWs bring added advantage in congested city greening. Instead of being widely known and appreciated for its benefits, GWs development faces many challenges and remains slow in most of the European countries. This study aims to find out the challenges and potential opportunities for GW development. For a detailed analysis, this research investigates GW development in Geneva, Switzerland as a case study. This allows the research to do an extensive analysis of the GW development and plays as a trade-off game between an in-depth study in a city versus the wider study in the European scale. The findings highlighted the lack of targeted policy and limited knowledge among the citizens as the major challenge and propose policy reforms focusing on GW development.

Keywords: Urbanization, population growth, green infrastructure, green wall, ecosystem services, Geneva, Europe

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Dedication

To my husband, Devdatta who has been a constant source of practical and emotional support and encouragement. He walked the long journey with me without which I couldn't have done this. And to my mother whose unconditional love supported me in every way.

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List of Abbreviations

UN:	United Nations	
EEA:	European Environment Agency	
JRC:	Joint Research Centre	
OECD:	Organization for Economic Co-operation and Development	
GI:	Green Infrastructure	
GW:	Green Wall	
ES:	Ecosystem Service	
UNOG:	United Nations Office in Geneva	
FOEN:	Federal Office for the Environment	
SEVE:	Greenspace Services (Service des Espaces Verts)	
VVS:	Vertical Vegetation System	
VGS:	Vertical Greening System	
UK-GBC:	UK Green Building Council	
ALW:	Active Living Wall	
SD:	Sustainable Development	
WCED:	World Council on Environment and Development	
PM:	Particulate Matter	
PM ₁ :	Particulate Matter with diameter less than 1 micron	
PM ₁₀ :	Particulate Matter with diameter less than 10 micron	
UHI:	Urban Heat Island	
SDG:	Sustainable Development Goals	
HEPIA:	High School of Landscape, Engineering and Architecture of Geneva (Haute	
	École du paysage, d'ingénierie et d'architecture de Genève)	
IDA:	International Development Association	
CHF:	Confoederatio Helvetica Franc (Swiss Franc)	
IPCC:	Intergovernmental Panel on Climate Change	
ETHZ:	Swiss Federal Institute of Technology in Zurich (Eidgenössische Technische	
	Hochschule Zürich)	
ARE:	Federal Office for Spatial Development	
UAC:	Unit for Community Action (Unité d'Action Communautaire)	
EPA:	Environmental Protection Act	
SBS:	Swiss Biodiversity Strategy	
OAPC:	Air pollution Control Ordinance	
NAO:	Noise Abatement Ordinance	
SPA:	Spatial Planning Act	
EU:	European Union	
CEU:	Central European University	
GDP:	Gross Domestic Product	
NGO:	Non-Governmental Organization	
USD:	United States Dollar	

1. Introduction

1.1. Green infrastructure and urbanization: an overview

Worldwide, urbanization is an inevitable process because of technological advances and increasing population. Since 2007 more than half of the world population lives in urban areas, and nearly 70% of the total world population is projected to live in urban areas by 2050 (United Nations 2013). This figure will probably increase as we proceed further into the future. As a result, urban areas are constantly evolving due to population growth and socioeconomic changes (Taylor n.d.). This creates a major impact on the environment with increasing grey structures and decreasing green space (Haaland and van den Bosch 2015).

Besides climate change, one of the greatest problems is this urban densification that results in the reduction of green spaces within cities (Jim 2004). Where urban sprawl is the flip side of the urban densification, researchers have argued that urban sprawl poses many threats to cities and their environment for its unsustainable land-use strategies (Allah Yar n.d.; Wilson and Chakraborty 2013; EEA and JRC 2006). Urban densification also brings the concept of compact city approach which has gained global attention in the last few years as a solution to urban sprawl (Haaland and van den Bosch 2015). The compact city concept has the potential to produce solution to urban densification with its sustainable land-use component (Kotharkar, Bahadure, and Vyas 2012). A compact city facilitates "*sustainable transportation*" with lesser travel distance, "*sustainable social cohesion*" with developed social culture, and "*sustainable economic viability*" with dense and proximate development pattern (Kotharkar, Bahadure, and Vyas 2012). As urban growth is increasing there is increasing need for sustainable city development and sustainable land-use strategies which can be achieved by the compact city approach. However, the implementation of the compact city concept suffers from major challenges while provisioning green space (Haaland and van den Bosch 2015). Urban green

space planning and management is one of the important issue in city development as it provides essential benefits to the citizens and the local environment (Anguluri and Narayanan 2017; Rasidi, Jamirsah, and Said 2012). Proper planning for green space incorporation is hence a necessity in urban sustainability.

Grafius (2018) proposed that the relationship between urban green space ecosystem services and urban form can be used in sustainable urban planning and designing practices (Grafius, Corstanje, and Harris 2018). Jenks and Jones (2010) argued that urban sustainability and urban forms are linked and proper urban forms are a tool to achieve sustainability (Jenks and Jones 2010); whereas Dempsey defined urban form as the physical characteristics of a city which includes the building patterns, facades, urban block layout, and distribution of green space (Dempsey et al. 2010). The urban forms are important features of urban areas and contributes to urban sustainability and human behaviour (Dempsey et al. 2010). Designing cities or urban areas hence is a very attractive and potential adaptive measure to tackle the urban densification and shortage of green space.

Increasing city green space within city greys' is one of the most effective and adaptive way to create a sustainable and resilient city as urban green spaces provide essential benefits to citizens and their surrounding environment (Haaland and van den Bosch 2015; Tzoulas et al. 2007). Urban green space also offer habitat for many species which increases biodiversity (Goddard, Dougill, and Benton 2009), contribute to air purification and temperature control (Bell, Morgenstern, and Harrington 2011; Bowler et al. 2010), regulate storm water (Zhang et al. 2012), provide carbon storage (Davies et al. 2011), increase aesthetic value, human-nature interaction, and social interaction (Pauleit 2003). The ecosystem services provided by urban green space is therefore countless and are crucial to achieve sustainability (Haaland and van den Bosch 2015). One of the sustainable ways to introduce urban green spaces in cities is the

application of the green infrastructures (GI) within the grey urban areas (Dhakal and Chevalier 2017).

Green infrastructure as defined by the European Union is "*a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of eco-system services and protect biodiversity in rural and urban settings*" (European Commission 2013a). GI provides a wide variety of benefits to human beings. Multifaceted benefits of GI include protection of vegetation and soil, restoration of hydro-ecological processes, and increasing biodiversity (James et al. 2009; Pauleit 2003; Tzoulas et al. 2007). GI also has a potential for reducing the heat-island effect, surface water run-off, and climate change adaptation with numerous sustainability benefits (Dhakal and Chevalier 2017; Pauleit 2003).

Despite of these widely known and accepted benefits, however GI implementation remains slow (James et al. 2009; Kasanko et al. 2006). Instead, grey infrastructure is predominant in most cities all over the world (Luis Pérez-Urrestarazu et al. 2015). Hence, there remains a major gap between the knowledge about the benefits of GI and its implementation in cities.

One of the very attractive GI is green walls (GW) or vertical vegetation, or vertical gardens. GW is a structure where walls of urban grey structures are covered with vegetation (Luis Pérez-Urrestarazu et al. 2015). It could be applied both on the external and internal walls of buildings depending on the type of green wall. GW has been believed to has its origin in 1930s when Stanley Hart White, a landscape architect at the University of Illinois introduced the idea of GWs (Hindle 2012). By now many researchers reported GW benefits on urban high-rise buildings (Gabriel Perez, Lidia Rincon, Anna Vila, Josep M. Gonzalez 2011; Jim and He 2011; Othman and Sahidin 2016; Davis et al. 2017). Başdoğan and Çiğ (2016) argued that green walls help provide a balanced urban ecology and enhance urban quality of life in addition to the creation of new job opportunities (Başdoğan and Çiğ 2016). GW also has the potential for microclimate control, temperature reduction (Elgizawy 2016), and noise reduction (Azkorra et al. 2015). GW provides a wider range of ecosystem services (ES) as described above with the added benefits of energy conservation to the buildings and an opportunity of direct interaction between humans and nature (S. Sheweka, Magdy, and Magdy 2011). In addition to all these benefits, green walls also have significant effect on stress reduction and positive psychological impact on people (Bringslimark, Hartig, and Patil 2009). With all the high-rise buildings in most of the urban areas, green walls could cover a larger surface area than any other forms of green space with probable potential of increased benefits (Haaland and van den Bosch 2015). GW application in cities are influenced by different national and regional policies (Irga et al. 2017; European Commission 2013a, 2013b). These policies which are mainly focused on green infrastructure development and increasing city green space, play a crucial role in forming the barriers and the probable drivers for GW application (Andreucci 2013). This research aims to study the knowledge gap in green wall development from policy and socio-cultural perspective and to identify the challenges and opportunities related green wall application in cities.

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Cities could have very different development trajectories and land use patterns, and this is true for European cities (James et al. 2009). European cities are among the most suffered cities in the world in respect to loss of green space, habitat fragmentation, and ecosystem health (Andreucci 2013). The problem is more significant in Southern European cities than in Northern European cities (Kabisch et al. 2016). Highly densified urban fabric and lack of conventional greens (city parks and public gardens) are among the many factors which are responsible for the loss of green spaces in cities (Virtudes and Manso 2016). The problem also remains in the quantity versus the quality issue where the shortage of private green spaces barely offsets the benefits of increasing public green spaces (Haaland and van den Bosch 2015) which creates urban green space and environmental inequalities (Wüstemann, Kalisch, and Kolbe 2017). Hence, designing urban areas and addressing the loss of green space is one of the major challenges in European cities (Haaland and van den Bosch 2015). Therefore, innovative strategies to introduce green space in cities is very important for sustainable city development. In regard to this, application of green walls is one among the many steps towards urban sustainability.

As mentioned above, European cities have different land-use patterns and development strategies which creates different political and sociological perspective for green space and hence green wall development. Studying the green wall application in Europe is therefore a challenge and might not be the best choice as this will provide a wider sense of the barriers and enablers but will lack the in-depth understanding. Instead, researching on green wall implementation in one city will provide the opportunity for an in-depth analysis of the existing issues and possibilities.

Among the many major European cities, Geneva is leading in terms of its political and economic importance. Geneva hosts nearly twenty international organizations including the United Nations Office in Geneva (UNOG) and the International Red Cross Committee (Ville de Genève n.d.). It also has more than a hundred international banks and the world's leading watch producing companies and possesses a strong "network of intellectual and economic" relation with the rest of the Europe and other continents (Maurice Cranston 2018). Given its political and economic stature, Geneva is an ideal place for a sustainable city movement. The Federal government of Switzerland and the city administration of Geneva are committed to sustainable development by protecting the green spaces in the city and in surrounding rural areas (Federal Office for the Environment 2013; Federal Office for the Environment 2017;

République et canton de Genève 2013). This makes Geneva an ideal city to study green wall development.

Geneva is the second largest city in Switzerland and is one of the greenest cities in Europe with more than 20% of the land area covered by green space (Service des espaces verts n.d.). Ville de Genève is the municipal administration of the city which acts through the department named as the greenspace services (*service des espaces verts* (SEVE)) for green space creation and maintenance within Geneva. SEVE works under the auspices of the department of urban environment and security (*département de l'environnement urbain et de la sécurité*), City of Geneva (*Ville de Genève*) (Service des espaces verts n.d.). The political and economic importance of the city enables opportunity for green wall development and ensures sustainable market for stakeholders and financiers. Despite its potential, Geneva lags far behind its European counterparts in GW development. Hence, there is a strong need to analyse the causes for lack of green wall development in Geneva. This research aims to study these causes while focusing on the policies underpinning green space development and discovering how these policies affect green wall development. This study also intends to find out the potential enablers and suggests recommendations for green wall cultivation.

1.2. Research objective

To study and understand how the policy and governance enables or hinders urban sustainability through the development of green walls, with specific attention to the city of Geneva. To investigate the challenges and opportunities for green wall development in cities, in order to find the gaps in urban greening policies and subsequently recommend potential possibilities to enhance vertical greening focusing on the city of Geneva.

1.3. Research question

- What is the role of national and local policies in enabling or hindering GW development in European cities, with emphasis on Geneva, Switzerland?
- What is the status of GW development in the city?
- How could urban policy contribute to advancing the development of GWs to a new level?

1.4. Research scope

This work is concerned with the application of green wall in European cities. The possibilities vary widely among different cities based on their political, geographical, and financial conditions. While it is interesting to find out the challenges and opportunities for green wall application in the European scale, this study only focuses on Geneva, Switzerland. As discussed before choosing Geneva as a case study for this research plays a trade-off game between the wider European perspective and the in-depth analysis. Geneva has been chosen because it has huge potential of green wall development considering its attractive political and financial market. Despite these huge possibilities the city has very few numbers of green walls. The motivation behind this study is to find out the gap between the knowledge and practice. The research aims to provide clarity on political impacts of green wall application in cities, especially in Swiss context. The research and its conclusion are addressed towards a wide-ranging audience from academia to urban planning and decision makers and other readers interested in urban development discourse.

1.5. Disposition

This thesis is organised into 3 chapters along with Introduction and Conclusion and Recommendation. Chapter I or the Literature Review chapter provides the state of the art with

explanations of the concept of green walls and their relation to sustainability. Literature Review chapter also provides the details of the Swiss green space development and the policy and regulatory instrument related to it. Chapter II is the Methodology chapter which describes the methods adopted for the research and data collection. Chapter III is the Results and Discussion chapter which gives the detailed description of the challenges and opportunities and answers the research questions. This thesis ends with Conclusions and Recommendations including possible policy pathways and future research.

2. Literature review

This chapter details the state of the art of green wall development incorporating the newest ideas and features. The chapter starts with detailing the concept of green wall and its contribution to sustainability and how green wall has been developed and grown in swiss market. The chapter also gives the details of the swiss green space policies and how it could lead to sustainable development in the country.

The literature review was a part of the methodology which was adapted to answer the research question for this study. Literature search generated only few articles (three) which specified the green space governance and development in Geneva (Nikolaidou et al. 2016; Tappert, Klöti, and Drilling 2018; Brenneisen 2006) but these articles do not specify on green wall application in Swiss cities. It could be concluded that there is a major gap of knowledge in the literature-both academic and grey on swiss green wall development which makes this study very significant to the decision-makers, researchers, as well as to the stakeholders of the Swiss green wall market.

Literature survey also includes researching on the national and local policy documents. Because of the gap in research articles about swiss green walls, this research was very dependent on the national and regional policy documents. After reviewing many national and regional policy documents (14), 9 of them were found to be the most relevant for the current study. The list of these documents could be found in appendix E. As reviewing the research articles about Switzerland did not provide profuse information about Geneva the search was expanded from only Geneva to the whole Switzerland which gave a broader image and helped to identify important themes and ideas which shaped the interview questions and protocols, the crucial part of the research methodology.

Before giving the details of the swiss green space policies and how it effects and shapes the sustainability agenda, it is pertinent to explain the benefits of green wall and its connection to sustainability. This will provide an insight on green walls and their potential benefits on human life and will help to understand the probable enablers and barriers for green wall development in Geneva.

2.1. The concept of green wall

Green wall or vertical vegetation system (VVS) or vertical greening system (VGS), or sometimes called as bio-wall is spreading of vegetation or plants on the building exterior or interior wall. These structures can or cannot be attached mechanically to the building walls depending on the construction and type of green wall (Luis Pérez-Urrestarazu et al. 2015). Green walls have different typologies depending on the structural complexity, design, vegetation type, and support structure. The major divisions are of two types: green façades and living walls. Green facades are the structures where plants which are rooted to ground climbs or cascades on building walls. The rooting system could be some plant boxes or some intermediate planters. Green facades are the simplest structured green walls. The plants used are of less biologically diversified and need very low maintenance and protection. The living wall system, on the other hand is comparatively complex and needs extensive maintenance. The design is based on some supporting structures and different attachment methods. Usually the structure is based on cloth (or felt) or panel (or box). The growing medium remains inside the pocket on the cloth or panel and could be made of organic or inorganic materials with added mineral nutrients. A mandatory irrigation system with optional fertigation, monitoring, and lighting system is necessary for living walls to sustain. The system also need a waterproof backing to save the building walls from the dampness of the wet plants and growing medium.

The irrigation system in the green walls are the most crucial part of the overall design. Green walls cannot sustain without a proper irrigation system. Usually irrigation systems are of two types namely, direct irrigation and recycled irrigation (Ambius 2018). In the indirect irrigation system, plants are connected to a direct water source. The water goes through the walls and the remaining water usually goes to the drainage system. In recycled irrigation system, the plants are connected with a recycled water system. The water flows through the plants and is collected at the bottom and then pumped again to keep the plants moist.



Figure 1: Green wall with irrigation system. Image source Furbish and Green Wall LLC

Another type of new living wall design is the hydroponic system where the plant doesn't grow on soil, instead it uses water and added nutrients for growth.



Figure 2: Gomes luxury vertical garden design. © Gomes-Design

The plant types in living wall systems could be of wide varieties. This depends on the climatic condition of the place, micro-climate, sun exposure, wall architecture, and irrigation and cultivation system. Some of the living walls have epiphytic plants while some have lithophytes. Epiphytes are a type of plant which grows on another plant or any supporting structure. They

depend on the air, rain or any other water source, and organic debris for nutrition (Melissa Petruzzello n.d.). Whereas lithophytes are a type of plant which grows on rocks or stones and derive their necessary nutrients from atmosphere, rain, or nearby dead plants. Epiphytes are very common for the living walls to have. The HortPark of Singapore is one such example with a living wall with epiphytic plants including vines (*Rhaphidophora tetrasperma* and *Monstera deliciosa*), orchid (*Vanilla planifolia* and *Vanda Miss joaquim*), creepers (*Hoya carnosa compacta, Hoya obovata, Rhaphidophora korthalsii*), ferns (*Nephrolepis spp, Adiantum spp, Polypodium*), and cactus (*Epiphylum oxypetalum*) (Elmich Pte Ltd 2015).

The plant selection also is dependent on the desired outcomes of the green wall projects and thus could be very tricky sometimes (Growing green guide n.d.). Some plants have greater aesthetic values for landscape designing, some have high drought tolerance, some have air and water purification potential, where some have high biodiversity value. The Westfield shopping center in West London has a living wall which was developed to illustrate the potential of a living wall in increasing the biodiversity in a small limited space within the city greys (UK-GBC biodiversity task group 2009).



Figure 3: Living wall in Westfield shopping center. ©ANS Global

One of the many experiments to living walls is to build them with ornamental and edible plants. Weinsmaster (2009) reported successful experiments of planting edible herbs (strawberry, thyme, lettuce) to create green walls (Weinmaster 2009). Some places in Australia also have reported to have Chinese cabbage (*Brassica rapa*), spinach (*Spinacia oleracea*), lettuce (*Lettuce sativa*), chili (*Apsicum spp*), and many more edible plants (Wall Garden n.d.).



Figure 4: Tomato, leek, strawberry, and cucumber in a living wall. ©URBANplanter

Indoor living walls are very similar to the outdoor ones excluding that the plant species are different as their exposure to the sun and wind will be very limited for most of the cases.

Excluding these two major classes, some researchers have worked on some intermediate green walls and named them as green screens (pre-grown on steel framework), live curtains (planted in planter box with hydroponic system), and urban hedges (interchangeable between green façade and living wall because of their features and ecosystem services) (Staffordshire University n.d.).

The final type of green wall is the "active living wall" (ALW), which acts as an active biofilter. An air current is forced through the wall and collected afterwards. This produces a clean, fresh, and cooled air (L. Pérez-Urrestarazu et al. 2016; Luis Pérez-Urrestarazu et al. 2015).



Figure 5: Fig E: Different types of vertical vegetation system. Image source (Luis Pérez-Urrestarazu, Fernández-Cañero, Franco-Salas, and Egea 2015)

2.2. Green wall and sustainability

Sustainable development (SD) is the term which was developed with the belief that human and nature can coexist in harmony. World Commission on Environment and Development (WCED) (1987) defined SD as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". Sustainability is the conception which grew out of SD with the realization that the environmental crisis caused by anthropogenic activities are escalating the degradation of our natural environment as well as the future human

wellbeing. The only solution remains within the prospering nature. In an urban context, high economic and social development creates a huge barrier for nature to flourish. The land use pattern and patches of isolated green spaces create a huge pressure on the natural ecosystem (Ranjha n.d.; Hodgson et al. 2009; Grimm et al. 2008). Increasing green spaces within the cities to improve its landscape pattern makes the city resilient and sustainable to adapt and mitigate the inevitable effect of climate change (Adhya, Plowright, and Stevens 2010; Adams 2006).

Sustainability is concerned with maintaining the delicate balance between environmental protection and urbanism (Rosenzweig 2003). And, green wall is one among the many creative approaches for maintaining the balance with its sustainable designing features. It offers benefits in all the three dimensions of urban sustainability as described in table

Social Dimension	Social interaction, aesthetics, human-nature interaction, education, health effects, and job creation (S. Sheweka, Magdy, and Magdy 2011)
Environmental Dimension	Nature conservation, increasing biodiversity, air purification, humidification, air cooling, reduction of urban-heat-island effect, carbon sequestration, and noise reduction (Elgizawy 2016)
Economic Dimension	Rain water management, energy savings, increasing property value, food production, and tourism (Dhakal and Chevalier 2017; European Commission 2013b, 2013a).

Table 1: Benefits of green wall in different sustainability dimensions

Reconciliation ecology is the science of creating and maintaining habitats and species diversity in places where people live and work (Luis Pérez-Urrestarazu et al. 2015). The aim is to modify the urban areas where people live and dwell to support greater range of species habitats (S. Sheweka, Magdy, and Magdy 2011). Green walls are a good example of reconciliation ecology as it creates plant and animal diversity within close proximity to human habitats. This also

provides the opportunity for a human-nature interaction which has been proved to have a positive effect on human physical and mental health (Weerakkody et al. 2017).



Figure 6: Benefits of green wall. Infographic by author ©2018, template: Venngage

Green walls also have considerable potential for particulate matter (PM) absorption from the atmosphere. Weerakkody (2017) showed that a collection of different species of plants in a green wall can act as an atmospheric PM filter by absorbing many particulate matters starting from PM₁ to PM₁₀ (Othman and Sahidin 2016; Jaafar et al. 2013).



Figure 7: The effects of air pollution on human lives. Image source: The World Bank 2016

Another positive impact of having green wall is air temperature regulation. Green walls have reported to reduce building air temperature in hot summer in tropical climate (Jaenicke et al. 2015) as well as in temperate climate (Rakhshandehroo et al. 2016; Luis Pérez-Urrestarazu et al. 2015; S. M. Sheweka and Mohamed 2012). It also reduces urban-heat-island (UHI) effects significantly (Yeh n.d.; Dalit Bielaz Sclar 2013). The shading from the leaves and the evapotranspiration from the plants help in controlling the UHI effect (Mohajerani, Bakaric, and Jeffrey-Bailey 2017; S. M. Sheweka and Mohamed 2012).

Urban heat island (UHI) effect is a global issue which threatens the habitability of the urban areas. It is the phenomenon by which the temperature of any urban region remains higher in comparison to the country side that directly surrounds the urban area (Santamouris 2013). The

temperature difference between the urban and surrounding area has been reported to be 5-15 °C (Stone, Hess, and Frumkin 2010). This temperature difference is the result of the urbanism which caused deforestation, less greeneries, reduction in evapotranspiration, low albedo, and anthropogenic heat generation (Yamamoto 2006).



Figure 8: Urban heat island effect. Image sourced from (Akbari et al. n.d.)



Figure 9: variations of surface and atmospheric temperature. Image sourced from (Akbari et al. n.d.)



Figure 10: Benefits of green walls. Image source Gretchencraig 2013

Green walls also contribute in building energy savings. The energy saving potential has mostly been studied in hot climates, where it has shown to reduce the electricity bills significantly. Researchers have studied and modeled the potential of green walls in energy savings and found it to be very effective (Perez et al. 2014; Grabowiecki et al. 2017; Gabriel Perez, Lidia Rincon, Anna Vila, Josep M. Gonzalez 2011; Wong et al. 2009).

Green walls can also be used as an innovative method for urban farming and can be used to reduce the pressure on conventional rural farming (Santo, Palmer, and Kim 2016; Marc Hernandez and Rosemary Manu 2018). United Nations (UN) Sustainable Development Goals (SDGs) highlight the importance of agriculture and sustainable city in SDG target 11.3 and researchers have argued that integrating urban farming in growing cities is one of the way to achieve the target (Marc Hernandez and Rosemary Manu 2018). Urban farming through green

walls also helps in access to food (SDG 10), food system resilience in case of need (SDG 11.6,

13.2) with increasing city green space and improved air quality (SDG 11.6, 11.7). Development

of green walls also contribute to achieve other SDGs and their targets. A detailed list has been

given in table 2.

SDG 3: Healthy lives and promote wellbeing	Green walls reduce air pollution and improve air quality. It also helps to control the	
	microclimate and the humidity which	
	supports healthier and productive lives.	
SDG 8: Productive environment and decent	Green walls create new jobs and help in	
work	economic growth. The life cycle of a green	
	wall from conceptualization to	
	decommissioning needs expertise from a	
	wide variety of people and provide	
	opportunities for an inclusive employment.	
SDG 9: Resilient infrastructure and	Green wall promotes resilient and innovative	
innovation	infrastructure development with its	
	sustainable features.	
SDG 11: Resilient and sustainable cities	Single green walls can have a small effect on	
	city resilience but when applied in larger	
	scale it helps in making cities resilient and	
	sustainable.	
SDG 13: Climate action	Green walls do not have a major impact on	
	climate change resilience because of the	
	scale. But it can contribute in removing CO ₂	
	and other pollutants from air which is the key	
	factor for global warming.	
SDG 15: Life on earth	Green walls promote biodiversity in local	
	scale.	

Table 2: Green walls' contribution in Sustainable Development Goals

Green walls have been identified as an intrinsic nature-based solution (NBS) to improve the biodiversity at local and regional level and is already in practice in many European cities (Enzi et al. 2017). Large green walls have the potential to significantly contribute in city resilience and wellbeing of the citizens. A living wall of 850m² in Vienna, Austria has reported to produce cooling effects on building equal to 80 air conditioning units with 3000 watts and 8 hours operating period (712 kWh) with O₂ production for 40 people per day (Scharf, Pitha, and Oberarzbacher 2012; Enzi et al. 2017).

2.4. Swiss green space and green wall development

Switzerland has huge potential for green wall development and expansion. The country has only 30% of its land area as human livable space (European Climate Adaptation Platform 2015). Most of the land is covered with high mountains, forests, and rivers. With this small area to provide adequate space for all the needs including housing, office, industry, transportation, leisure, and agriculture, the pressure on nature is very high. The National government is well aware of the situation and is very active on keeping the cities green. Most of the swiss cities have very high proportion of green spaces compared to most of the other European cities. But, as the cities are growing in terms of population and infrastructures, there is increasing need for more greeneries. Green wall is one among the very attractive green space choices for congested cities as it doesn't need any land coverage. Swiss cities have large parks, gardens, private gardens, vegetable farms, and many other green space types but are lagging far behind in green wall development from the other countries in Europe. The country has few green walls (200+), most of which are indoor ones. Some cities in Switzerland like Zurich are more developed in green walls than other Swiss cities. Most of the green wall companies are based in Zurich which might be the reason of the city having more green walls than others. Some Swiss cities are like Basel doesn't have plenty of green walls but has the largest area of green roofs per capita in the world (Hydroplant 2018).

The concept of green wall started developing in Switzerland in the beginning of 1970s (Bartschi et al. 2012). The technology used to build green wall at the beginning was very poor and didn't survive for long. From 1970s to 2018, the country went through significant growth in the technology and had attracted attention of many green wall investors and experts. Since then the Swiss green wall market is growing very slowly. Currently, Switzerland has few green wall manufacturing companies (Appendix D) who are continuously investing in developing new

user friendly, easy to handle, and long-lasting technologies to create a more attractive green wall market in the country. One of the many recent design strategies is the green wall with easy plant replacement system. This technology has been invented by Gomes-Design, one of the leading green wall manufacturing companies in Switzerland. They claim this design to be a "consumer product" where the maintenance doesn't need any expertise and is easy to regulate (Gomes-Design 2018).

Excluding these privately-owned companies, green wall development has recently gained attention from many academic researchers. High School of Landscape, Engineering and Architecture of Geneva (*Haute École du paysage, d'ingénierie et d'architecture de Genève* or HEPIA) is a leading architecture institute in Geneva. Few researchers from HEPIA along with a green wall manufacturing company, Skyflor developed a green wall in 2013 in the city as an experimental study. The project was funded from the public fund granted by the government to study the potential of green walls as a passive acoustic insulation system. The study resulted in a successful application of green wall in the city of Geneva. The detail of the study can be found in Appendix G. With all these development and introduction of new and innovative technologies, the Swiss market for green wall is expected to grow in near future.

2.5. Climate change and sustainable development in Switzerland

Switzerland is one among the many countries in the world which is suffering significantly in biodiversity and species conservation due to its fragile ecosystem and extensive land-use strategies for agriculture and infrastructure development (Swiss Spatial Planning Association
2012). Figure 11 illustrates the key challenges for climate change adaptation in Switzerland in different sectors.



Figure 11: The key challenges in climate change adaptation in Switzerland. Adapted from IDA Climate 2012

Among the challenges stated above, the greater heat stress in agglomeration and cities, increasing levels of summer drought, greater risk of flooding, rising snowline, impaired water and air quality, change in habitats, species composition and landscapes can be directly linked to urban green space development and can be solved with the application of more green spaces in the cities. Most of the green wall installation in cities are in small scale and has low direct impact on climate change adaptation and city resilience. On the other hand, GWs have significant effect on the UHI, air quality, rain water management, and habitat creation in local level (Xing, Jones, and Donnison 2017) and hence is very important to consider as a potential urban green space in sustainable city development.

As the average temperature in the cities are increasing due the effects of climate change and global warming, the heat stress and heatwaves are like to become longer, frequent, and intensive (Interdepartmental Committee on Climate (IDA Climate) 2012). Geneva is among the many cities in Switzerland where the heatwaves are having most affects. Figure 12 shows the most affected areas in Switzerland due to heat stress.



Figure 12: Most affected areas in Switzerland due to heat stress. Image source: IDA Climate 2012

According to the IDA Climate report (2012), the heat stress can be broken by the effective construction of the ecological infrastructure where urban greens can create open spaces for good air circulation, contribute in cooling through evapotranspiration and evaporation which also helps to reduce the health risks. Changing climate also effecting the precipitation pattern causing frequent summer drought which is predicted to be longer in future. The change in precipitation pattern also is expected to cause frequent winter flooding in whole of Switzerland. GWs do not directly reduce the flood risk, but it can reduce the flow of rain water to the ground and help in storm water management. The city of London has recently developed a green wall designed by Gary Grant from the Green Infrastructure Consultancy. The wall is 21m high with 10,000 plants and is expected to reduce surface water flooding with its rain water harvesting system (Andrews 2013).

Heat stress is also creating pressure on the fresh water resources of the country. Most of part of Switzerland is dependent on the ground water as their fresh water source; whereas the city of

Geneva is mostly dependent on the Lake Geneva. Increasing temperature is causing quick evaporation from the inland water streams, lake, and other water sources. This increases the concentration of the pollutants present in the water. This water again when infiltrates and reaches the ground water, contaminates the main water source of the country. The high amount of precipitation in winter is also resulting in higher soil erosion which removes the top soil that enhances the nutrient leaching in inland and ground water (Interdepartmental Committee on Climate (IDA Climate) 2012). Overall, the increasing heat stress is severely degrading the environmental condition of the country making it more vulnerable to climate change effects.

The possible causes for the air quality impairment are the probable increase in high pressure areas (Interdepartmental Committee on Climate (IDA Climate) 2012) and increase in motor vehicles on the roads.

The biodiversity, habitat change or fragmentation, and the change in species composition are the most affected sectors in Switzerland due to climate change and global warming. The distribution of animals and plants in their natural habitats varies depending on the climatic condition of a place. Once the climate change has significant effect it can drastically reduce the number of species in the country. The IDA Climate (2012) has projected decline in the local plant species, loss of habitats, and change in species composition (Interdepartmental Committee on Climate (IDA Climate) 2012). This will have significant negative effects on the ecosystem services provided by different species. GW production in larger scale is a potential solution to these effects as GW can save some species locally and can help to restore the value of ecosystem services they provide (Collins, Schaafsma, and Hudson 2017).

The pressure produces from the climate change acts as a driver for Switzerland which leads the country towards sustainable development. The country earns every second franc (Swiss

currency CHF) abroad and manages nearly one-third of global wealth. The country also consumes natural resources to a scale of about thrice it produces nationally. All these creates a strong interdependence between Switzerland and the rest of the world which makes the sustainable development as a "*commensurate responsibility*" (Bartschi et al. 2012) and the country is expected to respond more in coming days. Climate change and SD shares a "*dual relationship*" (IPCC 2007) where SD works hand-in-hand with climate policies resulting in a better socio-economic development. Climate policies focusing on increasing green infrastructures (including green walls) is thus one among many approaches to achieve urban sustainability (European Commission 2013a). Hence, green wall introduction in larger scale could be one of the foremost agendas for Switzerland to contribute in SD. However, GW development in Geneva faces considerable challenges while implementation. Table 3 highlights key barriers and enablers for GW development in cities.

Barriers	Economic	Perception of higher cost				
	Social	Confronting developers, Skepticism about long-term				
		performance				
	Governance, policy,	Confronting municipalities, resistance within				
	and management	regulatory committee				
	Technical	Design challenges, perception of unknown				
		performance				
	Environmental	Weather and climatic conditions				
Enablers	Economic	Public-private budget				
	Social	Education, awareness				
	Governance, policy,	Law, regulatory instruments				
	and management					
	Technical	Advanced engineering skills				
	Environmental	Ecosystem services				

Table 3: Barriers	and enablers	for GW development

2.6. Swiss green space policy and planning

The benefits of green wall, as discussed earlier contribute to sustainability and resilience of cities (Tedesco, Giordano, and Montacchini 2016). Therefore, the policies and laws that specify

on sustainable city development affect the implementation and growth of green walls. Some European cities have defined laws for GI development. Geneva, on the other hand was found to have no laws or policies which directly focus on GI application in the city. Hence, the literature search has been extended from only GI development to SD policies that affect the city green space development. This has helped to find out some important regulatory instruments which have significant potential to enhance the growth of GW in the city.

Switzerland is one amongst the many European countries which keeps sustainable development as a priority for its land-use strategies and spatial planning for cities (Bartschi et al. 2012; ARE and ETHZ 2008). Efficient infrastructure, economical land-use, and protection of biodiversity are the top most priorities for Swiss spatial planning. The Swiss administration is very sensitive about the effects climate change (Bartschi et al. 2012) on biodiversity because of its intensive land use for agricultural and modern infrastructure development (Luis Pérez-Urrestarazu et al. 2015). The Federal Constitution of the Swiss Confederation¹ was developed aiming to implement the measurement for sustainable development throughout the country (Federal Constitution of the Swiss Confederation 1999). The Federal Office for Spatial Development (ARE)² is responsible for the spatial planning and sustainable development along with the cantons, cities, and municipalities (Federal Office for Spatial Development (ARE) n.d.; Tappert, Klöti, and Drilling 2018).

Geneva, as discussed above is one of the political and economic center for the country which attracts more inhabitants every day (Tappert, Klöti, and Drilling 2018). This creates a major imbalance between the number of job opportunities available and the housing options (Tappert,

¹ Federal Constitution of the Swiss Confederation: The Federal Constitution of the Swiss Confederation was adopted in 18th April 1999. It aims to protect the liberty and right of people, promote SD, and is committed to preserve the natural resource (Federal Constitution of the Swiss Confederation 1999).

² Federal Office for Spatial Development (ARE): ARE is the federal government's specialist authority responsible for spatial development, mobility, and sustainable development (The Federal Council n.d.).

Klöti, and Drilling 2018; Nikolaidou et al. 2016), putting pressure on the housing sector for new construction and densification of the existing housing areas (Nikolaidou et al. 2016). To answer this, the city has created a very strong urban planning strategy, Geneva 2020: A Communal plan for the city of Geneva for sustainable renewal of the city-center (GENEVE 2020: Plan directeur communal de la Ville de Genève, Renouvellement durable d'une ville*centre*)³ which aims to integrate green space within the urban structures (Quincerot and Weil 2009). This strategy introduced small scale urban gardens locally called as vegetable gardens (*jardin potagers*)⁴ which are mostly small private or public gardens. The city has both the topdown and bottom-up initiatives which support the small scale garden actions (Nikolaidou et al. The bottom-up approach is the most popular approach as it includes citizens' 2016). participation in the gardening initiative to meet the needs of the inhabitants (Quincerot and Weil 2009). The top-down approach involves several municipal administrative departments including the Unit for Community Action (UAC: Unité d'Action Communautaire) which acts under the Department of Social Cohesion (Département de la Cohésion Sociale), Greenspace services (SEVE: Service des espaces verts) which acts under the Department of urban environment and security (Département de l'environnement urbain et de la sécurité), Municipal property management (Gérance immobilière municipal) which acts under the Department of finance and housing (Département des finances et du logement), Department of construction and development (Département des constructions et de l'aménagement), and the Service agenda 21: Sustainable development (Ville durable) (Nikolaidou et al. 2016; Ville de Genève n.d.).

³ *GENEVE 2020: Plan directeur communal de la Ville de Genève, Renouvellement durable d'une ville-centre:* The plan was adopted on 16th September 2009 by the city council and 14th October 2009 by the State council. It is a municipal master plan which refers the development projects in the city territory (Service d'urbanisme 2017).

⁴ Jardin potagers: As a part of the Agenda 21 service aimed to sustainable city development Jardin potagers were inaugurated in 23rd September 2013 in Geneva (Equiterre 2013).

Environmental laws in Switzerland are based on the basic principles such as the precautionary and polluter pays principle which have great influence on the nature of legislative acts and ordinances (Federal Office for the Environment (FOEN) 2013). The overarching act is the Environmental Protection Act (EPA) which was adopted in 1994 (Federal Office for the Environment (FOEN) 2013). Swiss environmental law involves broad-based decision-making process which includes political parties, private sectors, and cantons. Being a democratic country, Switzerland puts a significant weight on the voice of its citizens in making any laws which might have direct influence on their life. Following figure (Figure 13) illustrates the decision-making procedure for any Swiss environmental law implementation.



Figure 13: Legislative process and implementing environmental law in Switzerland (Federal Office for the Environment (FOEN) 2013)

The Confederation is responsible for creating goals to accomplish the environmental protection and for creating specific measures to achieve the goals. The Cantons acts to implement the goals in accordance to the laws. Whereas, the Confederation also helps the Cantons in close collaboration with private sectors to reify voluntary performance and proper execution of the rules. The environmental laws and plans which directly influence the green space development and maintenance in the country are the Swiss Biodiversity Strategy (SBS) Action Plan, Air pollution Control Ordinance (OAPC), Noise Abatement Ordinance (NAO), Spatial Planning Act (SPA), the Action plan for adaptation to climate change, Agglomeration policy, and Action plan for sustainable development strategy.

The Biodiversity Action Plan focuses on the "*direct and long-term promotion*" of biodiversity to maintain a "*countrywide ecological infrastructure*" (Federal Office for the Environment 2017). The aim of the plan is to ensure spatial and functional connectivity between habitats throughout Switzerland. The plan also encourages the promotion of biodiversity which can have direct positive impact on population as example, air quality, noise reduction, microclimate control, and use of nature in built-in environment (Federal Office for the Environment 2017). This can be directly implemented in the city scale to further the effects of nature on city lives. The plan does not emphasis on green infrastructures or green walls directly, but it has all the elements to be useful for green wall application as well. The plan also publicizes the strength of biodiversity to increase the knowledge and awareness among citizens. The Confederation finances and supports the promotion of biodiversity through the Action Plan. The Biodiversity Action Plan has 27 total measures (Federal Office for the Environment 2017) out of which the followings (in Table 1) could be directly use in city green space creation and maintenance.

Table 4: Relevant measures for Biodiversity Action Plan in cities

Measures	Chapters
Design of countrywide ecological	4.2.1
infrastructure	
Evaluation of the impact of Federal subsidies	4.2.4
Consideration of ecosystem services in	4.2.5
spatially relevant decisions	
Incorporation of biodiversity factors into	4.2.6
existing sustainability standards	
Biodiversity requirements in model building	4.2.7
regulations	
Raising awareness about biodiversity	4.3.5

Temporal structure of the Action Plan and alignment with the NFE (New Fiscal Equalisation) programme periods

				Implem	entation	Phase I			Imp	lementat	tion Pha	se II	
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
Immediate measures	V *	decision *-2023					sis	ncil 24-2027			ation		
Synergy measures		Council on 2019*					act Analy	eral Cou decision ation 20			all Evalua		
Pilot projects		Federal (financi					đ	Fed			Overa		
Programme agreements in the area of the environment		2016 - 2019			2020 - 2023				2024	- 2027			

* In accordance with the Federal Council decision of 18 May 2016 on the financing of immediate measures in the areas of nature conservation and forest biodiversity 2017-2020.

**Additional funding for the continuation of the immediate measures will not be required until 2021...

The Spatial Planning Strategy for Switzerland was developed with a high land use pressure because of the limited available living area in the country (around 13,000km²). This resulted in creating a high value for the environment and landscape use (Swiss Spatial Planning Association 2012) featuring small to medium sized cities with highly developed economy and living standards. The cantons directly contribute in the spatial planning focusing on environmental protection and nature and habitat protection. The law on promotion of housing construction and property comes under the Federal Spatial Planning law which actively encourages greenery incorporation within city planning. The Spatial Planning law also strictly enforces the protection of residential areas from noise and air pollution with green space and tree integration in settlements. The integration should be done in a way that the buildings or infrastructures do not have adverse effects on the environments and the inhabitants (Swiss Spatial Planning Association 2012). Swiss Spatial planning is a state responsibility and includes the relevant environment law, agriculture law, nature and habitat law, infrastructure law, land law, and tax law. The planning strategy is a common responsibility of the federal,

Figure 14: Swiss Biodiversity Action Plan implementation phases and periods. Image source: (Federal Office for the Environment 2017)

cantonal, and communal level and is linked with the financial planning at the appropriate level. The Federal Office ensures that the plan is properly incorporated and implemented at the cantonal level (Swiss Spatial Planning Association 2012).

Figure 15 shows the potential of different policy instruments in GW development in Geneva at different jurisdictional level.



Figure 15: Influence of national and local policies on GW development in Geneva

It can be concluded from the above discussed sections that Switzerland has very strong reasons to introduce green walls in its cities. The country is suffering from a fragile ecosystem which is the biggest threat for sustainable development. On the other hand, being politically and economically strong, Switzerland can attract many stakeholders in its green wall sector. The country also has very strong biodiversity and climate change policies which acts as instrument for SD. However, instead of all these potential drivers Switzerland is holding back its green wall market. The literature search verifies that there is a gap between the knowledge about the strength of green walls and the development of green walls in the country. Not many researchers have explored the application of green spaces and green walls in the country. This gap makes this research a significant one which contributes to fill the gap to some extent and could be helpful for the decision-makers and stakeholder of the Swiss green wall market.

3. Methodology

Methodology aims to structure the research in a way so that the researcher can find out the answer to the research question. "Methodology" and "methods" are terms which are often used arbitrarily, but researchers have distinguished them as two very different concepts (Harding 2013). Sapsford (2006) defined methodology as the "*philosophy of methods*", while Clough and Nutbrown (2012) claimed methodology as the "*purpose*" and methods as the "*tools*" to approach the purpose of any study (Sapsford 2006; Clough and Nutbrown 2012). In this study "methodology" is the way which leads to answer the research question by producing results; whereas "methods" are the specific tools to achieve that. This chapter explains the methodology including the research strategy, the methods of data collection, and challenges faced during the investigation to find out the barriers and drivers for green wall application in cities.



Figure 16: Research methods. Image source Given 2008.

3.1. Research strategy

As discussed in the introduction, conducting research on green wall implementation requires a dual focus between wider European scale analysis vs the in-depth analysis in cities. The European scale can provide a broad knowledge but will lack the detailed issues and possibilities a city has for green wall application. Hence, studying the European scale is a challenge which can be complemented by individual case studies. This research studies green wall development challenges and opportunities in Geneva, Switzerland through a case study. Geneva was chosen because of its lack of green wall development instead of its political, economic, and geographical importance, which lie in the favour of green wall.

The objective of the research is to learn about the challenges and opportunities behind the green wall development in Geneva and how the national and local policy influence their development. Literature review indicated a gap between the need for green walls growth and their relative absence in Geneva and other Swiss cities. The literature review also indicated a knowledge gap on Swiss green wall development and the lack of emphasis on green walls in national and local green space policies. This directs the research towards studying the sociological and political aspects of green wall implementation in Geneva. This research used mostly qualitative research methods in sociological and political research (Bryman 2012). Denzin and Lincoln (2000) described qualitative methods as "interpretive" and "naturalistic" approach (Norman K. Denzin and Yvonna S. Lincoln 2000). While Harding (2013) argued that qualitative method is best in sociological and political studies when the sample size is small (Harding 2013). Given the small size of the city and the immature green wall market with socio-political issues, the research objective and condition justify using qualitative research methodology.

3.2. Conceptual framework

A conceptual framework is a visual or written presentation of a set of key factors and variables and the relationship among them; it provides a link from the literature to the methodology and data analysis in designing a research (Reichel and Ramey 1987; Robyn Smyth 2004). A conceptual framework works as a tool to help to understand the research problem and to emphasize on the different aspects of the problem and the solutions related to it (Bordage 2009). Figure 17 represents the conceptual framework for this study. The life cycle for green wall development in cities starts from conceptualization and goes through planning, implementation, maintenance, and finally ends in decommissioning. In Switzerland, green wall development is affected in multiple levels namely local, cantonal, and national level. In smaller scale productions, the local level is the most influencing one. As most of the green walls are produced in smaller scale (for individual user or building or wall), the local level has direct effects on green wall development in cities and is the most important of all the levels. The three levels interact and influence each other in different dimensions namely,

- Economic
- Social
- Governance, policy, and management
- Technical
- Environmental

These dimensions are the key factors that interact with each other and create enablers and barriers for green wall development. These enablers and barriers directly facilitate or hinder green wall application in cities.

The study has been developed based on this framework which will be used in the results and discussion chapter to present the findings of the research.



Figure 17: Multi-level framework for the green wall development in Geneva

CEU eTD Collection

3.3. Data collection methods

Data collection involved policy documents review and interviews. Document review served as the starting point of understanding green walls and their benefits and contribution to sustainability. Given the significant advantages of green walls, the literature review included books, journal papers, research articles, thesis, reports, conference proceedings, and policy documents. The green wall concept, though developed during the last century, is widely accepted and applied recently. Keeping this in mind the literature survey is focused mainly on the articles which have been published in recent years, with some exceptions. Searches were conducted using EBSCO publishing, AGRIS, Elsevier, BioOne, Mendeley, Springer, Scorpus, Google scholar, University publications, EU webpages, EEA webpages, and some private companies and research institutes webpages. Searched key words included 'green wall', 'living wall', 'green facade', 'sustainability', 'sustainable development', 'sustainable cities', 'sustainable urban development', 'green wall and sustainability', 'green wall policy', 'green space development', 'green infrastructure and policy', 'green wall in cities', and 'green wall ecosystem services'. To avoid the shortcomings and limitations of keyword searchers (Knehans n.d.; Levy and Ellis 2006) detailed database searches, a grey literature survey, and citation search have been conducted (Webster and Watson 2002).

An important part of the literature review was to study the policy documents concerning green space and green wall development in Switzerland and Geneva. These documents included construction policies and plans in Switzerland, green space creation and maintenance policy, activity reports of the environment and urban security department, regulations of the plans and land use in the city of Geneva, regulation on the delegation to the development of the territory, regulation of the municipal fund, fund regulation for energy and climate for the city of Geneva, Swiss biodiversity policy, action plan for Swiss biodiversity strategy, spatial planning in Switzerland, Swiss land use statistics, federal agglomeration policy, national urban policy in Switzerland, report on green Swiss financial market, and report on best practices in sustainable development in Switzerland. These policy documents were found on national, municipal, and cantonal government webpages. The details of the policy documents can be found in appendix E. A few policy documents and reports have been received from the office of the city of Geneva (Ville-de-Genève) and greenspace services (Service-des-espaces-verts or SEVE), and from interviewees. These documents were studied in detail to learn about relevant policies in green wall development.

The second main data collection method was interviews. Interviews were semi-structured with open ended questions; this allowed more control over the interview topic and the interviewees to respond with flexibility (Given 2008). As the literature survey didn't produce definite challenges excluding the issue of lack of policy, the interviews were designed with open-ended questions which highlighted on several challenges and opportunities which were not covered in the research articles. It was the most crucial part of data collection method as the lack of previous research made it difficult to analyse policy enablers and barriers of green wall application from only the literature survey. The interviewees were selected based on their role, contribution, and knowledge and experience related to green space and green wall. The interviewees were contacted and invited to participate via email or telephone. A total of 16 interviews have been conducted, among which 8 were face-to-face, 5 via telephone, and the remaining through email. To get a holistic view of the green wall application challenges and opportunities, the interviewees were selected to represent a wide range of expertise as shown in table 5.

Table 5: Interviewee type with description

Interviewee type	Number of interviewees	Detailed description
Government Official	4	City administration officials, responsible for Geneva's green space designing and maintaining
Entrepreneur	1	Individual experts, run own company
Employee/Businessman	6	Employee of green wall manufacturing companies
Academic	2	Researchers from academic institutes
User/citizen	2	National and international residents
Politician	1	Member of an active political party

The questions asked from each group of interviewees were different depending on their role and expertise with some common questions. The list of interviewees and semi-structured and open-ended questions with interview guide for each group can be found in appendices A, B, and C respectively. A draft questionnaire was prepared, reviewed and revised before the final interviews. The questions were based on the green wall application challenges and opportunities in the following aspects,

- Application or implementation of green wall
- Monitoring of green wall
- Resource or socio-cultural aspect of green wall
- Policy and planning on green wall

The interviews and the questions were prepared according to the Central European University (CEU) ethical policies for conducting interviews. The responses were made completely confidential and anonymous excluding the permission and interests of the interviewees.

<u>3.4. Data analysis</u>

This section presents the data collected through the interviews and literature survey. does not to answer the research question but creates a bridge between the methods and the results. This will allow the reader to have a better understanding of how the results were concluded from the data. As discussed previously, this study has been developed based on qualitative research methodology. The study follows two methods namely, interviewing and literature review. The semi-structured face-to-face interviews produced critical data with detailed information. A total of 16 persons have been interviewed. The interviewees have been grouped into 6 categories as discussed in previous section and in Appendix A. These categories are based on their professional background and contribution to this research. This section will describe the data analysis for the interviews.

Among the interviewees, the officials from the city administration and green wall manufacturers play a major role. They provided detailed information about green wall development in Geneva based on their personal views. The interviews with academics provided information about the growing research interests, whilst users spoke about their personal experience with green walls. Interview with the executive assistant from the SEVE brought out the issue of a high proportion of international floating population in the city. To better understand the problems associated with high proportion of international residents, interviews with an international resident. The interview with a native citizen as well as an interview with an international resident. The interview with the politician was also very important as the political party known as the "*Green Party*" is concerned about climate change and is dedicated to making the city sustainable and more resilient.

The interviews and the research articles have been analysed using Microsoft excel and NVivo pro 12. NVivo analyse text by allowing the user to create different nodes and distribute the type of data under them (Figure 18). This also allows the user to compare the nodes and to create

graphs, bar charts, word cloud, cluster analysis, and other visual interpretations of the data. The data collected from the interviews and the literature were text-based. After going through all the interviews and the policy documents, the key challenges and opportunities mentioned and discussed by the interviewees were identified. They were then validated from the policy documents and the research articles. Key challenges and opportunities were then grouped according to their specific aspect namely,

- Economic
- Social
- Governance, policy, and management
- Technical
- Geographical/environmental

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🖷 Externals	÷-0	Opportunities	0	0	RM	4/16/2018 11:58 AM	RM	4/16/2018 11:58 AM
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Figure 18: Data analysis in NVIVO 12 with different nodes

These groups are the nodes used in NVivo for the data analysis. All the challenges and opportunities fall under these groups. The tables in Appendix F give the details of the groups and the challenges and opportunities under them.

Extensive analysis of the interviews and the policy documents produced 21 challenges and 19 opportunities for green wall application in Geneva. Each of these challenges has been assigned a strength value or attribute value based on the responses. For example, the main challenge for green wall development in Geneva is *"lack of any defined policy for green walls"*. This challenge was identified by 11 interviewees. And, the policy documents on city green space development (6 in total) also identified the absence of green wall development policy in Geneva. This gives the challenge a strength value of 17 (11+6) (Appendix F). A detailed description of all the challenges and opportunities found out from the study with their strength value have been discussed in the results and discussion" chapter.

3.5. Limitations

The main limitations are due to some challenges experienced during the data collection period. Some of the interviewees were not comfortable speaking about the issues they faced in green wall application. Others were not comfortable highlighting the shortcomings of green space development policies. Some answers were biased with personal bitter experiences. In addition, considering the busy schedule of the interviewees some interviews were short where enough information was difficult to produce. On the other hand, the number of interviewees were very limited- especially for the citizen group. Also, as only three research articles were found on the green space development and its benefits in Geneva. This gap of knowledge pushes the study to widen the spectrum of the literature survey to the overall green space development in Switzerland and in Geneva. The country and the city do not have any policy which emphasis on green wall development. All the national and local policies are focused on either biodiversity or city park maintenance. This made the research difficult to proceed without any defined help on green wall application potential and regulations from any policy documents. Further, the local language of Geneva is French, and all the local policies are only available in French. Few of the national policy and reports are available in German only. This created a linguistic problem for the literature survey and interviews where native fluency was needed.

4. Results and Discussion

This chapter provides a descriptive and in-depth analysis of the results from the research. "Data" and "results" are two different forms of the findings of a study (Foote 2009). "Data" represents the facts or numbers which could be presented in tables or figures as raw data or summarized data; whereas "results" are findings in the form of statements which adds meaning to the "data" (Annesley 2010). The analysis of raw "data" will be discussed first in this chapter followed by a detailed illustration. This will help the reader to have a better understanding of how the data led to answering the research question. In addition, this will also benefit the reader with an in-depth analysis of the findings. The findings reported in this chapter follows the standard guidelines (Annesley 2010) and are completely unbiased and aims to answer the research question. This thesis will use the term "findings" rather than "results" which is more suitable for qualitative data analysis (Sutton and Austin 2015).

As discussed in the Literature Review chapter, the interviewees were categorised in 6 groups depending on their relation and experience on green walls. Figure 19 shows the interviewee category frequency where most of the interviewees are business and government officials. All the interviewees were asked their preferences on green wall application in the city. And, the results are shown in figures 20 and 21. Most of the interviewees (10 out of 16) responded in favour of green wall development where few (5 out of 16) responded against green walls. Figure 21 further divides the preferences based on the interviewee category discussed in table 6.



Figure 19: Interviewee categories



Figure 20: Interviewees' preferences on green wall development in Geneva



Figure 21: Types of interviewees and their preferences on green wall development in Geneva

As discussed in the Literature review chapter, the barriers and enablers identified from the policy documents and interviews were assigned strength values. The detailed description can be found in page 44. The higher the strength value, the greater the importance of any barrier and enabler is. Depending on the strength value the key challenges (9 of them) and opportunities (10 of them) have been short-listed and represented in tables 9 and 10. In the tables, the dark green cells represent the lowest value and dark red cells represent the highest value and all the other shades of green, yellow, and red fall between them. The tables also sum up the overall key challenges and opportunities strength value which allows the reader to compare between the barriers and enablers and to understand current status and possibilities of green wall development in future.

The overall strength value for the key challenges (85) is much higher than the overall strength value for key opportunities (73) which is in sync with the city having very few green walls. The

challenges faced by Geneva for green wall application outweighs the opportunities. Not only are the strength values high for the challenges but most of the opportunities do not directly impact green wall development. The connection between the key challenges and opportunities will be further discussed in detail in the "Conclusion and Recommendation" chapter.

No.	Key challenges	Strength value
1	Lack of defined policy	17
	· · ·	
2	Lack of initiative from government	11
3	High capital and maintenance cost	11
4	No appreciation for new technologies	10
5	Lack of encouragement	9
6	Lack of knowledge among citizen	8
7	No incentives or subsidies	7
8	High labour cost	6
9	Problem with irrigation system	6
Total	Overall key challenges	85

Table 6: Key challenges for green wall development in Geneva

Table 7: Key opportunities fo	r green wal	l development i	n Geneva
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No.	Key opportunities	Strength value
	Development	12
2	Broad green space policy	12
3	National policy on biodiversity and climate change	11
	5	
10	Congested city	10
7	Ecosystem services	10
1	SEVE in charge of green space	8
5	High income of citizens	6
		-
8	Growing interest among researchers	5
4	Public budget for green space	6
6	Abundant vertical surfaces	5
9	Job creation	5
Total	Overall key opportunities	73

4.1. The framework

To better illustrate the findings of the research, figure 22 introduces a simplified multi-level framework.



Figure 22: Multi-level framework for GW development in Geneva showing multi-dimensional interactions

The framework is a detailed version at the multi-dimensional level of the conceptual framework (Figure 17) discussed in methodology chapter and was built and adopted in the study based on the key research findings. The framework is multi-level where the term multi-level has been used to advocate multi-dimensional perspective. Green wall development in Geneva has been found to be dependent on five key dimensions as described in table 11.

Dimensions	Description
Governance, policy, management	Covers the aspects of green wall
	development challenges and opportunities
	from the political and legal aspects.
Economic	Includes financial barriers and drivers.
Geographical/environmental	Refers to barriers and drivers that arise from
	a geographical location, climate,
	geographical features and lands, population,
	and pollution.
Technical	Includes the barriers and drivers from the
	structural and design perspective.
Social	Details the challenges and opportunities arise
	from citizens, society, and stakeholders.
	Also, the relationship and connection
	between the government and the locals.

The challenges and opportunities lie within these dimensions and are interrelated. They influence each other intra and inter-dimensionally. The arrows indicate the positive and negative impact at different dimensional level for green wall development in Geneva. The challenges and opportunities are a result of the interactions among the dimensions. To understand the framework, it is mandatory to understand each of the dimensions in details. The following sections will explain each of the dimensions and how they influence green wall development in Geneva. The findings have been grouped in two categories as challenges and opportunities.

4.2. Challenges

This section provides details of challenges identified through the research study for green wall development in Geneva.

4.2.1. Governance, policy, and management

National and local policies play a very important role in shaping the green wall market in Geneva. The city doesn't have any defined policies for green wall development (Interviewee IV). All policies are either based on some related issues such as the biodiversity protection or protecting city trees (Federal Office for the Environment 2017; Federal Office for the Environment 2013). Geneva has a separate department for green space development and maintenance named as Greenspace services (Service des espaces verts or SEVE) under the auspices of the city of Geneva (Ville de Genève) (Service des espaces verts n.d.). SEVE is responsible for urban green space; and their main role is to protect trees. As the active green space policies are focused on the planting and maintenance of the trees on the streets or in parks, the city administration doesn't put any effort to build or invest in green walls around the city. One of the interviewees on this topic mentioned that usually cities don't have any specific policy on green walls like the green roofs have (e.g. Building regulation for green roofs in Basel), but they are considered as one of the attractive options for city greening (Interviewee VIII). However, Geneva's city administration does not consider green walls as one of the potential choice for green space within the city. This creates no initiative from the city administration for green wall development which is the most frequently mentioned challenge for Geneva. An independent consultant mentioned that due to the lack of policy and initiative by the municipal government, the market is immature (Interviewee VI). According to him, "it might take another 10-20 years for the market to grow and mature". Another important challenge as mentioned by another businessmen is that this lack of interest by the government makes it difficult to get official permission for GW projects (Interviewee X). It takes very long (2-3 months) to get all the necessary permissions for building a green wall which makes it less attractive for some customers and discourage companies.

4.2.2. Economic

Green walls are usually expensive to create and maintain. As discussed in the literature review plants need extensive maintenance which requires three to four maintenance visits by a service provider per year. This creates a "vague impression" of "complicated maintenance" on the developers about green walls (Interviewee X). The term "vague" here presents the opinion of many researchers and businessmen. According to them maintaining a green wall is not more complicated than maintaining a regular private garden (Interviewee VI, VIII, IX, X). However, the maintenance cost in Switzerland is very high because of expensive human labour. The price to build green wall can vary from 600 Swiss francs per square meter for simple structures to 1600 Swiss francs per square meter for more complex (Interviewee VI, IX, X), plus maintenance cost. Another financial barrier for green wall development is the lack of public budget, incentives, or subsidies for the manufacturers or developers, because of the absence of policy. All interviewees except the citizens pointed out the absence of incentives or subsidies as a major challenge. Some of them referred to some other European cities like Amsterdam, Berlin, and London where GW developers get some incentives from the government (Interviewee V, VI, VIII, IX, X). According to the interviewees, the motivation for developers to invest in green wall development is mostly for creating and maintaining their public image (Interviewee VI, VIII, IX). This does not work as an effective motivation in Geneva as citizens lack knowledge and interest in green walls (Interviewee VII, IX, X). This is a social challenge that is explained in the section 4.1.5. in detail. One of the academic interviewees argued that financing is the biggest barrier for green wall projects in the city (Interviewee XII). He suggested that the funding for green wall development should be a "hybrid type" public-private

partnership. According to the interviewee, funder of the projects doesn't benefit by the ecosystem services provided by the green walls which is mostly for the citizens or the neighbourhoods. This creates a lack of interests among investors and hence could only be solved by introducing attractive subsidies, council tax reductions, or special prizes for green projects (Interviewee X).

4.2.3. Geographical/environmental

The geographical condition of a place is a major factor influencing green wall performance and lifetime. Switzerland is located in the temperate climate zone where the climate is heavily influenced by the Alps and the Atlantic Ocean. The northern part of the country faces mild and damp winter whereas the southern part is influenced by the Mediterranean climate. Geneva is in western Switzerland and has a mild and humid winter and hot summer. Figure and shows the average annual temperature and precipitation in Geneva.



Figure 23: Average annual temperature in Geneva. Image source www.about.ch



Figure 24: Average annual precipitation in Geneva. Image source: www.about.ch

The city usually gets moderate snow fall most winters with some exceptions in few years, when the city gets heavy snow fall which usually lasts for 1-2 weeks (MeteoSwiss 2018). These harsh winters make the plants freeze and die and affect the green walls severely. One of the interviewees, a local citizen was very concerned by plant survival during winter and argued that "*the plants usually catch frost in every winter and die within few days*" (Interviewee XIV). One of the interviewees argued that the use of plastic pots in GWs represents poor design, as the entire plant, including its roots can completely freeze (Interviewee VI). Once the roots are frozen, the plant usually dies within a few days. Specially designed green walls with advanced plantation systems allows the plants to survive severe winters but are not very popular because of their high cost (Interviewee VI, XIV).

Green walls are very attractive GIs in cities because of their potential to improve the air quality. They have proven benefits of air borne pollutant absorption as well as carbon sequestration (Weerakkody et al. 2017; Elgizawy 2016). Many researchers have studied the air purification potential of green walls and found it significant (Abhijith et al. 2017; Pettit et al. 2017). Geneva being one of the European cities with high air quality lacks the immediate need for green wall application. The city, as described in the introduction is known as the city of parks (Ville de Genève n.d.). It has nearly 52 parks (including smaller and bigger ones) in total (Interviewee IV) which represents more than 22% of the land area of the city as green space. The Swiss citizens are very protective of their parks and trees. Geneva has about 70,000 trees in total out of which 10,000 are on the streets (Interviewee IV). Most of the parks have very old trees which have been donated by a few Swiss families centuries ago and they are symbolic to Geneva. The SEVE, responsible for urban green spaces works with the environment and security department under the auspices of the city of Geneva (Ville de Genève) to protect these parks as well as the trees. This high proportion of green space keeps the city air pollution free. The city council is also very active in keeping the air clean (Federal Office for the Environment (FOEN) 2013) and believes in the polluter pays principle which helps keep the pollution in control. Switzerland also has an Air Pollution Control Ordinance (APCN) controlled by the Federal Administration which work closely with the cantons, politician, business, and environmental groups (Federal Office for the Environment (FOEN) 2013), the lack of pressure for further air pollution control measures weakens the case for green walls that cost more and may need to complex design and regulatory criteria (Interviewee IV, VI).

4.2.4. Technical

The structure of green walls includes plants, substrate for the plants to grow, pot, panel, or a system to hold the substrate, and an irrigation system with continuous water flow. The irrigation system using either direct tap water or recycled water is crucial for the plants to live and the green wall to work well. Maintaining the irrigation system could sometimes be challenging (Interviewee X) for some complex green walls particularly and in cold weather. This can lead to few occasional failures causing the whole green wall system to fail and ends up in replacing all the dead plants. One of the interviewees also mentioned that the controller attached to the

irrigation system can sometimes malfunction, resulting a failed irrigation system (Interviewee VIII). Poorly designed green walls can also have occasional electrical and mechanical malfunction (Interviewee V, X). These design problems sometimes end up killing all the plants and result in the need to replant all the plants again. Hence, appropriate design is the key for reliably performing green walls. Plant replacement may also be needed if some of the plants die due to some natural cause which is very common. Replacing plants in the green wall installations could however be difficult depending on the design. Some very high walls complicate the process to several folds which need more human labour with additional machineries to reach the top of the wall increasing the maintenance cost (Interviewee IX). Very high walls are also difficult to install. The green wall designed by HEPIA in 2013 (detailed description in literature review chapter page 23) is an example where the trickiest part was the installation (Interviewee XIII). The green wall was created in the labs of HEPIA and was taken out to the location where it was installed. The green wall was 12-meter-high (which is not very high in comparison to many other green walls (>30m)) and was built in several blocks and then assembled on site. The project was detailed in the literature review section and in Appendix G.

Taking climatic condition into account, plant selection is another important design aspect. Plants that are small in size, or herbs, or edible plants which are native to Geneva produces the best result. Most of the plants suitable for green walls do not survive low temperature during winters because of the cold climate (Interviewee XIII). Some businessmen spoke about customers choosing the wrong plants based on aesthetic preferences (Interviewee IX, XI). This may lead to a non-functional green wall during winter which again discourages other potential developers and users.

Another technical problem in constructing and installing green walls is that the involvement of many experts: botanist/gardener (for plants), landscape architecture (for irrigation and

designing), manufacturer (for production), designer (for designing), city officials (site visit, verification, and permission), electrical and mechanical specialists (construction and installation), and few more human labourers which again creates the impression of complicated construction and maintenance on the citizens (Interviewee X).

4.2.5. Social

The second biggest reason for Geneva not having many green walls is related to social issues. While no survey results are available, based on the interviews and literature review if appears that public awareness of GWs in Geneva is low. The one thing locals know about green walls is that "*it looks good*" and "*it is expensive*" (Interviewee XIV). The lack of knowledge is also widespread among many government officials (Interviewee I, II, III, IV). All the green walls in the city were developed by private companies with the exception of the green walls made by HEPIA where the project was sponsored by the government. According to the Executive assistant of SEVE (Interviewee IV), Swiss citizens value the aesthetics of green walls but due to limited understanding of their functions and benefits locals do not prefer GWs over other green space types. Also, most of the interviewees (10 out of 16) agreed that Swiss citizens are very traditional in their thoughts and lifestyle and they prefer to follow traditional practices. Green wall being a novel technology is perceived as a risky by locals which also discourages them. The city council do not practice any initiative to encourage and spread awareness about green wall benefits. All government efforts on green space is focused on the parks⁵ which are very symbolic to the city (Interviewee IV).

Another significant barrier as mentioned by the executive assistant of SEVE (Interviewee IV) is the large share of international residents in the city. Geneva being home to many international organizations has an international environment with a high proportion⁶ of non-Swiss residents

⁵ The parks in Geneva are more than 100 years old and are protected by both the council and the citizens.

⁶ Geneva canton has nearly 40% of its population as international residents (République et canton de Genève 2016).
who visit and live in Geneva for very short duration (for a few months to a few years). According to the executive assistant, "*the international residents do not care much about the city's green space*". This high proportion of the residents has the minimal interest in GW development in the city and they contribute as a social barrier for green wall development in Geneva (Interviewee IV).

4.3. Opportunities

Despite of the challenges in green wall development, Geneva has some opportunities which act or might act as enablers. This section will provide details of the potential enablers. The opportunities found through the study have been described in relation to the dimensions mentioned in the framework for better understanding.

4.3.1. Governance, policy, and management

As mentioned earlier in section, Geneva's the city council has Greenspace service (*Service des espaces verts* or SEVE) which is responsible for green space establishments and maintenance. The department has 12 employees who work on designing green spaces and 40 works in maintenance (Interviewee IV). Having a separate department which only focuses on the green spaces in the city is an opportunity for Geneva to promote and develop more green walls. SEVE follows the instruction and policy made by the department of urban environment and security (*département de l'environnement urbain et de la sécurité*). The department has specific policies for green space development and maintenance, which they strictly follow (Interviewee IV).

Switzerland is among the many European countries facing a threat to biodiversity and are hence very strict about biodiversity protection (Federal Office for the Environment 2017). The country has national legislations on biodiversity and habitat protection (Federal Office for the Environment 2017; Federal Office for the Environment (FOEN) 2013). Excluding the specific biodiversity acts, biodiversity protection and promotion as well as sustainable use of biodiversity has been mentioned in the "*Environmental Protection Act*" and "*Spatial Planning Act*" (Federal Office for the Environment 2017). These acts though do not directly emphasize on green walls but could be used to promote and implement them. Green walls provide biodiversity and habitat to species (Collins, Schaafsma, and Hudson 2017; Mayrand et al. 2018). Hence the biodiversity protection and maintenance through environmental legislations could be promoted by green walls. Green walls also provide a wide range of ecosystem services as discussed in the introduction and literature review chapters. Ecosystem services (ES) and their economic value are of great importance to Switzerland (Federal Office for the Environment 2017) that green wall can contribute to. These environmental and biodiversity protection law is one of the instruments to promote green wall in Geneva. Compared to urban parks, forests, or other large green spaces, the contribution of GWs in ES is small and is available only in local scale. But the added benefit of green walls is that they can be installed very close to human settlements, where their benefits can directly impact locals.

Excluding the environment and biodiversity protection laws, the spatial planning in Switzerland is a common responsibility for all cantons and communes including Geneva (Swiss Spatial Planning Association 2012). Land use planning, nature and habitat conservation are mostly the responsibilities of the cantons. The spatial planning law includes nature and habitat conservation and environmental protection law. Spatial planning law also highlights

- Protection of residential areas from air and noise pollution
- Integration of green and open spaces in residential areas
- Protection of the environment in residential areas from any harmful effects of infrastructure and concrete (Swiss Spatial Planning Association 2012)

All these clauses advance the expansion of green space in Swiss cities and have the same potential to support green wall development and acts as a driver. Geneva city administration also has a yearly budget for green space development and maintenance. In 2018, SEVE had a budget of 6 million CHF for green space development (Interviewee IV). The council planned to spend the money on maintaining parks, planting more trees on the streets, and buying spatial analysis software to identify new sites for green space expansion. In addition to the budget, the council is also planning to raise the same amount of money from private sponsors such as Swiss banks and watch producing companies. Private donations and budget for the green space are very important drivers for green wall development in Geneva.

4.3.2. Economic

Switzerland, as discussed earlier is among the richest countries in the world. The GDP of the country is very high, and the average monthly salary of the citizens is about 10000-15000 CHF (Interviewee X). Because of its wealth the country has the potential for investing in green wall projects extensively (Interviewee VI, IX, X). Excluding this economic benefit, Geneva is one of the most politically influential cities in the world and is called as International Geneva (*Genève internationale*) as it hosts several international organizations, diplomatic missions, and non-governmental organizations (NGO) (Ville de Genève 2017). Their presence serves a very strong driver for Geneva to attract financers to invest in green walls.

Geneva is becoming highly congested which is creating pressure on its housing sector because of its job market and increasing population (Nikolaidou et al. 2016). To alleviate the pressure on the environment, the department of urban environment and security (département de l'environnement urbain et de la sécurité) is planning to create more green spaces within the city (Interviewee II, IV). One of the interviewee here argued that green walls are a solution for this problem as it is cheaper than creating a new park and it does not require any allocated large tracts of land (Interviewee X). Green walls here add a benefit both in economic and environmental terms.

Green walls also increase the aesthetic value of buildings and create a very healthy environment for people. This increases the property value which could be attractive for the real estate agencies and the owner (Interviewee VI, IX). Another important economic driver is that green walls which are of smaller GWs (< 5*5 m2) are less expensive to create and could be afforded by many developers (Interviewee IX). Although smaller and thus less expensive these green walls can still provide similar benefits people.

4.3.3. Geographical/environmental

One of the most attractive drivers for Switzerland to have green walls is that only 30% of the country is suitable for human settlements; most of the other areas are covered with mountainous and non-livable (Swiss Spatial Planning Association 2012). This makes the cities congested which increases pressure on urban environment. In 2016, the Canton of Geneva had a population of 202,428 (République et canton de Genève 2016). In 2016, the city had a population density of 12,433.9 per sq. km (Federal Statistical Office 2017). While Switzerland has a total population of 8.3 million (The World Bank Data 2016), Geneva contributes to more than 2.5% of the country's population. This makes the city congested with very few vacant spaces for developing new greeneries. Green wall being a vertical greenery does not need any land area and can be created on existing buildings. Hence, the congested city with growing population is among the many drivers for green wall implementation in Geneva.

4.3.4. Technical

The ecosystem services provided by green walls is the strongest driver for their development. As discussed in the literature review section, green walls have many benefits including increased biodiversity, air purification, humidity control, sound absorption, energy savings, micro-climate control, and aesthetics (S. M. Sheweka and Mohamed 2012; S. Sheweka, Magdy, and Magdy 2011; Elgizawy 2016). These features of green walls have been appreciated by most interviewees (11 out of 16). They all believed this to be the strongest reason for the city to develop new green walls. Gomes-Design is one of the leading green wall manufacturing companies in Switzerland. Their sales and marketing executive (Interviewee IX) claimed that the technology for green wall development improved significantly. He claimed that their product is a "consumer product" with a benefit of "easy installation" and "easy maintenance". Green walls are designed in a way where the plants can be easily replaced by non-experts. This not only makes the product easy to handle by users themselves but also keeps maintenance costs very low. He also claimed that their green wall is very sturdy, and the system has advantages over other companies currently on Swiss market (Interviewee IX). Gomes-Design also has a green wall system where the wall acts as a wet wall with added fire prevention characteristics. One of the biggest barriers for green wall installation for Swiss users is maintenance and related costs. New technologies like the one that Gomes-Design developed creates an attractive driver for Swiss citizens to adopt green walls. Another interviewee who is a very young businessman also mentioned these new technologies which are attracting the Swiss market. He also argued that the overall procedure is very slow, and it might take "another 10 years" to have a decent size market for green walls (Interviewee X).

Being a vertical greenery, green wall doesn't cover any land area and can be implemented anywhere. Some green walls are designed and created in the construction department/lab of a company and can be just mounted on any existing building walls. This is a very important structural feature specially for cities where there is not any more land left to green walls (Interviewee VI, VIII, IX, XI, XIII).

4.3.5. Social

Social opportunities include the growing interest among stakeholders and researchers. A few stakeholders who are of non-Swiss origin are getting interested in investing in Swiss green wall markets. Some private green wall manufacturing companies mostly from the UK and Germany (Appendix D) are getting into the Swiss green wall market slowly. These companies hope to grow their business in Switzerland in 5-10 years. A few Swiss businessmen and few Swiss companies along with some entrepreneurs are also investing in green walls. They are trying to encourage the locals and a few potential clients by providing free consultation on green wall benefits (Interviewee IX). Some researchers and experts from Swiss universities are also getting interested in green walls. One of the researchers from HEPIA, who is a specialist on architecture and plants said that he finds green wall projects fascinating and would like to continue working on them in the future (Interviewee XIII). Currently, he is working on a newly made stone wall on the road side in Lausanne, a city close to Geneva. The plants (mostly moss) are grown in a greenhouse with soil and a metallic structure to hold the soil together. The plants are then transferred to holes in the stone wall. This system doesn't need any irrigation facilities and depends only on rain water. According to the researcher, this might turn out to be a very attractive option for green walls for the city council in Geneva. Creating green walls also expand the job market for young professionals.

The social and political dimensions are the most important dimensions of all because of the highly democratic society which has direct influence on the local policy making. Interviewee with the businessmen and city administration pointed out the traditional way of thinking of the Swiss citizens. The green wall concept has started a long ago when it was mostly famous for

its aesthetic value; the ecosystem services it offers were only known among the researchers and were not very popular. Swiss citizens are aware of the aesthetic value of green walls, but they do not have any knowledge about the other ecosystem services green wall produces. Hence, they do not consider green walls as an adaptation and mitigation measure for climate change and a tool to sustainable development. this creates a lack of interests among the citizens which directly effects the city administration to reform the existing policies in favour of green walls. On the other hand, the lack of knowledge is also widely spread among the city officials and decision-makers which holds any kinds of encouragement or initiative from the city council. Hence, the social and political challenges are interlinked and shape each other. The third major challenge for Geneva to grow green walls more is the high proportion of existing greenery and high quality of air in the city. This also creates a negative pressure on the governance and policy which pushes away the city administration or the decision-makers to reform the policies in favour of green walls.

On the other hand, the high GDP and high income of the citizens along with the presence of high numbers of financers and bankers in the city supports the society to create more green walls. This has the potential to play as one of the major driver for green wall development in Geneva which the city administration can use wisely. Also, the advanced technologies and the ES provided by green walls create a positive pressure on the environment which helps to reduce the congested city problem. The technological advances also influence the economic dimension by creating user-friendly green walls which are more attractive to the citizens. Figure 25 depicts the key challenges and opportunities for green wall development.



Figure 25: Key challenges and opportunities for GW development in Geneva

5. Conclusion and Recommendations

This thesis began with describing the problem of urban densification and its impacts on society and the environment, especially the reduction of urban green space. The application of green walls was proposed as an attractive choice due to the ES they provide and their link to sustainability. Because of its political, economic, and geographical advantage, Geneva was selected as a case study for this research. As discussed in the introduction, instead of being a leader Geneva is lagging in green wall development. Keeping this in mind the study was aimed at finding out the probable barriers and drivers for green wall application in Geneva.

Besides summarizing key challenges and opportunities and how they impact green wall development in Geneva, this chapter also provides recommendations on how the drivers could outweigh the barriers and tip the scale in favour of green wall development in the city. This chapter ends with suggestions for future work.

Among the various challenges described in the Results and Discussion chapter, the following social, political, and environmental challenges (Figure 26) have been identified as the most important. These challenges have been identified based on their strength value which was discussed in the methodology chapter. The challenges are interlinked and influence each other significantly. The most important challenge is the "*Lack of any targeted policy for green wall application*" which also contribute in creating additional challenges. Geneva has municipal policies which are focused on the green space development and maintenance. The aim of these policies is to support local biodiversity and to foster its improvement.



Figure 26: Interaction among the key challenges in different dimensions for GW development in Geneva.

As interview and literature review data showed, none of the policies emphasizes green wall development. This lack of targeted policy results in the lack of GW initiatives and encouragement from the city administration. This contributes to limited knowledge among citizens which also leads to no appreciation of new technologies. Both these political and social problems act as barriers to green wall development in Geneva. The third most important barrier - which by itself is positive - is the high proportion of green space and low baseline pollution in the city. The citizens are emotionally and historically attached to their city parks and trees and are very satisfied with the green cover. This reduces interests among the decision-makers to reform existing policies in favour of green walls which would contribute marginally to the urban environment with existing high proportion of green space and come with a high price tag.

These barriers or challenges can be outweighed by restructuring current policies and the introduction of new policies focused on promoting the development of GWs. Social barriers can also be addressed through organizing awareness raising campaigns and workshops focused on the potential of green walls. The data also showed a link to the national policies on biodiversity and climate change and local policy on green spaces. These policies along with the budget for urban green space improvement are important levers for green wall application in Geneva. The interviews showed the growing interests among the researchers and a few stakeholders which also plays as a driver for green wall development. The growing interest might be an early indicator of the potential future GW development. Geneva being one of the politically and economically important city within the world draws attention of many investors who can be support green wall projects within the city.

The potential enablers (detailed in the results and discussion chapter) can outweigh the barriers as follows:

- SEVE which is in charge of the city's green space has the power to invest in green walls and to spread awareness among citizens.
- The national policy for biodiversity and climate change have the potential to influence the city's green space policy and to incorporate green wall development.
- Annual municipal budget for green space development could be used for advancing green wall development.
- Geneva being the home for many major financial institutions has the capacity to invest in green wall projects if the interest of these companies could be raised.

Figure 27 shows how the enablers could outweigh the key challenges in a positive scenario for green walls.



Figure 27: How enablers influence the challenges and produce more opportunities for GW development

5.1. Recommendations

This section provides a few recommendations which could help to address the challenges and open a pathway towards the growth of green wall development in Geneva. These recommendations are based on findings from the research and analysis of challenges and opportunities. A few of these recommendations were raised by the interviewees as suggestions and probable solutions. While some of the recommendations have been hinted at the previous section, the brief overview is presented below.

- Through the revision of the existing policies for green space development and maintenance within the city. Restructuring of local policies to incorporate green wall development and to make use of the applicable provisions of the national policies in support of green wall development.
- Introduction of incentives, tax rebates, and subsidies within restructured policies, for green wall producers and users. This could attract financiers to invest in green wall projects.
- Launch of campaigns and workshops about green walls in city life. Feedback from the existing users and citizens about their experience. Encouraging citizens and emphasizing in the GW advantages, e.g. potential of rainwater harvesting through green walls. This will encourage the citizens, as the Swiss people are very supportive recycling and reusing materials.
- Creation of an open market for a green wall industry where non-Swiss companies can also participate. Creation of a healthy competition between Swiss and non-Swiss companies for green wall development. Introduction of prizes or other business benefits that can have symbolic, promotional, or economic value.
- Allocating part of the municipal budget to green wall development in the public areas.

The following figure (Figure 28) presents a detailed and simplified step-by-step recommendation for the growth of green wall installations in Geneva.



Figure 28: Step-by-step recommendations for growth in GW development in Geneva

5.2. Suggestions for future research

The study could be expanded and continued in the future in two ways.

- a) To study the social dimensions of green wall application in terms of policy reforms and how policy reforms could contribute to strengthening the social impacts of GW development.
- b) Compare green wall development in European scale and to learn about similarities and differences and to study how policy measures could support GW development in different urban context.

5.3. Significance of the study

Switzerland, with a population of 8.3 million (2016) and a GDP of 668.8 billion USD (2016) is one of the richest countries in the world (The World Bank Data 2016). Geneva is the second most popular city in Switzerland (after Zurich) and is the home to more than 100 banks and other international financial institutes. The city has a significant potential to attract more investment in green wall development. Geneva is also one of the world's most important cities in terms of international politics. Despite hosting several leading environmental organizations, Geneva falls short in green wall development. The main reason for this is political and social. Lack of interest among the citizens and the government contributes to limited interest among stakeholders and financiers. Hence, there remains a gap between the potential growth and the current situation in green wall market in Geneva. Until now very few researchers explored green walls in Switzerland, and none of them have studied the potential opportunities for green wall growth in Geneva. This makes this study unique and a starting point for further work by researchers, service providers, and decision-makers.

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7. Appendices

7.1. Appendix A: Interviewee details

Interviewee category

 Table 9: Interviewee or respondent category and number

Category	Number of respondents
Government	4
Entrepreneur	1
Business	6
Academic/ researcher	2
User/citizen	2
Politician	1

Interviewee details

Government

- 1. Interviewee I: Anonymous, Département des constructions et de l'aménagement, Villede-Geneve. Interviewed on 26th March, 2018.
- 2. Interviewee II: Anonymous, Département de l'environnement urbain et de la sécurité, Ville-de-Geneve. Interviewed on 26th March, 2018.
- 3. Interviewee III: Anonymous, Service des espaces verts, Ville-de-Geneve. Interviewed on 5th April, 2018.
- 4. Interviewee IV: Olivier Robert, Deus environment urbain, Service des espaces verts. Interviewed on 13th April, 2018.

Entrepreneur

1. Interviewee V: Maurice Maggi, Landscape gardener. Interviewed on 28th March, 2018.

Business

- 1. Interviewee VI: Anonymous, Green wall consultant, Switzerland. Interviewed on 12th April, 2018.
- 2. Interviewee VII: Anonymous, ANS Global. Interviewed on 4th April, 2018.
- 3. Interviewee VIII: Gary Grant, Director, Green Infrastructure Consultancy Ltd. Interviewed on 22nd March, 2018.
- 4. Interviewee IX: Heikki Heer, Sales and Marketing, Gomes Design AG. Interviewed on 29th March, 2018.
- Interviewee X: Joshua Egerton, Director, Future ECOsystems. Interviewed on 23rd March, 2018.

6. Interviewee XI: Nicolas Disch, Head of Planning and Projects, Hydroplant AG. Interviewed on 8th May, 2018.

Academic

- 1. Interviewee XII: Prof. Martin Schlaepfer, University of Geneva. Interviewed on 19th April, 2018.
- 2. Interviewee XIII: Robert Perroulaz, Sciences de la vie, Haute école du paysage, d'ingénierie et d'architecture de Genève. Interviewed on 23rd April, 2018.

User/citizen

- 1. Interviewee XIV: Anonymous, Geneva. Interviewed on 11th April, 2018.
- 2. Interviewee XV: Laurenne Niederhauser, HEPIA. Interviewed on 1st May, 2018.

Politician

 Interviewee XVI: François LEFORT, Député au Grand Conseil, Membre du Bureau. Interviewed on 25th May, 2018.

7.2. Appendix B: Interview guide

Dear Madam/Sir,

I am an Erasmus masters student studying environmental sciences, policy, and management (MESPOM). MESPOM is a joint master's degree among four European and two North American universities. Currently, I am in my last semester and writing my thesis under the supervision of Prof. Laszlo Pinter from the Central European University, Budapest, Hungary.

The aim of my research is to find out the challenges and opportunities for Green Wall development in cities. To keep my research precise and within the limited time-frame, I am focusing only on the Swiss city Geneva. I am studying the policies and practices underpinning the green wall development and how they influence the socio-cultural and financial perspective.

With this letter, I am inviting you to participate in this research with this open-ended questionnaire. The aim of this questionnaire is to explore how you perceive and value different aspects of Green Wall planning and application. And, what in your view are the drivers and barriers for its application. The questionnaire is titled "Questionnaire on urban green wall planning and development" and consisted of six parts, with 47 questions, and estimated to take sixty to ninety minutes per interview.

The questionnaire fulfils the ethical norms of the Central European University and is completely confidential and there is no risk in answering. If you do not wish to include your personal details, you may skip the Part I of the questionnaire.

Thank you for taking the time to assist me in my educational endeavours. Your help will contribute to my research to a great extent.

With regards, Rituparna Majumdar <u>http://mespom.eu/</u> Central European University, University of Manchester Email: <u>Majumdar_Rituparna@student.ceu.edu</u>, <u>rituparna.majumdar@postgrad.manc</u> <u>hester.ac.uk</u>, <u>rituparna.majumdar@mespom.eu</u> Ph. No: <u>+41766527477</u> Cher Participant,

Je suis un étudiant Erasmus Master en Sciences, Politiques et Gestion de l'Environnement (MESPOM). MESPOM est une maîtrise conjointe de quatre universités européennes et de deux universités nord-américaines. Actuellement, je suis dans mon dernier semestre et écris ma thèse sous la supervision du professeur Laszlo Pinter de l'Université d'Europe centrale, Budapest, Hongrie.

Le but de ma recherche est de découvrir les défis et les opportunités pour le développement de Green Wall dans les villes. Pour que mes recherches restent précises et ponctuelles, je me concentre uniquement sur la ville suisse de Genève. J'étudie les politiques et les pratiques qui sous-tendent le développement du mur vert et leur influence sur les perspectives socioculturelles et financières.

Avec cette lettre, je vous invite à participer à cette recherche avec ce questionnaire ouvert. Le but de ce questionnaire est d'explorer comment vous percevez et appréciez les différents aspects de la planification et de l'application du Mur Vert. Selon vous, quels sont les facteurs et les obstacles à son application? Le questionnaire est intitulé "Questionnaire sur la planification et le développement du mur urbain" et se compose de six parties, avec 38 questions, et on estimé à prendre soixante à quatre-vingt-dix minutes par interview.

Le questionnaire est complètement confidentiel et il n'y a aucun risque de répondre. Si vous ne souhaitez pas inclure vos informations personnelles, vous pouvez ignorer la partie I du questionnaire.

Merci d'avoir pris le temps de m'aider dans mes démarches éducatives. Votre aide contribuera dans une large mesure à mes recherches.

Cordialement, Rituparna Majumdar <u>http://mespom.eu/</u> Central European University, University of Manchester Email: <u>Majumdar_Rituparna@student.ceu.edu</u>, <u>rituparna.majumdar@postgrad.manc</u> <u>hester.ac.uk</u>, <u>rituparna.majumdar@mespom.eu</u> Ph. No: <u>+41766527477</u>

7.3. Appendix C: Open-ended questionnaire

Questionnaire on urban green wall planning and development

Name	
Contact details	
City	
Organization	
Department	
Position	
Age	
Years of experience with city	
development/sustainable development/green	
wall/environment	

Part I: Basic information of the interviewee

Common questionnaire for all the interviewees

What, in your view is the importance of green walls in city development? How do you compare green walls with other green spaces in the city?

Are you satisfied with the green space in Geneva? How would you compare Geneva's green space quality and quantity with other European cities?

What are the strengths and weaknesses of green walls in your opinion? Do you have green walls in your office or home? Are you satisfied with its performance? Would you recommend green walls to anyone else?

What, in your view are the enablers and drivers for green wall development in Geneva? Are you satisfied with the role city administration play for new green wall projects?

How did the quantity and quality of the green space in the city changed in last 10 years? Is there any improvement in green wall development?

Are you aware of the current green space policies? Do you think the policies are being implemented properly? Is there any gap? What would you recommend improving that? Are you aware of the benefits of green walls? Are you willing to pay for the service?

Part II: Green Wall application or implementation

Is there any role city municipality plays in developing green wall project/s? If any, what was it? What is the city council's view on green wall development?

Do you know who finance the green wall project/s? Are there any Swiss bank involved?

Can you name some organizations who work on green space and green wall development in Geneva?

What are the policies for green space development in Swiss cities and in Geneva?

What, in your view are the barriers and drivers for green space and green wall development in Swiss cities and in Geneva?

Do the stakeholders participate in the policy implementation for the Green space development? If yes, who are they and how?

Part III: Green Wall Monitoring

Who is responsible for green space maintenance? Is it by government/non-

government/public-private partnership?

Are there any common actors responsible for Green walls monitoring in the city? If yes, who are they? If not, who monitors the individual Green Walls?

Part IV: Resource or Socio-cultural aspect

What are the motivation and uncertainties for the financers in financing Green space? Are there any financial issue?

Are there any incentives for Green Wall application, like development incentives, grants, rebates in installation, awards, fee discounts?

What are the view of the citizens? Was there any citizen survey organized by government or non-government actors? Are there any communication issues like lack of knowledge or awareness among the citizens or stakeholders?

Is there anything the city municipality planned to promote Green Wall application in next 10/20 years like major initiatives, codes, or practices?

Part V: Green space/ Green Wall Policy and Planning

Is there any urban green infrastructure (GI) integrated in current Green Space policy and Practice for Switzerland? If any, which are they? Does green wall (GW) come under them? And, what kind of planning tool and approach they follow?

Is there any biodiversity or climate change policies which might influence the green space policy or implementation?

What role the stakeholders/your organization play in the policy making?

What are the gaps or limitations of the current policy approach for green space implementations in Switzerland and in Swiss city Geneva?

Part II: Green Wall application or implementation

How many Green wall development projects you have worked on? How many of them are in Switzerland and where?

What was your experience in Green wall development in Switzerland? How do you compare your experience in green wall development in Switzerland with other countries?

Is there any role city municipality plays in developing the project/s? If any, what is it? Do you need to get any official permission for these projects from the city administration? What in your experience was the trickiest and easiest part in the project/s?

Who financed the project/s? Were there any Swiss banks involved with financing?

Did you work with any other institute or organization for the project/s? If yes, who are they and what role they play?

In your view what are the most important motivation or drivers and barriers for Green space application in Geneva?

Part III: Green Wall Monitoring

Is there any mechanism to monitor green space implementation in Geneva? If yes, what are they and how do they work? Who are responsible for the monitoring? Is it by government or non-government actors?

What are the responsibilities for individual stakeholders in monitoring Green Wall in the city?

Part IV: Resource or Socio-cultural aspect

Who is financing the green space green wall projects? What are the motivation in financing them? Are there any Swiss banks involved? Are there financial issues?

Do you know why there isn't many green walls in Switzerland?

Are there any issue with the construction material availability or performance?

Are there any issue with data on monitoring or performance?

Are there any incentives for green wall application, like development incentives, grants, rebates in installation, awards, fee discounts? Do you think this might encourage the stakeholders or users for green wall development?

What are the view of the citizens? Were there any citizen survey organized by government or non-government actors?

Are there any communication issues like lack of knowledge or awareness among the citizens or stakeholders?

What is you plan in developing green wall in next 10/20 years?

Part V: Green space/ Green Wall Policy and Planning

Is there any Urban Green Infrastructure (GI) integrated in current Green Space policy and Practice for Switzerland? If any, which are they? Does Green Wall (GW) come under them? And, what kind of planning tool and approach they follow?

Participation in Green Wall application- what are the role of new participatory practices, if any?

Are there any non-governmental actors involved? Or are there any public-private partnerships? If any, what are they?

What are the gaps or limitations of the current policy approach for Green Wall implementations in Switzerland?

Is there any room for improvement of the current policies in Green Wall application? If any, what are they?

Part II: Green Wall application or implementation

How many Green Wall development projects you have worked on? How many of them are in Switzerland and where?

What was your experience in Green Wall development in Switzerland? How do you compare your experience with green wall development with other countries?

Is there any role Ville de Geneve played in developing the project/s? If any, what was it?

What in your experience was the trickiest and easiest part in the project/s?

Who financed the project/s? Is there any Swiss bank involved?

Did you work with any other institute or organization for the project/s? If yes, who are they and what role they play?

What kind of official permissions you needed to take and from who?

How did the quantity and quality of Green Space and hence Green Wall in the city change during the last few years?

How much area of the city is covered with Green Space? How much of them are covered with Green Wall?

How much emphasis does the city administration put on conserving, restoration, and creating new Green Wall? What are the priorities for the Green Wall development in the city, like increasing green space, aesthetics, biodiversity, micro-climate, and air pollution?

What is your vision for Geneva's Green Infrastructure and hence Green Wall development?

What are the most important motivation or drivers and barriers for Green Wall application in Geneva?

Part III: Green Wall Monitoring

Is there any mechanism to monitor if the policy for city Green Wall has been implemented? If yes, what are they and how do they work?

Are there any common actors responsible for Green Wall monitoring in the city? If yes, who are they? If not, who monitors the individual Green Walls? What are the responsibilities for individual stakeholders in monitoring Green Wall in the city?

Part IV: Resource or Socio-cultural aspect

What are the uncertainties in green wall projects? Are there any financial and technical issues? Which issues are more specific for Swiss cities and for Geneva?

Are there any incentives for Green Wall application, like development incentives, grants, rebates in installation, awards, fee discounts?

Do you know the view of the citizens? How satisfied your customers are?

Are there any communication issues like lack of knowledge or awareness among the citizens or stakeholders?

Is there anything your department planned for green wall application in next 10/20 years like major initiatives, codes, or practices?

Based on current issues have there been any solutions developed elsewhere in the Europe which might be feasible to apply in Swiss cities and in Geneva?

Part V: Green space/ Green Wall Policy and Planning

Does your organization participate in any urban green infrastructure (GI) policy integration in current green space policy and practice for Switzerland? What kind of planning tool and approach they follow?

What, in your view, are the gaps or limitations of the current policy approach for green wall implementations?

Is there any room for improvement of the current policies in Green Wall application? If any, what are they?

Part II: Green Wall application or implementation

From how long do you have green walls? What is you experience in having a green wall? Are you satisfied with the product? Would you recommend it to anyone else?

How do you compare green walls with other greeneries in the city? Do you think green wall could be a possible solution to city sustainability?

What, in your view is the negative aspect of green walls? Can you recommend any possible improvement in green wall designing?

What is your view about the green spaces in the city? Are you satisfied with them? What, in your view might be the way to improve the greeneries?

Part III: Green Wall Maintenance

How do you maintain your green wall? Do you find it difficult? If yes, what are the issues and what do you suggest for and easy maintenance?

Do you find the maintenance more expensive than other greeneries? Do you think any incentive or subsidies from the government will attract more users?

Part IV: Resource or Socio-cultural aspect

Do you know the view of other citizens, users, or your neighbours on green walls? Was there any workshop or campaign ever organized by the city officials to spread the strength of green walls?

Part V: Green space/ Green Wall Policy and Planning

Are you aware of the current national and city policies on green space? Do you know if the administration is working well to implement the policies? Are you satisfied with their work?

Do you think that there is a room for improvement for the policies? If yes, what is that? Do you know the green space policy for any other cities or countries? If yes, what is your view and how would you compare other cities with Geneva?

Part II: Green Wall application or implementation

How do you value green space in cities? What do you think about green space in Swiss cities?

What is your view about green wall? Do you think they are important for cities? What do you think the strength and weakness of green walls?

Is there any role city municipality played in developing green wall project/s? If any, what was it?

What in your experience was the trickiest and easiest part to develop a green space in a city?

Do you know who finance the green space project/s? Are there any Swiss bank involved? Can you name some organizations who work on green space and green wall development in Geneva?

What is the city council's view on green wall development?

Do you know any policies for green space development in Swiss cities and in Geneva? Part III: Green Wall Maintenance

Do you know who is responsible for green space maintenance? Is it by government/non-government/public-private partnership?

Are there any common actors responsible for Green walls monitoring in the city? If yes, who are they? If not, who monitors the individual Green Walls?

Part IV: Resource or Socio-cultural aspect

What are the view of the citizens? Were there any citizen survey organized by government or non-government actors?

Are there any communication issues like lack of knowledge or awareness among the citizens or stakeholders?

Is there anything your group planned to promote Green Wall application in next 10/20 years like major initiatives, codes, or practices?

Based on current issues have there been any solutions developed which might be feasible to apply elsewhere in the Europe?

Part V: Green space/ Green Wall Policy and Planning

Is there any Urban Green Infrastructure (GI) integrated in current Green Space policy and Practice for Switzerland? If any, which are they? Does Green Wall (GW) come under them? And, what kind of planning tool and approach they follow?

Is there any Biodiversity or CC policies which have influence on the Green space policy or implementation might?

What role the stakeholders/your organization play in the policy making?

What are the gaps or limitations of the current policy approach for Green space implementations in Switzerland and in Swiss city Geneva?

Part VI: Closing

Snowball sampling:

Can you recommend any other people or experts who are dealing with Green Space Green Wall development in Geneva whom I can talk to?

Can you recommend any documents or reports which would be helpful for me read for this project?

Thank you.
Key green wall companies in Switzerland								
Swiss origin/ based in Switzerland	Non-Swiss origin/ outside Switzerland and works in Switzerland							
Living Nature Landscape, Chiasso	ANS Global, UK							
Skyflor, Lyss	Green Infrastructure Consultancy, UK							
Hydroplant, Zurich	Style Green, Germany							
Future EcoSystems, Valais	Artaqua Schweiz GmbH, Germany							
Gomes-Design AG, Altendorf	Jardin de Babylone, Paris							

7.5. Appendix E: List of policy documents analysed

Nati	onal	Local						
French/German name	English name	French/German name	English name					
	Action Plan for Swiss biodiversity Strategy, Federal Office for the Environment (FOEN)	RAPPORT D'ACTIVITÉS 2016, DÉPARTEMENT DE L'ENVIRONNEMENT URBAIN ET DE LA SÉCURITÉ	REPORT of ACTIVITIES 2016, DEPARTMENT OF THE URBAN ENVIRONMENT AND SECURITY					
	Spatial Planning in Switzerland: a short introduction, Swiss Spatial Planning Association	Règlement relatif aux plans d'utilisation du sol de la Ville de Genève	Regulations on plans of land use of the City of Geneva					
	Land use in Switzerland, Results of the Swiss land use statistics, Federal Department of Home Affaires (FDHA)	Règlement relatif à la délégation à l'aménagement du territoire	Regulation on the delegation to the development of the territory					
	Federal agglomeration policy (2001), Federal Office for Spatial Development (ARE), State Secretariat for Economic Affairs (SECO), in association with other federal offices	Règlement relatif à la mise en oeuvre de l'IN- 3 « Sauvons nos parcs au bord du lac! »	Regulations on the implementation of the IN-3 "Save our parks at edge of the lake! "					
	Federal agglomeration policy 2016+, Federal Office for Spatial Development (ARE), State Secretariat for Economic Affairs (SECO), in association with	Règlement relatif au plan d'utilisation du sol localise « Petits Délices »	Regulation plan on localized land use "Little Delights"					

other federal offices		
Swiss Environmental law: a brief guide, Federal Office for the Environment (FOEN)	Règlement du Fonds de responsabilité solidaire pour les marchés publics de la Ville de Genève	Fund Regulation solidary responsibility for public procurement of the City of Geneva
Tour of Switzerland's best practices in sustainable development, Federal Office for Spatial Development ARE	Vive nos arbres, Communiqué de presse de la Ville de Genève et de l'Etat de Genève	Long live our trees, Press release of the City of Geneva and the State of Geneva
Spatial Planning and Development in Switzerland, Swiss Federal Office for Spatial Development ARE, ETH Zurich		
Sustainable development in Switzerland: A Guide, Federal Office for Spatial Development		

7.6. Appendix F: Barriers and Enablers for green wall development in Geneva

Barriers		Inte	erview	1				Literature	Total	
		Res	spond	ents				_		
		Government	Entrepreneur	Businessman	Academic	Politician	User/citizen	National and loca policy documents	Research articles	
Governance, policy, management	No push from city administration	4	1	4		1	1			11
U U	Lack of defined policy	4	1	5			1	6		17
	Less matured market			1						1
	Takes too long to get official permission		1							1
Economic	High capital and maintenance cost	3	1	5	2	1	1			11
	No incentives or subsidies		1	5	1					7
	High labour cost			4	1	1				6
Technical	Problem with irrigation system	3	1			1	1			6
	Problem with plant replacement			1			1			2
	Consplicated installation with many experts'		1							1
	invogvement									
	Plant selection			1						1
	Construction and maintenance problem with very high walls			1	1					2
	Electrical and mechanical problem		1	1						2

Barriers for green wall development in Geneva (found through interviews and literature survey)

Social	Lack of interest among local stakeholders		1	3					4
	Lack of knowledge among citizens	1	1	4	1		1		8
	No appreciation for new technologies	4	1	4			1		10
	International population	1							1
	Lack of encouragement	4	1	4					9
Geographical	Harsh winter conditions				1	1	1		3
	City with lots of greeneries		1	2					3
	Less polluted city			3					3

Enablers for green wall development in Geneva (found through interviews and literature survey)

Enablers		Inte	erview	V				Literature	review	Total
		Respondent								
		Government	Entrepreneur	Businessman	Academic	Politician	User/citizen	National and loca policy documents	Research articles	
Governance, policy,	Specific department in city council in		1	3	1			2	1	8
management	charge of creating and maintaining city									
	green spaces									
	Green space policy and planning		1	2	1	1		7		12
	ENational policy on biodiversity and climate	2			1			8		11
	Schange									
	Budget for green space development	3			1	1		2		6
Economic	EHigh income of citizens		1	4			1			6
	Increased property value			2						2

	Less expensive than creating and			1					1
	maintaining parks								
	Less expensive for small size			2					2
Technical	New technology with easy maintenance			2					2
	(customer product)								
	Only needs vertical surfaces, no need for			4	1				5
	any land area								
	Easy plant replacement technology			2					2
	Wet wall with fire prevention system			1					1
	Ecosystem services	2	1	5	2				10
Social	Interested stakeholders of non-Swiss origin		1	3					4
	Growing interest among experts and		1	3	1				5
	researchers								
	Growing interests among few businessman		1	2	1				4
	Job creation		1	4					5
Geographical	Less livable area for humans					1	1		2
	Congested city with less space for parks		1	4	1	1	1	2	10
	and other greeneries								

CEU eTD Collection

7.7. Appendix G: Green wall development project by HEPIA

The green wall developed by HEPIA and Skyflor was an experimental study to measure the potential of green walls as an acoustic insulator in the city of Geneva. The green wall was created in the laboratory of HEPIA and was carried out and was hung on an existing building wall. They used a ceramic structure to build a wall on which they planted the seedlings. The ceramic structure was a unique design developed for this project. The porosity of the structure was very high creating a continuous easy water flow in plants and in substrate. Figure 13 and 14 shows the structure of the ceramic wall and how plants grow in it. The study resulted in a successful implementation of green wall and produced significant contribution in the traffic noise absorption in peak hours. The only problem reported is the cold-climate intolerance of the plants (Interviewee XIII).



Figure 29: Structural lays of green wall made by HEPIA and Skyflor. Image source: HEPIA



Figure 30: Top and front view of the ceramic structure made by HEPIA. Image source: Author



Figure 31: Structural details of the green wall developed by HEPIA



Figure 32: Plant growth in ceramic structure made by HEPIA. Image source: HEPIA