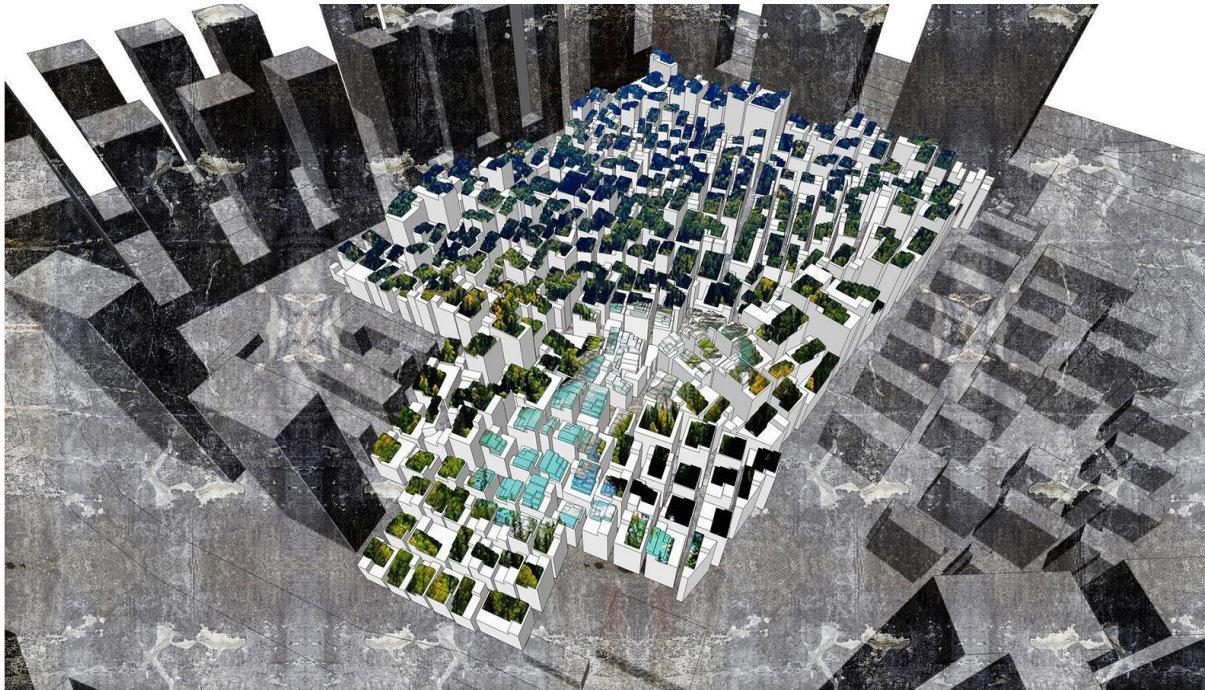


# THE PRACTICE OF GRASSROOTS GREEN ROOF PROJECT IN SHENZHEN, CHINA



Master's Thesis for the Spatial Planning (Planologie) program  
Nijmegen School of Management  
Radboud University  
November 2019  
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# **THE PRACTICE OF GRASSROOTS GREEN ROOF PROJECT IN SHENZHEN.CHINA**

Master's Thesis Spatial Planning

Specialization: Land and real estate development

Faculty of Management

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Date: November 2019

Word count: 37434

## **Preface**

This thesis explores within the sponge city context, What are the challenges and opportunities to foster the participatory, green-roof grassroots innovation initiative in Gangxia, Shenzhen China, especially in regard to building in urban village.

When I was doing an internship in Shenzhen, I found a green roof project built on the residential building of Shenzhen urban Village in the online report, which caught my attention. I also lived in an urban village. I have an intuitive understanding of the living environment of an urban village, and most of the urban village has no open green space because of the high building density. The intuitive feeling given to me is the planning of the urban village is out of touch with the world outside. The project of the green roof of the Gangxia 1980 is an attempt to break through this disconnect and create sponge construction in urban village. For me, researching this project is interesting. I want to know how this project is produced, how it is practiced, and whether this project model can be extended to other urban village projects.

In the process of continuously completing the thesis, I would like to especially thank my thesis supervisor Professor Pascal.J. Beckers. Because of my previous personal problems and hesitation led to the extension of my thesis, Professor Pascal.J. Beckers has always been patient with me, giving quick and intuitive feedback on my questions, helping me to improve the critical thinking of academic papers. I am also very grateful to Prof. Erwin van der Krabben for his internship recommendation, through the internship in Shenzhen I found this research project. I also would like to thank all the people who accept my interview and survey invitation, their feedback on my research question are essential for the analytical work of this research. I would love to thank my friends and family those who support me through the entire process of thesis writing.

Yiyu Wang

November 2019

## Summary

This dissertation provides an examination of the practice of grassroots green roof project in Shenzhen, China. The research was primarily informed by the rapid growth, development, and expansion of the urban centers, specifically cities, which has resulted in the scarcity of the green infrastructures within these regions. Therefore the study aims at examining the practice of grassroots green roofing projects in enhancing resilient and healthy climate within urban settlements.

The primary purpose of the study was to examine the challenges and opportunities presented by grassroots green roofing projects with respect to the sponge city context. The research aimed at achieving the following objectives; to explore and explain sponge city strategy, to determine the organization of green roof implementation in the urban village and the stakeholders. Categorized it to a grassroots innovation project, to determine the current community involvement in the green roof project and to examine the potential solutions towards fostering the green roof implementation in urban villages through grassroots innovation. Literature relevant to the study was fully explored and reviewed to ensure acknowledgment of others scholar's works and avoid duplication of research efforts.

The study employed an anti-positivist research philosophy to facilitate the utilization of qualitative research methods to ensure an in-depth exploration and examination of the research phenomenon. A case study research strategy was adopted for the purpose of the study in narrowing the focus on this particular research. Interviews were utilized as the data collection instruments whereby four participants were interviewed, and relevant secondary data were fully explored. Content Analysis was utilized in analyzing the data collected through interviews. The study focused on examining green roofing project a case of Shenzhen, Ganxia urban village where different stakeholders such as NGOs, private companies (Glocal Company) as well as the community participate either directly or indirectly to the project. The project is managed by a private company named Glocal, with collaboration from other stakeholders such as NGOs and the local administration as well as the surrounding community. Through collaboration, networking, and learning and implementation coordinated by the different stakeholders, the vision of the Gangxia village is achieved.

From the findings of the study, there are various challenges that impact the development of green roofing project within the context of sponge city which includes, the complexity of technologies required for the implementation of the initiative, lack of linkage mechanisms in distinct sector,

unsatisfactory conditions within the urban villages buildings, inadequate funding to facilitate the implementation of the projects and the inadequacy of understanding by the public with respect to the construction and renovation of the sponge city initiatives. On the other hand, the opportunities presented by this initiatives involve the creation of employment, development of community-based organizations, and the reduction of environmental pollution that, in turn, enhances a resilient and healthy climate. Based on the findings, the study recommends that the residential building in Shenzhen should have an excellent public opinion foundation, an increase of funding towards this type of project, and the creation of awareness regarding the design concept in relation to sponge city.

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# CHAPTER ONE: INTRODUCTION

## 1.0 Overview

This chapter presents the research introduction addressing the following research study areas, research background, research problem statement, research content, research objectives, research questions, and the special and scientific relevance of the study. It provides an introductory part to the research from which the other chapters will be based as well as putting forth the significance and relevance of this particular study through the objectives it aims at achieving.

## 1.1 Research Background

Notably, the tremendous changes in the climate, inappropriate planning policies within urban settlements and rapid urbanization levels in many regions around the world have contributed to the water management and related problems in urban settlements such as flooding, water shortage as well as pollution. Therefore, the efforts to tackle and remedy this particular problem results in the emergence of an urban water management strategy referred to as sponge city. This particular water management strategy has been implemented in China since 2013 in the effort to manage their urban water and avoid the consequences of inappropriate management of water thereof (Nguyen et al., 2018). A sponge city relates to a center or a city with the capability to mainstream the urban water through managing it into the urban planning design and policies. Therefore, ultimate planning, policies, and legal framework are critical tools in the implementation, maintenance, and adoption of the sponge city water management infrastructure to facilitate the collection, storage, and treatment of excess rainwater.

Additionally, the sponge city water management mechanism is not only used in managing excess water, but it also aids in reusing rainwater, which aids in mitigating the effects of dirty and little water in urban settlements. Zevenbergen, Fu, and Pathirana (2018) asserted that, as a primary response to the increasing rains water and impacts of floods in different regions of China, the Chinese government called for the increased uptake of the sponge city as a water management approach across the country in 2013. The government provided financial and educational support to the community members to foster the sponge city implementation process within selected pilot urban settlements or cities. As a result of the underlying benefits noted from the implementation of this particular approach, sponge city has gained popularity and ground such that the city governments have accepted it fully. The best successful practices undertaken in Chinese cities have been shared and exchanges internationally between research centers with city administration providing guidance on the design and implementation of the new technological concepts

(Hermaputi & Hua, 2017). Therefore, the sponge city approach is a significant urban water management approach whose benefits cannot be ignored.

According to Nguyen et al. (2018), the sponge city approach's primary aim is to facilitate an effective and efficient water management system through its four principles, which include; ecological water management, urban water resourcing, urban permeable pavements, and green infrastructures. Ecological water management involves the protection of the ecosystem through meeting human needs specifically for water as well as an array of other products by providing fresh water through natural ecosystems. Urban water resources ensure that the water is adequate within the urban settlements regions, while urban permeable pavements are essential material that allows the water infiltration through the pavements, sidewalks, and streets, reducing water runoff.

Similarly, green infrastructure is another aspect of sponge city as it a water management approach that protects, mimics, and restores the natural cycles of water in urban regions. It is an effective and economical water management approach that enhances the safety of the community through the quality of life. Green infrastructure involves the planting of trees, vegetation among other plants with the aim of restoring the wetlands rather than the development of a costly water treatment plant. One of the green infrastructure initiatives is green roofing that involves planting vegetation among other plantations on the building's rooftop, which acts as water catchment areas; thus, reducing stormwater and water runoff effects (Xiao et al., 2014). Green roofs are among the most effective energy efficiency measure through which rainwater management and cooling of the building can be enhanced as well as its ecological benefits and community landscape value. Thus, the green roof rainwater management aspect reflects the sponge city approach; hence, it's among the sponge city construction initiatives due to similarity in functionality and aims. In addition, sponge city policies offer a strong foundation and basis for green roof initiatives.

Despite the implementation of sponge city strategy in China, green roof infrastructure development in this region is relatively new as many cities focus on the new structures and building for this particular initiative. The sluggishness in relation to the development of green roofs is contributed by the lack of advanced technologies and professionals to promote and spearhead the greening of the roofs besides the existence of considerable favorite policies. For example, the penetration of the green roofing initiative in Shanghai is estimated to be below 2 percent, as well as other major cities in China (Chen, 2017). The need for advanced technology to enhance the green roof initiative and the focus on new build structures within cities exempts the inform settlement within urban

areas from this particular initiative. Therefore, informal urban settlements should also be pictured in the city planning with respect to water management systems to ensure that these regions are secluded in the city water management planning, design, and implementation. As a result, to discover the possibility of implementing green roofs in the informal housing area is essential to avoid their exemptions, especially in China, where more focus is placed on newly built structures. Therefore, this paper focuses on exploring the challenge and opportunity of grassroots innovation green roof project is facing and how the local community can get involved with the project, how SNM might help to foster this type of grassroots innovation project within the sponge city program.

## 1.2 Research Problem Statement

Water management systems especially is a significant endeavor which can be enhanced through the utilization of sponge city approach and strategies. Sponge city strategies provide effective ways through which water and related problems can be effective management in urban centers including informal urban settlements areas. In the efforts to manage storm waters, China has implemented the sponge city strategy to avoid the aftermath of the effects of this particular (Nguyen et al., 2018). However, to enhance the effectiveness and efficiency of water management systems through the utilization of the sponge city strategies its principles such a green infrastructure, grassroots innovation, community engagement are critical aspects whose implementation in China is relatively low due to the rapid urbanization rates.

The rapid expansion and development of the city have caused the green infrastructure in the city to become scarcer (Lai et al, 2014). Cities need green space to facilitate its protection and restoration of the natural water cycles within these settlements which in turn enhances a resilient and healthy ecosystem; hence the need for three-dimensional greening technologies. Among these technologies, roof greening has become an excellent way to build green infrastructure in areas with high urban construction density. Roof greening was developed in China in the 1990s and today, it has been developed in many cities. Unfortunately, the speed of its development is relatively slow due to the (Liu et al, 2010). This is because the focus is placed on new build structures and the lack of advanced technologies as well as professionals to facilitate the development of the green roofs, especially in informal urban centers making it hard to implement despite its significant benefits towards water management and greening of the roof.

The Urban Village is a product of the rapid development of Chinese cities. Urban villages continue to meet the needs of the rapidly increasing urban population expansion (Wang, Wang, & Wu, 2009).

In Shenzhen, for example, there are 1044 urban villages, with more than 10 million people. Urban villages provide 60% of the city's housing supply (Hin & Xin, 2011). Therefore, the residential environment in the village is increased and the green infrastructure is reduced, the layout of the buildings is not sustainable, and the transformation of the villages in the city is inevitable. Therefore, the need to utilize innovations such as grassroots innovations to facilitate the development and implementation of the green roofing initiative in these urban villages can hardly be ignored. This is because, through grassroots innovation, the green roof initiative has higher chances of success as it will involve third parties such as NGOs among other agencies which will offer educational and financial support to the residence of the urban village regarding the importance of the initiative to enhance collaboration.

Combine the climate adaptive action and the need for urban village transformation. Among them, roof greening of the existing urban villages buildings becomes a possible solution. This is due to the dense construction of the villages in the city and the lack of public space; hence roof greening has become a possibility of greening the villages (Lai et al, 2014). In addition, it acts as a source of employment and food production mechanism in these regions; therefore, creating awareness regarding its benefits will result in community engagement and participation in these particular projects. Community engagement and participation in every developmental project is critical as it ensures its continuity by eliminating resistance from society and fostering coordination and collaboration with the supporting agencies. As a result, the effectiveness and success of the green roof initiative project are dependent on the community engagement and participatory levels; thus, its importance cannot be overlooked.

Based on the need for urban greening renovation and the construction of the sponge city, it is important to practice green roofs in urban villages. However, the complicated management mechanism and property rights of the urban villages in the city has resulted in significant challenges to roof greening from the municipality level. Therefore, the purpose of this paper is to explore what are the challenge and opportunities in the sponge city grassroots innovation project in china, with Shenzhen serving as an example. This is achieved through an in-depth study of the sponge city strategy, roof greening, and grassroots innovation. Further, the challenges faced by urban village roof greening renovation are explored to discover ways of fostering grassroots roof greening projects. This paper uses the roof greening project of Gangxia 1980 as a case study. Through this case study, the paper explores the grassroots innovation character in green roof project and the mode of practice and promotion of the grassroots green roof project.

### 1.3 Research content

This paper aims at examining the challenges and opportunities presented by fostering a participatory approach in green roofing as a grassroots innovation initiative within the sponge city context. This research will first explain the sponge city strategies and their significance in relation to green roofing initiatives. Secondly, it assesses how the green roofing initiative can be viewed from the grassroots innovation programs through exploring ways through which distinct shareholders collaborate in these projects to enhance their successful implementation. In addition, the application of strategic niche management in relation to fostering the green roof initiative specifically as an example of grassroots innovations. Finally, the paper will identify the motivation of the community to participate in the roof greening initiative, explain the significance of the community engagement in these particular initiatives. The specific content includes the following points;

1. Analyze the sponge city strategies, how the green roofing initiative can be attributed as grassroots innovation as well as how distinct shareholders collaborate in enhancing the green roof initiative. Provide theoretical and conceptual foundations for the research.

2. Explore the essence of the strategic niche management application in fostering the green initiative specifically as grassroots innovation. This will provide the relationship between the green roofing and grassroots innovation programs.

3. Analysis of the community engagement in relation to its significance to the green roofing initiative in informal urban settlements.

4. Identify the current legal policies, planning policies, and implementation methods applicable to roof greening.

5. Assess the problems faced by community participation and roof greening projects through case studies. Taking the Gangxia 1980 project as an empirical case that analyzes the current policy issues, technical issues, and management issues of roofing greening in urban villages.

6. Finally, based on the analysis results, the proposal to promote community participation in the roof greening of urban villages is proposed.

### 1.4 Research objectives

- 1.To explore and explain sponge city strategy
- 2.To determine the organization of green roof implementation in the urban village and the stakeholders. Categorized it to a grassroots innovation project
- 3.To determine the current community involvement in the green roof project
- 4.To examine the potential solutions towards fostering the green roof implementation in urban villages through grassroots innovation

### 1.5 Research questions

1.What are the challenges and opportunities to foster the participatory, green-roof grassroots innovation initiative in Gangxia, China, within the context of the Sponge City program?

Sub-questions

- 2.What are the sponge city strategies?
- 3.How can the green-roof initiative be characterized from the perspective of grassroots innovations?
- 4.How do different stakeholders collaborate in the project?
- 5.How can strategic niche management be applied to foster the green-roof initiative as an example of a grassroots innovation?
- 6.How can this initiative engage with the local community?

### 1.6 Social relevance

Surface water flooding is perceived as one of the major concerns in relation to water management in a considerable of Chinese cities, which has been contributed by the rapid rates of urbanization, change in land usage and the socio-economic development processes. Therefore, the need for devising ways and measures through which this particular problem can be rectified is critical especially within the Chinese society to curb the surface water flooding problem. As a result, the People's Republic of China embarked on the establishment of sponge city concept back in 2014 in the effort to tackle the water flooding issues through various ways which included; water conservation, attenuation of the peak runoff. Therefore, the concept of the sponge city is relevant and significant to the current Chinese society due to rapid urbanization rates which have resulted in the establishment of informal urban settlement; hence, the need for sponge city is apparent to facilitate surface water flooding management in these regions.

The rapid development of urban centers in China population has increased tremendously result in the development of informal urban settlements. This is an indicator that needs to devise ways

through which the changes in climate in the established settlements are apparent and cannot be overlooked. For instance, the rising temperatures, food, and water shortage are among the concern problems faced by the individual in Chinese societies' especially those residing in informal urban settlements. The integration of grassroots climate-adaptive projects is essential to address the changes of climates in regions where the less privileged and marginalized groups reside. Grassroots innovation involves the planting of vegetation and trees to provide shade especially during hot seasons which is a common problem in most Chinese cities. Therefore, the need for grassroots climate-adaptive projects in these societies is apparent to enhance healthy and climate resilience in distinct regions.

The increased number of urban villages in different regions in China has resulted in various challenges such as food and water shortage. However, through the implementation of green roofing initiatives, these issues can be eradicated. This is because green roofing involves the planting of several plants which can be used as food crops; hence, providing food to the surrounding society. In addition, it acts as a source of employment to those who engage in this activity since they sell their products to others; thus, improving their living standards. The presence of urban villages in various Chinese regions justifies the essence of green roofing since it not only enhances food provision but also aids in the regulation of the heat temperatures and management of the surface resulting in a conducive and habitable environment.

Climate changes affect the surrounding community especially those without adequate knowledge and resources on how to cope with the changes in climate. Therefore, the need to enhance the communicate engagement in various projects which aim at enhancing the climate is very essential. For instance, the success of the grassroots innovation project is dictated by the willingness of the community involved in relation to participation and commitment to the project. This is because in case the community resists, it becomes hard for the project to be successful. Therefore, community engagement in relation to the grassroots climate-adaptive project is relevant in current Chinese societies since it dictates the success of the project initiated.

### 1.7 Scientific relevance

Notably, this case study provides significant insights into the aspect of green roofing in relation to its significance in facilitating a healthy and resilient climate, especially in urban villages. It explores the relationship between the green roofing initiative, grassroots innovations, and sponge city. The green roof is a segment of grassroots innovation since it is conducted at the grassroots, in this case,

the informal urban settlements through the help and collaboration of various stakeholders to provide financial among other forms of support. In addition, the green roof initiative reflects sponge city strategy as they both strive towards the management of surface water. Therefore, through the challenges and opportunities identified by this study, policymakers will be able to pinpoint the opportunities presented by this particular initiative as well as issues or challenges that hinder the successful implementation of green roofing programs ; therefore, they can devise means to overcome the identified challenges resulting in effective and efficient implementation of green roofs.

### 1.8 Chapter summary

This chapter presents the research introduction and background to gain an in-depth understanding of the green roofing and grassroots innovation concept as well as their historical developments. In addition, it provides the research objectives which the research strived to achieve and research questions that the research aimed at answering. The second chapter provides a review of literature relevant to the study to facilitate the acknowledgment of other scholar's work to avoid duplication of research efforts. It also aimed at generating research from which the study addressed and filled where possible.

## CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

### 2.1 Overview

This chapter examines the literature relevant to the subject under study. It provides a critical review of the relevant works of literature conducted in the past to ensure the acknowledgment and understating of the contributions made by other scholars within this particular area of study. The significance of the literature review in research cannot be overlooked since it aids in eliminating duplication of research efforts by acknowledging other scholars by means of complete referen ce.

### 2.2 Sponge City

Currently, due to the shortage of water resources in China, sponge city has become a hot spot for urban development and construction in China. Wu Haibo's application of low impact development technology in flood control and drainage planning points out that the creation of the sponge city is a low-impact development model that conforms to nature, maintains the original water ecology, and coexists harmoniously with nature. It's also known as low impact design or low impact development. The fundamental purpose of the sponge city is to save and regulate water resources.

The sponge city takes low-impact development (LID) as its core guiding ideology to solve the issues of waterecology, water environment, water security, and water resources (Ahiablame, Engel, & Chaubey, 2012). This strategic goal is to be achieved through a combination of gray and green infrastructure, which is sustainable urban development. Low-impact development (LID) is defined as the use of source reduction, process control, and end-of-treatment methods for infiltration, filtration, storage, and retention to prevent disasters. LID was first proposed in Prince George's County, Maryland, and the USA in the 1990s for optimal management practices for urban storms (Guillette & Studio, 2005). Specific measures for LID include permeable road surfaces, green roof, rain garden, stagnant grass ditch, rainwater regeneration system, etc.

Sponge City means that the city is spongy and has excellent "elasticity" in adapting to environmental changes and coping with natural disasters (Chan, Griffiths, Higgitt, Xu, Zhu, Tang, & Thorne, 2018). When it rains, it absorbs, accumulates, sweeps clean, and releases the water when needed. In recent years, some cities in China have experienced severe glut after heavy rains (Ahiablame, Engel, & Chaubey, 2012). In October 2014, the Ministry of Housing and Urban-Rural

Development issued the trial implementation of the "Technical Guide for Sponge City Construction," making the eco-friendly construction methods such as low-impact development and rainwater system planning become essential for urban development. Sponge-type urban construction mainly consists of infiltration and utilization of rainwater in urban green space (Chan et al., 2018). The infiltration and utilization of rainwater can be through urban ecological rivers and green roofs and squares.

There are three ways to build a sponge city, from the regional level, city level, and the building level. The initial step is the restoration and protection of the overall regional ecological water system (Li, Dong, Wong, Wang, Kumar, & Singh, 2018). Secondly, is the design and renovation of the sponge city in the urban planning area. Thirdly, the rainwater utilization and reclaimed water reuse of the building. In the construction of sponge cities, the primary way of building design and renovation is the promotion of popularity of green roofs, permeable parking lots, rainwater collection, utilization facilities, and the reuse of water in buildings whereby the water reuse rate in buildings is generally not less than 30% (Li et al., 2018).

### **The six-word policy of sponge city engineering**

**Seepage:** By constructing and renovating the roof of the building (the method of greening the roof), the permeable road surface and the natural ground, the runoff can be reduced from the source to purify the initial rain pollution. Change the design of the underlying surface of the city, use water-permeable materials to achieve smooth infiltration of rainwater, enter the sponge system, and store it for reuse, or directly into the ground to replenish groundwater to prevent and slow down the city. The subsidence of the stratum plays a role. (Wu et al. 2015).

**Stagnation:** By constructing a recessed green space, adjusting the pool and planting grass ditch, the purpose of delaying the peak time of runoff is achieved. Prevent the rainwater from entering the underground pipe network and exhaust it, causing waste, and applying relevant settings to intercept the infiltrated rainwater.

**Storage:** Rainwater storage facilities that are used to recover and renovate rivers and lakes and wetlands in urban built-up areas, and collect rainwater in the ground for reuse. Also known as rainwater harvesting modules, multiple rainwater harvesting modules are installed underground. Forming a huge underground reservoir system, rainwater collected or simply treated can be used

as medium water (middle water refers to reclaimed water, said urban sewage or domestic sewage after treatment has reached a certain water quality standard, at a certain It can be reused within the scope, but it cannot be used, including water and large buildings in the sewage treatment plant after deep treatment, bathing water in the residential community, washing vegetable water), water can be applied to the toilet, pavement Clean, green management, water features and fire protection.

Net: Through the sewage treatment facilities and related ecological measures, the rainwater pollutants are filtered, diluted, decomposed, and the non-point source pollution is reduced so that the urban water environment is improved. In the park green space, plant design can be used as the main bearer of the park green space purification rainwater work. If the hydrological conditions at the park base site are good, the artificial wetland method can be adopted, and the rainwater garden can also be paralleled to achieve a two-pronged function, using rainwater. The garden's storage function improves the ecological environment. In urban parks, wetland plants are mainly used to achieve the effect of purification, and it is more cost-effective than artificial purification. Through the construction of artificial wetlands in the city, the rainwater is purified through wetlands to improve water quality and ensure ecological balance.(Yu.2016)

Use: The rainwater collected and treated by the sponge system can be used for watering, road washing, car washing, and landscape water.

Row: When the rainwater is applied and the rainfall exceeds the maximum treatment threshold of the rainwater harvesting system, the rainwater can be properly discharged into the underground pipe network to avoid causing a greater load on the sponge system. It mainly includes the renovation of the village rainwater and sewage diversion pipe network and the drainage facilities of low-lying water points.

In the design guidance section for the construction of sponge cities promulgated in 2014, it was proposed that buildings with smaller roof slopes can adopt green roofs, and the design of green roofs should comply with the provisions of "Technical Specifications for Roofing Engineering" (GB50345) (Li et al., 2018). This encourages the promotion of green roofing for new and existing buildings.

## 2.3 Green roof

Intensive development of infrastructures associated with cities and suburbs such as roads, buildings, and parking spaces, has a significant effect on the natural environment in that they progressively reduce the pervious surfaces (Getter & Rowe, 2006). In natural habitats, a lot of the rainwater penetrates into the ground or goes back to the atmosphere through evapotranspiration.

Intensive development takes up space that was previously covered by forests and agricultural lands and converts them into urban and suburban settlements thus significantly adding to the increase in impervious surfaces (Nurmi et.al., 2013). This trend is worrying especially with increased global awareness and inclination towards sustainable development in response to the progressing threats on the environment and lurking dangers such as global warming (Getter & Rowe, 2006). These concerns have made it necessary to direct efforts towards recovering green space, especially in urban areas.

One possible solution for this problem exists in Vegetated or green roofs. “Green roofs are roofs that are partially (or almost completely) covered with vegetation” (Nurmi et.al., 2013). Installing plant material on rooftops produces a number of both ecologic and economic advantages such as the management of stormwater, conservation of energy, and reduction of the urban heat island effect, and increased longevity of roofing membranes, as well as providing a more aesthetically pleasing environment in which to work and live” (Getter & Rowe, 2006). Additionally, the creation and conservation of green roofs offer business openings for “nurseries, landscape contractors, irrigation specialists, and other green industry members while addressing the issues of environmental stewardship” (Getter & Rowe, 2006).

### 2.3.1 Types of green roofs

There are several disparate classifications of green roofs that differ on the basis of the soil depth, the species of plants, the mass, the manner in which it is used as well as the number of enhancements on the roof (Greensulate, 2016). In general, green roofs are described as extensive, intensive, or hybrid.

#### **Extensive Green Roofs**

An extensive green roof is a portable, modest maintenance option that is convenient for extensive areas with the utmost benefits and minimized human access. This type of green roof can be rested

above a slanted or flat rooftop (Greensulate, 2016). The planting method for these roof types varies from 7 to 10 centimeters in depth. Normally, drought-resistant sedums and grasses are popular for this type of roof because of their shallow roots and minimized water uptake

A variety of plants on extensive green roofs is kept at a minimum so as to regulate moisture requirements and also facilitate ease of maintenance. However, this type of roof may need to be watered periodically, especially during dry periods in regions that experience extended periods between rainfalls (Greensulate, 2016). Although the modes of the installation may differ, one distinct characteristic of extensive green roofs is that installation is fast, therefore providing an immediate green effect. Installation is also relatively simple as they are regularly added to pre-existing roofs (Greensulate, 2016).

### **Intensive Green Roofs**

An intensive green roof is represented by deeper planting methods, increased plant variation as compared to an extensive roof, and extended facilitation for human access and usage. Intensive green roofs are normally made up of grasses, ground covers, flowers, shrubs, and trees, which provide biodiversity on the rooftop (Greensulate, 2016). On many occasions, Intensive green roofs incorporate paths and walkways which traverse between various architectural features so as to allocate space where individuals can keep in touch with the natural environment. Additional infrastructures such as benches, tables, planter boxes, greenhouses, ponds, and fountains offer people places to relax, dine or work in park-like settings (Greensulate, 2016). Once the plants are installed and the soil is moist these rooftop green spaces can weigh as much as 150 pounds per square foot. The irrigation and drainage systems have to operate at peak efficiency to reduce the chances of overloading the roof's structure (Greensulate, 2016).

### **Hybrid/Semi-intensive Green Roofs**

As the name suggests, hybrid roofs are made up of a mixture of both extensive and intensive roofs. They make use of most of both of these green roof types (Greensulate, 2016). They provide flexibility for various roof styles, broad plant variety, all with little maintenance and price of an intensive roof.

### 2.3.2 Advantages of green roof

#### **Storm-water management**

Urban areas are usually characterized by hard, impenetrable surfaces of lanes, access roads, and buildings. This state generates problems because impervious surfaces considerably increase storm-water runoff, reduce groundwater rejuvenation and increase stream channel as well as river erosion (Mentens et al., 2006). Among the greatest environmental issues in urban regions is that water systems are forced to endure extremely fluctuating volumes of surface water runoff.

Extreme runoff enhances the possibility of flooding downriver as surface water runoff overreaches channel volumes, leading to the possibility of property destruction and human trauma. An increased amount of surface water runoff also has the potential to overburden urban sewer systems. Integrated sewerage systems are made up of a single conduit that conveys both wastewater and runoff water to treatment facilities (Deutsch, Whitlow, Sullivan, & Savineau, 2005). In a case where runoff water overreaches its volume, the combined sewerage risks overflowing into natural points, causing untreated waste to be deposited into rivers, an occurrence referred to as combined sewage overflow (CSO). During periods of heavy rainfall in urban areas, the volume of stormwater may multiply by up to ten or twenty times in comparison to ordinary cases. One solution to this problem exists in constructing underground tanks to store excessive runoff. Another technique to solve the runoff problem is to employ vegetated surfaces such as green roofs as a substitute or a corresponding solution to other existing runoff water control measures. Therefore, green roofs store water during rainfall events, delay runoff and return precipitation to the atmosphere through evapotranspiration (Nurmi et.al. 2013).

#### **Membrane durability**

Green roofs prolong the lifetime of the roofing membrane by guarding against heat intensity, daytime variations, and UV radiation. The subjection of the roof substances results in the disintegration of the roof materials. A significant amount of research shows that green roofs at the minimum extend the lifetime of the roofing membrane to 40 or 50 years (Nurmi et.al. 2013).

#### **Noise insulation**

Noise pollution is progressively presenting itself as a serious problem in urban settings. Noise

creates a nuisance for people and generates economic challenges by decreasing productivity among staff members and also lowering property values by minimizing demand (Connelly & Hodgson, 2008). According to (Nurmi et. al. 2013), more than 170 million individuals in the EU reside in neighborhoods where noise is a cause of discomfort. Approximately 80 million individuals or 20% of the European population are subjected to noise extents that are intolerable. (Nurmi et.al. 2013)

The consequences of subjection to excessive noise levels include discomfort, sleep hindrances and increased danger for negative health effects. The leading cause of noise pollution in urban settings is transportation mainly from the road and a substantial amount from air transport. Green roofs can be applied as a measure to enhance the transmission loss of roofing so as to boost the noise protection features of a building. According to a research conducted by Connelly & Hodgson, (2008), lightweight green roofs (substrate depth 40-150 mm, drought-tolerant plants) produce a greater transmission loss in comparison with a supplementary ceiling component. (Nurmi et.al. 2013).

### **Regulation of Building heat**

Green roofs play an important role in minimizing the quantity of heat transmitted through the roof during hot weather. This property causes the energy requirements of the building's cooling system to diminish. Green roofs minimize heat fluctuation through the roof by means of evapotranspiration, by practically concealing the roof and by enhancing the cushioning and heat mass. However, green roof outcomes on energy requirements for cooling is a complex specification to approximate since it is largely determined by the type of building, the proportion between roof and ground areas, geographical setting and vegetation type. The advantage is generally enhanced in warmer climates and in facilities characterized by low-quality insulation though it might also depreciate in hot arid regions with a deficiency of water. Therefore, the cumulative cooling requirements are determined by among other factors the building type, location, and use.

### **Microclimate regulation**

In urban settings, vegetation has predominantly been interchanged with impervious and generally dark coverings. These circumstances lead to an urban heat island effect, where urban areas are reasonably warmer than the encompassing suburban and rural areas, especially during night-time. Studies have shown that green roof infrastructure has the potential to reduce average surface

temperature significantly. However, while some outcomes of green roofs such as reducing energy demands during winter are positive, others such as an increase in mortality in the event of a heatwave are negative. (Nummi et.al. 2013)

### **Reduction of air pollution**

Plants have the ability to filter out granular elements and gaseous contaminants in the atmosphere. Particles are ultimately washed away into the soil by rainwater, and part of the pollutants are assimilated into plant tissues. An array of airborne pollutants can be mitigated by green roofs. Various studies have demonstrated the capability of green roofs in the reduction of pollutants such as sulfur dioxide, dust particles, and nitrous acid as well as pollution from diesel engines. The negative health effects associated with air pollution from particles include heightened respiratory complications, declined lung operation, as well as increased hospital admittance and associated health care calls for respiratory and cardiovascular diseases. (Nurmi et.al. 2013)

However, air pollution as it ascribes to wellbeing is not the only concern. Some cities, for instance, Washington, D.C., are at risk of missing out on federal funds due to failure to conform to federal air quality requirements for particulate matter. Assuming that 20% of all current ‘green roof ready’ structures in Washington, D.C., enforced the technology, the resultant plantings would get rid of a similar amount of air pollution as 17,000 street trees (Deutsch et al., 2005).

### **Aesthetic and psychological benefits**

Green roofs contribute to both aesthetic and psychological advantages for populations residing in urban centers. Encounters with nature are proven to provide restorative effects such as increased happiness. However, benefits resulting from aesthetics in urban settings are among those that are the toughest to determine. The greening of urban areas has also been established as a positive influence on property valuations. This outcome is complex and largely determined by other factors such as location, however, it still partly demonstrates the effective aesthetic and psychological significance of urban greening and it is plausible to advance it to green roofs that are physically or visually accessible.

### **Increasing biodiversity and providing urban habitat**

Since almost all extensive green roofs are distant from the general population, they can present an uninterrupted habitat for microorganisms, insects, and birds (Getter & Rowe, 2006). Quantifying the expansion in biodiversity is not simple and the techniques differ across various studies. Most of the research, however, indicates positive results from an increase in urban biodiversity.

### 2.3.3 Cost of green roofing

A significant number of cities have undertaken studies on the costs and benefits of green roofs. In many instances, a consolidation of incentives and regulations are used in cities such as San Francisco, Portland, Seattle, Chicago, Toronto, Milwaukee, New York City, Washington, D.C., Toronto, Paris, London, and Tokyo (Lilauwala & Peck, 2017). Private funding for green roofs has been newly launched in the U.S. market under the PACE program (Property Assessed Clean Energy), making it possible for building proprietors and developers to gain off-balance-sheet long-term funding for installation and maintenance costs applied to a building's tax assessment (Lilauwala & Peck, 2017).

Notably, the green roofing initiative takes root across the globe with different states and cities enforcing laws that enhance its implementation to facilitate an eco-friendly environment. In October 2016, Francisco became the first state within the American civilization to enforce that building to be built with green roofs enhancing an eco-friendly building design that facilitates sowing plants above the roofline. The initiative taken by Francisco builds on a trending initiative that is being adopted around the globe due to its benefits to the plant thereof. The enacted law requires that 15 to 30% of the newly developing or merging development projects to incorporate green roofing, solar or blend the two initiatives (Lilauwala & Peck, 2017). The primary reason behind the implementation and enforcement of green roofing inclusion laws within Francisco for all upcoming construction projects signifies the significance of the initiative; hence its implementation in informal urban settlements is critical due to underlying benefits.

Additionally, Martin (2019) concede that the United States is perceived as among the largest green roof expanses with extensive projects found in Ford Motors Company specifically the River Rouge plant, Dearborn and Michigan with approximately 42 thousands square meters of green roofing assembly covered with plants such as sedum among others. With respect to the North America region specifically Washington DC, green roofing has taken a top spot with the installation of green roofs in accordance with the 2018 Green Roof Industry survey to enhance healthy cities. According to Erlichman (2013), green roofing initiative has been a driving force in North America due to its

significance in resilience and sustainability planning whose estimated market growth since 2013 stands at 5 to 15 percent. Washington DC continues to be the North Americas' driving force with respect to the green roofing industry due to its multifaceted approaches and policies that combine innovation, requirement, and incentive-based market solutions to control the municipality storm water as well as management concerns.

The implementation of green roofing initiatives in Washington and San Francisco resulted in other different municipalities to employ and establish the initiatives in their states due to the benefits. Other states such as New York, Denver, Toronto, and Portland have all engaged in the adoption of sponge green roof management policies which have the potential to fuel the market opportunity and growth in the coming years (Lilauwala & Peck, 2017). The initiative Green Roofs for Healthy Cities introduced back in 2013 have highly contributed and encourage other states such as Toronto to design and adopt policies that support the green roofing approach to enhance the building of a healthy, resilient and more sustainable society. A survey conducted by Dvorak and Volder in 2010 recorded that among the top cities within the United States which engaged in green roofing Seattle, Portland, Philadelphia, Chicago, New York, VA, Newark. In addition, the survey findings documented that an estimate of a thousand completed projects within 39 different states in the American civilization and five Canadian provinces has recorded effective and successful green roofing utilizing nearly 5.4 million square feet for green roofing initiative.

Similarly, the United Kingdom despite the English nature that the UK policymakers have largely ignored the green roofing initiatives, the implementation of this initiative dates back to 1938 in London. The Derry and Tom's department store in London established the Kensington Roof Garden which is a notable roof garden built by the department back in the late 1930s (Kadas, 2006). In the recent civilization, London, as continued the green roofing culture since various green roof gardens, are present within the region such as University of Nottingham Jubilee Campus and Sainsbury Millennium store in Greenwich, London. A considerable number of green roofing projects in London are based on residential regions where worker and residents do not have direct access to local parks and gardens. In addition, green roofs are utilized to blend buildings within rural areas by companies such as Rolls-Royce Motors which has one of the largest green roof gardens in Europe with approximately 32,000 meters squared within their factory at Good wood, west Sussex. Therefore, the implementation of green roofing within rural and urban areas within states around the globe in a clear indication that a considerable population and civilization around are conscious regarding the benefits of green roofing to the community and the planet at large;

hence, adoption in informal urban housing settlement is critical can hardly be refuted.

Relevant experts from the Shenzhen Garden Research Institute said that the construction of 1 square meter of green space in the central city of Shenzhen, plus the compensation for land acquisition and demolition is about 3,000 yuan, while the current construction cost of light roof greening is less than 100 yuan per square meter. It is only 3% of the cost of building urban green space; and the late maintenance cost of simple roof greening is very low, about 5 yuan per square meter (ref). These charges comprise all features of green roof development, starting from the waterproofing membrane to soil substrate creation to planting (LID, 2018). The highest expenditure related to green roof formation is the soil substrate/growth method and the plant elements associated with it. Green roof retrofit projects may be characterized by inflated costs linked with traffic and resource scheduling considerations and the on-site accessibility of machinery and materials. The expenditure on planting may also increase if plants are placed separately as opposed to pre-growing them on vegetation mats. However, despite their high initial capital costs, a look at life cycle costs and benefits shows that green roofs still make economic sense on many urban sites. (Marritz, 2012).

#### 2.3.4 Cost-benefit analysis

The cost-benefit analysis for the installation of a single small-scale green roof that is of sound investment and can be a profitable long-term investment (Lilauwala & Peck, 2017). Determining the viability of green roofs requires consideration of a large-scale implementation project. One such project is a study that was undertaken by Green Roofs for Healthy Cities of a new 20,000 sq. ft., 3 story office building which was used to show the costs and benefits of an extensive green roof versus a conventional roof over 25 years. The study revealed that for over 25 years, the net present value (NPV) of installation, maintenance, and replacement cost of a green roof was \$21.1 more than the conventional roof per square foot (Lilauwala & Peck, 2017). However, over the same period of time, the NPV had significant benefits in the areas of stormwater management (\$15.1/sq. ft.), energy (\$5.7/sq. ft.), biophilia (\$8.5/sq. ft.), and real estate/economics (\$21.9/sq. ft.) more than offset the initial cost premium for building owners and/or tenants. Additionally, a number of environmental benefits (\$6.5/sq. ft.) in the form of reduced heat island, improved biodiversity, and improved air quality are generated. Economic benefits to the community are in the form of increased tax revenue from job creation and other community benefits are estimated at \$8.8/sq. ft) (Lilauwala & Peck, 2017).

This study provides a strong case for the cost-benefit analysis of green roofs. It proves that these

roofs have corresponding positive effects physically, on the ecology and financially as well. They safeguard the roof's waterproofing membrane from outside forces that may result in significant damages and avert accelerated aging as a result of UV degradation. The integration of the effective layers and the vegetation encloses the building against heat loss and generates potential energy savings during the intense air conditioning months of the summer. The installation and maintenance of green roofs also create numerous employment and business opportunities for individuals. Most importantly, the stormwater holding potential of green roofs provides the greatest advantage in savings for the individual property owner and the municipalities as well.

### 2.3.5 Green roof business model

Largely because of the environmental advantages associated with the adoption of green roofs, they present a business opportunity to exploit on the projected demand. In addition to the environmental benefits, green roofs also have potential as aesthetic installations, extend the lifetime of the underlying roof membrane, and can also be used to grow food in urban areas (Koulikov & Lashaw, 2007). The summation of these advantages is vital in publicizing the idea among the general population, which is currently largely unaware of the green roof concept.

The green roof industry has been in operation for quite some time in developed countries. In the United States, the industry has existed since the mid-1990s, although it is still growing. Meanwhile, green roofs in Germany, have been integrated into buildings since the late 1970s (Koulikov & Lashaw, 2007). The initial establishment of superior standards, comprehensive research on environmental and economic advantages, and the formulation of revolutionary technologies have established the German green roof industry as mature and competitive. Their green roof businesses are properly experienced and, in a position to offer effective services at low prices. In the United States, environmental considerations have been the chief motivation for the establishment of green roof businesses. In various parts of the nation, there are firms dedicated to some or all features of green roofs, however, their geographic disposition is scarce.

Currently, green roofs are largely demanded by upper-middle-class city residents who understand the benefits of a roof and have the capability to pay substantially for them (Koulikov & Lashaw, 2007). At an average cost of roughly \$20 per square foot in Shenzhen, China, green roofs are still not an offering that is accessible to a significant part of the general public. However, there are expectations from the government to establish subsidies and incentives for green roofs as the appreciation of their environmental advantages progressively takes place. Propelled by the increase

in the general public's awareness of environmental issues, it is expected that green roofs will become available to the middle class in a few years. When this eventually happens, the total number of green roof orders could increase significantly which will be monumental for the business' operation.

In conclusion, it is evident that the benefits associated with green roofs are numerous, a cost-benefit analysis also shows that their adoption makes financial sense. The green roof business also shows a lot of potential and with the support of the government and various stakeholders it has the potential of flourishing into an extensive industry.

### 2.3.6 Government policies and incentives

There are a couple of government policies that are associated with green roof development in different metropolitan cities in China. Currently, China has not yet formulated a unified national definition of urban village roof greening. However, different definitions are given in many local specifications. Beijing's Roof Greening Code (DBn/T281-2005) defines roof greening as the tops of various buildings and structures not connected to the natural soil layer on the ground. The definition of roof gardens in the Shanghai Roof Greening Technical Specification (Test) (2008) is based on the top of buildings and structures. The greening method based on the plant configuration and not bordering the natural soil is a general term for various types of roofing plants. The definition of roof greening in the Guangzhou Roof Greening Technical Specification is the top of various buildings and structures, and the terraces and gardens built on terraces. The definition of roof greening in the Tianjin Roof Greening Technical Regulations (2006) is also referred to as the roof garden. This refers to the greening on the roof of the building. In this paper, roof gardens and roof greening are considered equivalent concepts for ease of study.

In November 1999, the Shenzhen Municipal People's Government of Guangdong Province promulgated the implementation measures for roofing beautification and greening in Shenzhen. The implementation measures included; Inspection, supervision, and evaluation of urban roof beautification and greening work. In 2000, Guangdong province promulgated the opinions on the urban roof beautification and protection (anti-theft) network, air conditioning and outdoor pipeline standard installation in the province of China, and proposed that the city refers to the practice of Shenzhen City and combine local practices to propose the construction of the city.

On June 19, 2011, the standing committee of the Guangzhou Municipal People's Congress issued

a notice on the official website of the Guangzhou Municipal Greening Regulations (Draft) for online comments. The Guangzhou Greening Regulations was officially put on the agenda and was expected to be formally promulgated at the end of the year. This will become the second municipal greening regulation on the post-Shenling Nanshan in Shenzhen. The Guangzhou Greening Regulations (Draft) clearly requires that the green space rate and three-dimensional greening of residential communities and private groups should not be less than 30% and not less than 25% in the old city reconstruction area and the urban village. New large-scale public buildings with a building area of over 20,000 m<sup>2</sup> should be subjected to three-dimensional greening and construction of a rooftop garden with an area of not less than 50% of the surface area. The roof greening construction area can be converted into a green space rate according to a certain proportion.

The new public fund project in Shenzhen must be completed for the roof greening project. The government subsidizes 50 RMB/m<sup>2</sup>, which is converted into 20% green space. In 2015, 200,000 m<sup>2</sup> of roof greening was planned. Shenzhen Luohu District issued the Shenzhen Luohu District Three-dimensional Greening Implementation Trial Measures, which stipulates that the simple roof greening subsidy unit price is: 180 RMB/ m<sup>2</sup>.

### 2.3.7 Project financing

The Green Roof Development as a project is implemented by the municipalities of a given state meaning that they are categorized as government projects. The financing of these projects is by the municipalities and various stakeholders involved in raising the funds from various sources as outlined below:

Financial institutions such as banks provide loans or financial guarantees and this is through direct funding from the financial institution to the municipality (the project committee). However, there are other instances where the financial institution may use a local retail bank to fund the project. In as much as this is a very reliable source of funding, it has a drawback in that loans are given to fund a profitable project, yet green roofing is not a profitable project making this specific source not so reliable (Worden, 2004). Governmental grants integrated within the governmental budgets which may range from Intercontinental, nationwide, regional to municipality level budgets. Europe has the Europe Union funding instrument budget which falls in this category. This requires that the government in general, sets aside a given amount of money for this particular project and this means that financial sources for the government such as taxes are increased so as to accommodate the added extra expenses (Rowe, 2005).

Private stakeholders such as organizations, institutions, real-estate inventors and financially stable individuals may decide to fund the green roof development project in conjunction with the government and the local government in most cases. Such an initiative is fueled by the fact that the individual, the organization, the inventor or institutions may be negatively affected by the adverse effects of climate change that is prevented by the green roof development (Herman, 2006). A group of people may come together to crowdfund the project and ensure it is effectively implemented, in other cases, they invest in the project measures. The solution that will require close to zero finances requires that the green roof development to be among the standards achieved by any building that is being constructed, especially in the metropolitan area where the projects are currently focused. It can also be integrated with the urban planning and design prior to the implementation to save the cost incurred by the municipalities in implementing the green roof development (Worden, 2004).

The finances are supposed to fund a couple of activities related to the project, for instance, there is a need to create awareness among the public by telling them what the project is all about, the reason why there is a need for its implementation and the benefits it will have to those who agree to assimilate it in their construction practices and in their buildings. Such campaigns require funding so as to cater to the financial needs of those involved in creating awareness (Herman, 2006). Economic incentives are included in the finances given for the project, these incentives are intended for those who agree to integrate the green roof in their already existing buildings. Unfortunately, it is costly to implement the green roof on existing buildings hence the need to propose a lucrative deal for those with already existing buildings (Rowe, 2005). Those constructing new buildings are also offered an incentive for the same purpose of integrating green roofs in their buildings.

#### 2.3.8 Green roof implementation in the urban village

In the recent civilization the concept of green roofing has tremendously gained popularity due to its technical, ecological, aesthetic qualities, and economic benefits. With respect to the development of urban centers, green roofing infrastructures with elements of environmental landscaping has gained popularity over the years which have resulted in the various interest third parties, the governments and NGO to intervene to enhance its implementation. Green roofing initiatives involves the integration of distinct innovations which facilitates to the reduction of harmful emission to the atmosphere, the ability to recover and the adaption to climatic changes (Korol, Shushunova, & Shushunova, 2018). Therefore, this characterizes the relationship between green roof initiative and grassroots innovations since it based on the innovation resulting in the

beneficial impacts to the resilience ecological system.

Stakeholders are essential elements in the success of any project since they provide a wide range of resources necessary for facilitate the effective completion of the projects; hence, the significance of stakeholder's collaboration can hardly be refuted. For instance, in grassroots innovations project different stakeholders such as NGOs, government ministries, community among other enterprises collaborate with one another to complete a particular task or project. Among the different ways through which stakeholders collaborate with each other includes through movements, strategic alliances, coalition, strategic co-funding of projects, partnerships as well as impact collective initiatives (Savage, et al., 2010). The collaboration process through which diverse groups of individual to organization with distinct perspectives exchange ideas in search for solutions which extends beyond being an active and passive participants since the collaboration incorporates all the aforementioned activities.

Community based projects such as energy and green roofing projects are attracting huge attention as critical innovation sources to facilitate sustainability with various settlement areas. Various research into grassroots innovation initiatives such as community based energy projects recognizes the challenges faced in survival rather than growing the wider change. However, Hargreaves et al., (2013) conceded that, strategic niche management application is critical as it helps in highlighting the essential roles played by the actors and intermediaries in the consolidation, diffusion and growth of the green roof initiative projects. As a results, strategic niche management can be applied in green roofing initiatives as grassroots innovation to enhance and facilitate the reformulation and identification of the roles of different players involves in the project ensuring it effectiveness and efficiency.

Notably, green roofing initiative is community based project especially within the informal urban settlements regions; therefore, the application of strategic niche management in green roofing can enhance community engagement and eliminate resistance (Hargreaves, et al., 2013). This is because the strategic niche management will establish a platform through which each member of the local community has a role to play in relation to the project; thus, engaging them fully into the project development. In addition, it will aid in the identification of the key project player such as the funder and information providers amongst the community member such that in case of any concern or question regarding the project there is an individual within the community who can offer possible solution and answers to the questions raised.

The significance of green roofing with respect to its implementation in different parts of the world cannot be ignored both at the societal and global levels. Green roofs provide substantial benefits in informal urban settlement regions such as employment opportunities, food production, and flood reduction, healthy and resilient ecosystem (Dvorak & Volder, 2010). A huge number of individuals residing in informal urban sectors are low-income earners as well as unemployed individuals in search of employment opportunities; therefore, green roofing initiative provides these residents with employment whereby they can grow a variety of food crops and sell them at a profit. Through this, green roofing provides a source of employment for a huge number of informal urban settlement residents as well as increases food production which aids in eliminating food shortages within these regions. In addition, through green roofing a healthy and resilient ecosystem is enhanced, this is because green roofing aids in cleaning air whereby the plants release fresh air and absorb emitted gases resulting in healthy and conducive settlement regions. Therefore, the need for green roofing in informal urban housing settlement is apparent to facilitate the creation of employment, reduce food shortages and enhance a healthy and resilient ecosystem.

Worldwide, especially Japan, Germany, the United States, etc. have made corresponding research on the regulation of rainwater runoff and runoff flow by green roof technology. This has been enhanced through the grassroots innovations such as green roofing whereby the vegetation and plants in the roofs act as water catchment areas; hence, reducing the amount of water that flows in the ground. A study conducted by Robert in the year 2009 whose focus was on "The Control Effect of Green House on Storm Runoff," gives the specific impact of greenhouses on storm runoff. Studies have shown that the green roof can remove annual rainfall due to the interception and evaporation from the roof. Greenhouses result in exponential effects on the atmosphere which affects the rain and in turn, leading to stormwater. The need to control the greenhouse effect is apparent such as the increased emission of gases in the atmosphere resulting in global warming, smog pollution as well as changes to the plant and vegetation growth nutrition levels. The emission of harmful gases on the atmosphere contributes towards acidic rain whereby the stormwater from such rain deters the growth of plants and vegetation; hence, controlling the greenhouse effect is critical to avoid the occurrence of acidic rain and the fore mentioned effects.

Green roofing is among the effective means through which the greenhouse effect can be considerably reduced. This is because green roofing aids in the absorption of gases emitted into the atmosphere by the plants and vegetation are reducing the chances of the occurrence of acidic rain

and in turn, enhancing the growth of plants which aids in controlling stormwater. Through this, destruction of property such as rusting of iron sheets due to acidity is reduced significantly as well as soil erosion since the presence of plants and vegetation aids in reducing soil erosion. The precipitation that has not been intercepted effectively extends the peak rainfall time through the infiltration of the green roof, reducing the flood peak flow in the catchment area (Heim & Lundholm, 2014). With the development of the urban economy and building technology, urban construction is expanding. The density of living is increasing and the available area in urban areas is getting smaller, so the more urban villages are being developed. Therefore, the popularization of roof greening in urban villages is important to ensure a healthy and resilient cities through the provision of clean air and reduction of floods due to the presence of vegetation and plants which absorb rainwater; thus, reducing floods in distinct catchment areas. Therefore, this particular study is relevant to the problem under question since it provides a way through which grassroots innovation such as green roofing adoption and implementation helps in controlling greenhouse effects despite it's resulting in a healthy and resilience ecosystem.

Yan & Huien (2007) pointed out that many large and medium-sized cities continue to explore new ways of greening and increase the per capita green area of cities to improve the urban ecological environment. Therefore, the original greening method of roof greening in urban Villages meets this demand. It only needs to transform the roof of the building to form a roof garden. It not only relieves the ecological pressure of the urban green space but also provides a place for people to rest and entertain. Currently, the environmental burden of the city is relatively significant. The roof greening construction in the urban village is also helpful to alleviate the environmental stress of the city (Yan & Huien, 2007).

#### 2.4 Grassroots innovation for climate-adaptive project

Climatic changes affects all regions around the world; however, the impacts are not evenly distributed across the globe. This is because the most susceptible regions are those with no or limited coping mechanisms and responsibility for climate change. Climate change has begun in earnest to facilitate the preparation of the higher temperature, drought resulting in food and water shortage as well as other impacts (Ensor & Berger, 2009). Therefore, the need for climate-adaptive measures are urgent and indispensable to enhance safeguarding developmental gains as well as address the needs of the marginalized and less privileged. Healthy ecosystems which are prone and resilient to disruptions are critical towards the achievement of not only environmental benefits but it also serves as human and economic development. Climate resilience is a critical component for

a healthy and resilient ecosystem, specifically within vulnerable countries which largely depends on natural resources and traditional agricultural-based practice to enhance subsistence livelihood (Biasillo, 2019). Therefore, the need for global mitigation efforts and climate adaptive to facilitate the reduction of climate changes through the adoption of grassroots innovation projects due to their affordability in vulnerable and less privileged communities.

Historically, the human race has experienced constant and tremendous climate changes that differ in distinct regions around the world. The changes in climate experienced in human history are unprecedented and lead to intense implications for each and every aspect of life in the world (Ensor & Berger, 2009). This subject living creatures as well as the aspect of life to great risk; therefore, the need for measures and actions to facilitate the reduction of climate vulnerability and increase in resilience towards these changes is apparent to enhance life support and adaptation globally. Without a block of concrete and united front to counter and enhance the adaptation to climatic changes, the communities and economies at a global scale could be disastrous. Primarily, the less developed and less fortunate regions around the worlds such as informal housing settlements are particularly essential since their scarce resources and weak infrastructure makes them more susceptible to climatic changes. As a result, the need for the establishment and initiation of climate adaptive projects such as grassroots innovations specifically green roofing in less developed regions is critical to enhancing a healthy ecosystem and resilient livelihood within these settlements.

In the effort to improve climate adaptation and resilience within different regions, the Global Environment Facility has invested a considerable amount of resources i.e., approximately 170 million dollars in the climate change adaptation initiatives led by UN Environment (Ensor & Berger, 2009). The initiatives range from small scale operations that are community-based to aid them in the improvement of their climate change resilience as well as regional and global based initiatives that build a concrete knowledge base, guiding policies and develop capacities in this critical segment. Among the approaches employed in enhancing climate, adaption involves provision of solutions to regions and countries to overcome the challenges and hindrances experienced through facilitating easy access to relevant information, facilitation of policy development and provision of resources. The provision of information regarding climate adaptation initiative raises the consciousness of individual within underdeveloped regions such informal housing settlements with respect to the ways through they can utilize grassroots-based innovation for climate-adaptive projects such as green roofing; hence, improving their climatic change resilience which in turn results in a healthy ecosystem.

According to Biasillo (2019), the Intergovernmental Panel on Climate Change (IPCC) documented the findings of research regarding the impacts of global warming to have raised above pre-industrial levels back in October 2018. The initiatives were in the context of devising ways and measures through which global response to the climate change threat could be strengthened. The report also documented the upcoming effects such as water shortage, heatwave, coastal flooding as well as a decrease in crop yields at a global level. The aftermath in relation to the release of the report specifically the speculated impacts alarmed different players to commit in finding ways through which the issue could be contained or reduced to ease human existence despite the effects of global warming. Ultimately, there is neither a lack of consensus regarding the climate changes nor the underestimation in relation to quantitative analysis on the regulation of the global climate (Ensor & Berger, 2009).

Additionally, reading the report raised the sense of the adaptation limits with respect to how much humans can adjust to an inevitable climate system disruption and the question of irreversible loss and damage. Biasillo (2019) attested that the need to establish and implement climate change adaptation projects is critical with the main focus on community-based organizations, scholars and activists with the purpose of analyzing and mapping grassroots solutions to enhance climatic adaptation. Grassroots innovations offer critical solutions towards climate change specifically in poor urban settlement regions as they act as self-relief organizing instruments during frequent floods, radiations among other climate-based challenges. Through grassroots innovations such as green roofing and planting of vegetation, it facilitates the provision of opportunities to reconsider the roles played by all community members despite their economic, political or social class as well as race in shaping climate change. These initiatives such as the greening of the roofs and planting of vegetation aids in the absorption of heatwaves, radiation as well as harmful gases that are emitted in the atmospheres and release healthy air for human consumption. Therefore, grassroots innovations is a critical ingredient for climate-adaptive projects as it offers ways through which climatic resilience and healthy ecosystem can be attained in the different geographical region especially those with limited financial resources such as informal housing settlements; hence, ensuring a conducive and habitable environment.

Notably, it's increasing acknowledged and recognized that a considerable number of marginalized groups and communities around the world are among the most susceptible groups affected by changes in the climate since they are inadequately equipped and funded to cope and adapt to the

changes. However, grassroots community-based projects whose aim is to enhance and restore the resilience of the marginalized communities, as well as the ecosystem which these societies rely on in comparison to climate change impacts, have been implemented and effective in various regions around the globe (Huq & Reid, 2007). Among the participating countries in the community-based grassroots projects includes Morocco, Niger, Guatemala, Samoa, Bangladesh among others whereby each has developed and implemented a community-based climate adaptation project based on grassroots innovations (Rawlani & Sovacool, 2011). The grassroots innovations provide knowledge base and skills on how to achieve climate adaptation at the community and local levels in different marginalized areas.

### 2.5 Strategic Niche Management for climate-adaptive project

Strategic Niche Management (SNM) relates to an approach which has been developed in the recent civilization which has the capability to enhance the induction of a broad socio-technical transformation and transition towards the attainment of sustainable development. A study conducted by Caniels & Romijn in 2008 documented that, SNM is primarily designed to enhance the introduction as well as diffusion of newly emerging sustainable technologies through the utilization of societal-based experiments in distinct fields such as biogas, wind energy, healthy ecosystem and eco-friendly food production to curb food shortage within rural and underdeveloped areas. Therefore, strategic niche management facilitates climate adaptation through the utilization of new sustainable technologies that facilitates a healthy ecosystem. This is because climate-adaptive projects are spearheaded towards ensuring a healthy and habitable ecosystem; hence, SNM contributes significantly towards climate adaptation, resilience, and a healthy ecosystem.

The ultimate goal of SNM is contributing towards a wide shift sailing to a more sustainable economic and environmental development through combining technological innovation, processes and social institutional system-wide transitions as well as transformation (Elzen, Geels and Green 2004; Hoogma 2002). With respect to the World Commission on Environment and Development, sustainable development is acknowledged as a developmental platform which meets and satisfies the needs of the current civilization without jeopardizing the future generation's ability to meet their needs. Thus, this is an indicator that sustainable development which is solely achieved through SNM involves creating and maintaining a suitable balance between economic, social equity and environmental (Climate) considerations; hence, it's suitable for climate-adaptive projects.

In addition, SNM advocates the creation of experiments particularly socio-technical whereby

various innovations are encouraged to engage in collaboration and exchange information, knowledge, expertise and experiences; hence, embarking on an interactive mode of learning which, in turn, facilitates the incubation of new project. The socio-technical experiments advocated by SNM acts as a pathway towards the creation of climate-adaptive projects as it provides a platform through which grassroots innovations can be shared and awareness created regarding climate-adaptive projects which aid in ensuring resilience and conducive environment especially in informal housing settlement where resources are limited to embark on massive climate-adaptive projects. Hoogma (2000) concluded that one of the ways through which niche technology can be employed in climate-adaptive projects through the invention and utilization of electric vehicles since they are environmental and climate-friendly in comparison to gasoline-driven vehicle. Therefore, through the exploitation of niche strategies climate-adaptive projects can be achieved which, can result in climatic adaptation in diverse regions.

#### 2.5.1 Social Network Theory (SNT)

Social Network Theory states that the economic-based behaviors are highly embedded within a local context and the connection between the players has a specific value for the performance both at an individual level and as a group. Primarily, this theory focuses more on the performance variable necessary to enhance niche strategies such as leadership, power, mobility, entrepreneurship, employment and teamwork (Caniëls, & Romijn, 2008). This theory is relevant and significant in relation to SNM since it establishes the effectiveness of the niche processes through evaluating the social networking mechanism utilized in establishing niche-based projects.

Networking is the core of the niche process since it aids in gaining a detailed understanding of the niche processes their importance as well as the suitable and effective implementation mechanisms; thus, aiding in the selection of the most ideal option based on the information provided regarding the project thereof. Further, the SNT theory provides a critical analysis of the perspective of the niche process in a systematic way to ensure the successful incubation of innovation and projects based on the primary need or goal (Caniëls, & Romijn, 2008). Networking is the core aspect as it provides a linkage between learning and convergence of expectations from which a successful project can be attained.

#### 2.6 Public participation

Citizen participation refers to the process through which private individuals in a specified state or region are provided with the opportunity to influence public decisions in relation to public projects

among other initiatives (Fagence, 2014). This is an essential endeavor as it the means by which the general public has a direct voice towards the public decision making regarding the issues affecting them. Citizen participation is an essential aspect in the implementation of public-based projects since it provides citizens with an opportunity to air their views, ideas and opinions regarding the best measures and easy through which the challenges can be addressed. In addition, the citizen in most cases have the first-hand experience of the problems; thus, giving them an opportunity to participate in development projects presents opportunities whereby distinct ideas can be coined and proposed from which a comprehensive solution is reached.

With respect to this research, the concept of citizen participation is critical towards the implementation of green roofing initiative in informal settlement regions. This is because providing a platform for citizens to engage and participate in the green space infrastructure results in the creation of awareness specifically those individuals with inadequate knowledge and skills regarding green roofing. Therefore, this provides a platform through which citizen consciousness is elevated into the significance of green infrastructure and more specifically green roofing in informal settlements. This provides a networking platform whereby citizens are introduced into concepts, knowledge and skills regarding who to implement and enhance green spaces within informal housing areas from distinct agencies such as NGOs, government ministries among other agencies. Additionally, this enhancing learning and networking which are among the key elements of strategic niche management which in the end facilitates the achievement of the vision and expectations of the informal housing residents through the application of knowledge and skills learned (Hossain, 2016).

In addition, through citizen participation, the collaboration between informal settlements residents and other agencies is enhanced which aids them in implementation the green space initiatives to facilitate conducive environments in these settlements (Bhaduri & Kumar, 2009). Through collaboration, different ideas regarding how to implement the green roof initiative will be proposed; hence, providing diversity in problem-solving. This is because, the raised ideas are evaluated to come up with the most effective and efficient idea that will aid in the effective implementation of the green roofing initiative as a measure to ensure a friendly climate within informal housing from which value of the green roofing initiative is created such as employment, reduction of radiation and good climatic conditions.

In 1969, Sherry Arnstein published the famous paper "The Ladder of Citizen Participation," which

divided public Participation into three stages and eight steps, thereby forming the theory of the public participation ladder Arnstein (1996), which is still widely used today. To provide a better understanding of the interaction between the public and the government in urban planning, the OECD (2001) defined citizen participation in government decision-making as falling into five levels of interactivity. The two theories are largely similar; that is, the ideal state of public Participation is that all relevant interest groups (governments, companies, community residents, non-profit organizations, etc.) set up a joint mechanism for planning and decision-making.

Public Participation can be divided according to the "Citizen Participation Ladder" proposed by Arnstein (1996). The degree of public Participation is gradually being strengthened: false (non-) Participation; symbolic Participation; substantial Participation; public Participation; operational Participation; educational Participation; informed Participation; Participation in consultation; Limited Participation; cooperative Participation; decision-making participation in eight forms, and three levels : the lowest level being "fake (non-) participation," which consists of two forms, namely "operational participation" and "educational participation." The lowest form is "operational participation," which means that some public authorities prepare programs in advance, and the public has to accept the programs. The second level is "symbolic participation," which takes three forms: "informative participation," "consultative participation," and "restrictive participation." The highest level is "substantial participation," which consists of three forms: "cooperative participation," "representative participation," and "decision participation." The highest form is "decision making"; Participation that is, citizens immediately understand the right to approve and manage the program. The 'Citizen Participation Steps' theory provides a benchmark for measuring the success of public participation in the transformation process.

# Ladder Of Citizen Participation

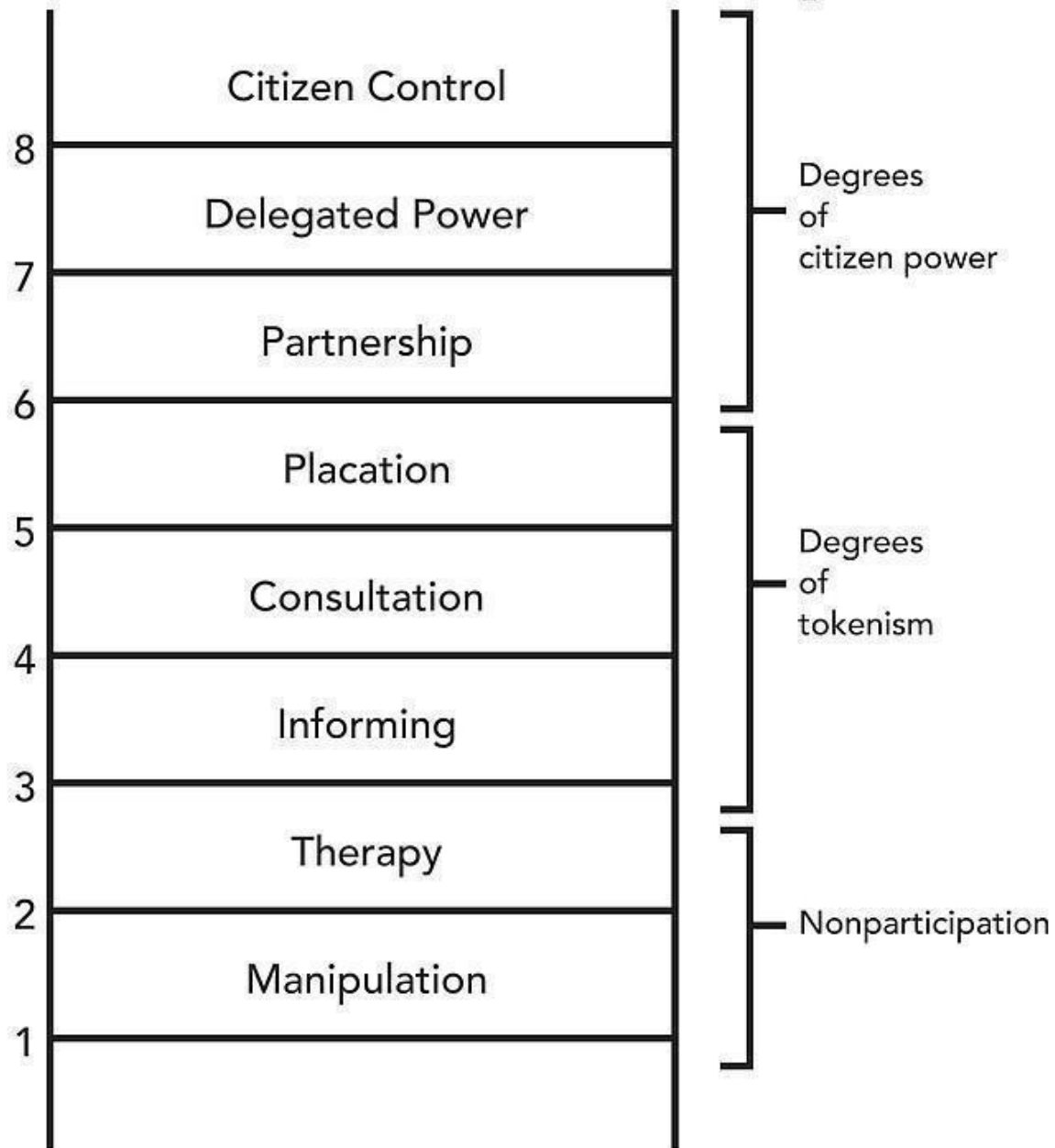


Fig 2. The Arnstein Ladder of citizen participation.

## 2.7 Community engagement

Community engagement involves the community-centered and oriented dialogues which enhance the understanding of the societal members' perceptions, viewpoints, opinions towards of the contexts and topics to facilitate a cohesive relationship amongst community members. According to Budiman (2018), community engagement comes in a variety of ways which involves community

building, education, deliberative dialogue, organization, research and direct services to the society in relation to specific community projects. Community engagement is critical as it ensures that the members of the society are involved in development projects and have access to valued social activities and settings. This results in the development of feeling that they can contribute to distinct social activities as well as develop functional capabilities that enhance full participation in community-based projects.

Therefore, community engagement in grassroots innovation projects is critical as it facilitates the collaboration and coordination between community members and third parties such as NGOs which results in the successful implementation of these projects. Community engagement is central to any public or societal related projects or invention as it involves the creation of awareness of the community at large regarding the risk and benefits of grassroots innovation projects resulting participation and reduction of resistance (O'Meara, Pendergast, & Robinson, 2007). This leads to the mobilization of the community members through raising their understating regarding the essence of the grassroots innovation projects which triggers and increases their participation and support of the project in their surroundings; leading to the success of the project. Therefore, community engagement is a key ingredient in ensuring the effectiveness and success of grassroots innovation projects within distinct communities, especially informal urban settlements.

A research study conducted by Farmer et al., in 2018 regarding the application of social theory in community-based services, the findings recorded that social innovation theory is a significant and relevant theory as it facilitates understating of what happens in each stage of the development of innovation projects. The participation and engagement of the local community members result in the innovations, which involve the adaptation of the existing ideas and experiences (Warbroek et al., 2019). Social innovation theory integrates various aspect such as social processes and open techniques such as volunteering, distant learning, among other aspects which have a social purpose. Particularly, this theory places more emphasis on the news forms of cooperation more specifically those that aim at the achievement of the sustainable society; hence reflecting community engagement.

Primarily, community engagement plays a critical role in the development and implementation of grassroots innovation projects which can hardly be refuted. For example, through community engagement, a positive attitude and mentality towards the usefulness of the initiated project are created amongst the community members resulting in full participation and resistance reduction.

In addition, grassroots innovation such as green roofing requires regular attention and taking of the plantation which means that without effective community engagement the project cannot be successful since the third parties such as NGOs might find it hard to make frequent visit to the project sites (Budiman, 2018; O'Meara et al., 2007). However, with effective community engagement, the community member can fully collaborate with the supporting agencies in taking care of the implemented project making it easy for the grassroots innovation projects to thrive in different settlements regions such as informal urban housing centers.

## 2.8 Theoretical framework

### 2.8.1 Sponge city and LID

Sponge City relates to the urban centers' specific cities with the capacity to facilitate the mainstreaming of urban water management with respect to the planning policy and design of a specific urban center. According to Xiang et al. (2018), a Sponge City should incorporate the appropriate legal and planning frameworks as well as toll necessary to enhance the implementation, adaptation, and maintenance of the water management infrastructure to ensure the collection, storage, and treatment of rainwater. Therefore, a Sponge City does not only have the capability to deal with the excess waters but also the reuse of rainwater which in turn aids in mitigation of the effects or impacts of the little and dirty water within urban settlements regions.

The concept of Sponge City has gained tremendous ground and popularity in the recent civilization resulting in acceptance by different city administrations and governments. For instance, in response to increased effects of floods, the government of China called for widespread awareness and uptake towards the Sponge City concept around China back in 2013 whereby the government offered financial support to facilitate boost the implementation of this particular approach in distinct selected cities (Zevenbergen, Fu, & Pathirana, 2018). As a result, the concept of Sponge City is significant as it ensures controlled rainwater which involves treatment, storage and maintenance resulting in the reduction and elimination of dirty water as well as providing a solution to the issues of water inadequacy within urban settlements.

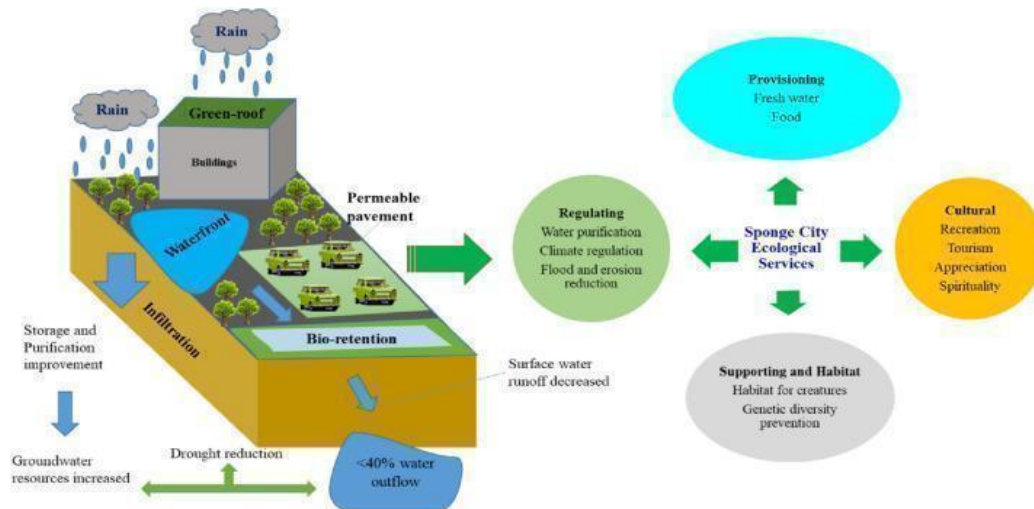


Figure 3. Schematic design of the Sponge City and Sponge City Ecological Services

source: Nguyen, Thuy & Ngo, Huu & Guo, Wenshan & Ren, Nanqi & Li, Guibai & Ding, Jie & Liang, Heng. (2018). Implementation of a specific urban water management - Sponge City. *Science of The Total Environment*. 652. 10.1016/j.scitotenv.2018.10.168.

Qin, Li, & Fu (2013) defines low impact development as the practices and systems that mimic the natural endeavors as well as processes to facilitate evapotranspiration, infiltration or the utilization of stormwater to facilitate and enhance the quality of water in specific habitats. Therefore, this approach aims at controlling stormwater to facilitate a conducive environment that is similar to the green infrastructure which aims at preserving and creating a green space through the utilization of rainwater in the region where there is a scarcity of water such as informal urban settlements.

Notably, dealing with universal water problems in urban areas such as storm floods, water shortage, and pollution, the need to facilitate the implementation of comprehensive and long term solution is apparent which includes the Sponge City construction and Low Impact Development projects. This is because through Sponge Cities excess rainwater will be controlled and maintained effectively and efficiently providing a remedy to water shortage problems. Similarly, the Low Impact Development strategy is essential as well as relevant as it offers measures through which stormwater can be managed in an effective way to eliminate flooding (Vogel et al. 2015). This is because both of these approaches aim at reducing the water run-off, pollution and facilitate the restoration of the downstream ecologies which ultimately resulting in water sufficiency in urban settlements. Therefore, the combination of Sponge City and low impact development approach is critical as it ensures water sustainability and climate-resilient cities as well as effective and efficient water management systems within urban regions. Also, both Sponge City and LID enhance green

infrastructure such as green roofing through the provision of water which is utilized in the green spaces specifically in informal housing areas where water is a major challenge; thus, the provision of rain and stormwater makes it easy to implement green roofing in this settlements.

Low impact development is a term mostly used in Canada and the United States describing land planning that is meant to imitate natural processes with the goal to protect water. The goal of water protection is achieved through the use of stormwater, infiltration, and evapotranspiration (Ahiablame et al, 2012). These LID processes are not only used to protect the water quality but also associated with the aquatic environment. LID gives a sustainable design to conservation by using natural features of an area and lowering the effects on the infrastructure and the entire ecosystem. A number of practices have been used that have followed the principles of low impact development. These principles include recreating and preserving natural landscapes, creating functional and impressive sites (Ahiablame et al, 2012). These principles have been followed in practices like rain gardens, bio-retention facilities, permeable pavements, vegetated rooftops and rain barrels among other practices (Palla, & Gnecco, 2015). The implementation of LID practices and principles, control water in a manner which reduces the effect of built places and stimulates the natural flow of water in a watershed and ecosystem. If applied on a large scale, low impact development is most likely restoring a watershed's ecological roles.

The green roof is one of the primary measures of LID by planting green plants on the roof. The green roof consists of an impervious roofing membrane, a high-permeability soil, planted plants that are resistant to high temperatures, drought-tolerant, and resistant to periodic rain (Ahiablame et al, 2012). LID is not only suitable for urban new development zones, but also old urban towns. This simpler, lower-cost measure can be integrated into the city's landscape, providing an opportunity to transform the landscape of the old town and quickly integrate into the urban infrastructure (Fang, 2012). The establishment of a green roof in a village building in the city is a practice of LID on old buildings because LID advocates reducing the impact of development on the main body and using innovative means to meet the requirements of storm water management. Therefore, it is suitable for the renovation of old buildings in the villages.

### 2.8.2 Grassroots Innovations

According to Smith and Seyfang (2009), grassroots innovation refers to a new concept that examines the diffusion and emergence of sustainability projects in civil society. The term grassroots innovation is primarily used to describe a network of organizations and activists which generates

bottom-up solutions to enhance sustainable developments in response to distinct local situations, values, and interests of the community or society involved. Its operations are based on the civil society arenas with the involvement of activists committed to enhancing social innovations as well as the use of greener technologies to provide solutions to the challenges or situations affecting a particular civilization (Smith & Seyfang, 2009, p. 585). Therefore, grassroots innovation is ultimately found in specified localities in community-based arenas and involves networks of organizations and activists who focus and undertake experiments to provide solutions for sustainable growth and development.

On the other hand, Hilmi (2012) defines grassroots innovation as the accidental innovation that emerges as a result of humans responding to difficulties and hardships in life. Grassroots innovations encompass the innovative products, processes, and services that are created at the bottom of the pyramid due to distinct individual necessities, challenges, and hardships. Thus, from the Hilmi definition grassroots innovation are the results obtained through unintended or somewhat accidental forms of innovation whose emergence and occurrence results from the attempts from human to solve specific problems affecting them and the surrounding community. Humans in both developed and undeveloped regions around the world are subjected to different problems; thus, the attempt to find a sustainable solution to remedy the problems results in grassroots innovations that differ based on the issues and challenges affecting a specific group of individuals.

Similarly, Bhaduri and Kumar (2009) defined grassroots innovations as the actions and operations of individual innovators who undertake innovative processes to solve specific problems in localized geographical regions and work outside the formal organization and institution realms such as business agencies and firms. These kinds of innovations emergence from the efforts of the mass poor based on the grassroots levels who implement a considerable number of solutions toward remedying the problems and challenges facing them and the society. Thus, the occurrence of grassroots innovation is not planned or coordinated like another innovation program, but it arises in search of a solution to the problems facing a specified group of people in different regions around the world. The green roof project for informal housing in this study can be seen as a grassroots innovation in a specific region that faces urban ecological challenges. Therefore, the grassroots innovation concept can be used as one of the research bases of this paper.

Therefore, from the above definitions, grassroots innovation can be viewed as the accidental form of innovations that occurs or emerges as a result of an individual or a group of people tries to figure

out a solution to a problem that affects a particular population. This is because most of the grassroots innovations are not planned like other official innovations whereby a team of experts of skilled personnel is involved in the invention of specific products or services. For instance, grassroots innovation is evident in informal housing through green roofing in the attempt of the residents of these settlements to solve the challenges that affect them such as rainwater management and Rainwater recycling as well as to create public green space which is scarce in informal housing areas. As a result, grassroots innovations relate to unplanned and uncoordinated innovation whose aim to remedy the challenge experienced by a group of individuals in the same region, neighborhood, or surroundings.

### 2.8.3 Key elements of grassroots innovation

Grassroots innovation encompasses various vital elements, namely; collaboration, ideation, implementation, and creation of value (Bhaduri & Kumar, 2009). Collaboration involves teamwork, which is critical in grassroots innovation as the community, or society members work together towards finding a solution to remedy their challenges or problems encountered. Secondly, ideation is another crucial element as it entails the generation of new and fresh ideas to facilitate and provide a solution to the problems experienced by a group of individuals. The generated idea undergoes implementation to test its functionality towards addressing the challenge facing the community. Another critical element is the creation of value once the generated innovation is implemented to ensure that it is valid and efficient in solving the identified problem in a specific region.

The critical elements of grassroots innovations are reflected in informal settlements in various ways. For example, in informal settlements, residents collaborate with each other to come up with a solution that faces them in general through providing different but relevant ideas that can aid in eliminating or declining the problems that they encounter in the settlements areas. Also, the ideas pitched by different residents towards rectifying their situation are evaluated to come up with the best possible solution after which the selected idea is implemented to provide a concrete solution to the problem encountered in informal settlements. The implementation element is critical as it is intended to test the functionality of the pitched ideas through collaboration to ensure that it addresses the identified challenges (Feola & Butt, 2017). Finally, value is created based on the capability of the implemented idea in relation to solving the identified issues whereby in case the proposed and implemented idea offers solution to the problems identified its value is created through raising the consciousness of other residents with respect to its significance in eliminating various challenges experienced in the informal housing to ensure conducive environments for the

resident as well as their surroundings.

#### 2.8.4 SNM (Strategic Niche Management)

Primarily, grassroots innovation is explored through the utilization of theories such as strategic niche management (Hossain, 2016). The grassroots concept comprises of a variety of mechanisms that involves niche sources for low consumption of social movements, community-based activities, and suitable practices. In this case, the paper will focus on addressing the strategic niche management theory and its utilization and application in grassroots innovations to facilitate in-depth insight which will, in turn, raise the understanding of individuals into its significance concerning usage in grassroots innovations. Niche theory is used in the provision of an elaborate explanation of the technological innovation dynamics within the social economy, which is the core of grassroots innovation undertakings. Besides, grassroots innovations are significant and functional for the niche development processes including but not limited to learning, capacity building, and network formation on the one hand and nurturing, empowerment and shielding niche innovations (Ornetzeder & Rohracher, 2013). Therefore, the significance and relevance of the strategic niche management theory for grassroots innovation is apparent and cannot be overlooked.

Strategic Niche Management (SNM) relates to processes involved in the management of the formation of niche processes through real-life experiments (Loorbach & van Raak, 2006). It involves the stimulation of new technological as well as social-technical based arrangements and process that involves the co-evolution of ideologies and innovations such as smart or electric cars in technological perspective and user preferences, regulations, complementary technologies in context perspective. SNM focuses on aligning the social and technical innovations in which the developments are worked upon simultaneously. Loorbach and van Raak (2006) attested that strategic niche management theory is based on the assumption that consumer needs and wants are flexible rather than fixed. This is because the needs and wants of consumers are primarily based on the reflection of the prior or past experiences which trigger the grassroots innovation whereby new experiences have higher chances of altering the perceived needs; thus, understanding the cognitive changes of project stakeholders to the project can lead to new grassroots innovations to solve new experiences.

SNM theory is relevant to the study as it focuses on aligning social innovations based on user preferences. Therefore, the application of the SNM theory will offer critical information concerning the aspects necessary towards the successful implementation of the green roofing initiative through

networking and learning which ultimately results in the achievement of the resident's vision and expectations. In addition, this theory pays more attention of the developmental process of a particular concept; thus, indicating that it will offer significant insights with respect to the critical elements in green roofing from the conception of the idea which is attained through networking which in turn enhancing learning of ways through the green roof initiative can be enhanced in informal housing such as creation of awareness to foster the understanding of the residents towards the necessity of green roof within their settlements.

Besides, SNM builds on the multi-level perspective concerning the socio-technical changes whereby the primary entities in this particular perspective are technologies that are part of the socio-technological regimes. The regimes are technologically centered, i.e., the economic, technological, and cultural aspects which are related to a specific technique or technology system (Hilmi, 2012). Notably, the multi-level perspective utilized by SNM comprises three levels, which include the landscape that involves the sizeable socio-technical regime, the regime of all rules and social constructs with the technology under study and niche regime. The niche regime deviates from other regimes providing significant opportunities to facilitate the development of technologies that are against the dominant regimes; hence paving the way for grassroots innovations. This implies that the strategic niche management theory does not pay attention to the present and dominant regimes instead it focuses on the developmental; thus, the implementation of new concepts such as grassroots innovation becomes accessible through the utilization of this particular theory.

#### 2.8.4.1 Critical elements of Strategic Niche Management

Notably, the strategic niche management theory comprises three key elements, which include; vision and expectations, networks, and learning (Hossain, 2016). The main aim and objective of the strategic niche management theory is the stimulation of learning regarding the challenges and problems, needs, different interests and aligning vision of society at large, and building networks to enhance a collective goal. SNM theory primarily focuses on the radical and unproven technologies to ensure local development as well as provides an elaboration regarding the dynamics of the social-technical grassroots innovations (Loorbach & van Raak, 2006). As a result, the critical elements of the SNM theory aims at learning more about the conical and technical feasibility as well as the environmental gains of distant technologies, i.e., to learn more about the social desirability of the available options.

Besides, it builds a network constituency behind a product, i.e., firms, public authorities,

researchers whose coordination is critical in bringing a substantial shift in the interconnected practices and technologies. The vision and expectation element aims at articulating changes in institutional and technological frameworks necessary for the economic success of the innovations and the stimulation of the innovations to achieve cost-effectiveness (Loorbach & van Raak, 2006). This facilitates the promotion and development of complementary skills and technologies, which in turn stimulates changes in the social organization significant to the broader diffusion of the new technologies or innovations.

Vision and expectation a vital element of the SNM theory is relevant to the study since informal settlements regions encountered a considerable number of challenges; thus, the residents have the vision to make the settlements better by eliminating the challenges. Through the vision, the residents expect to achieve challenge-free residence areas by working towards the attainment of their vision. According to Schot and Geels, (2008), achieving the vision and expectation requires networking between various residents to come up with a practical and robust solution to solve the problem whereby learning element becomes critical. This is because through learning and understanding the problems experienced in the informal housing areas it becomes easy to innovate a solution through which the vision and expectation can be fully achieved; thus, enhancing a conducive and habitable environment. For instance, rainwater management is a significant problem affecting informal settlement areas; thus, the vision and expectation are to ensure flood control in these regions. Therefore, networking between residents and non-residents is the crucial element in attaining rainwater management since different individuals offer distinct measures to ensure rainwater management through which informal settlement residents learn ways through which they can ensure rainwater management such as the implementation of green roofing which facilitates rainwater management and create public green space.

#### 2.8.5 SNM as a research tool for this study

According to Raven (2005), strategic niche management theory can be viewed as both a policy tool as well as a research model. This is because, for the research model, the theory is utilized in enhancing and fostering the understanding of technological-based innovations trajectories; thus, it has predominantly utilized in historical case studies. Ultimately, strategic niche management has emerged as a research strand which seeks to understand how to create and nurture niches specifically in developing sustainable innovations to facilitate triggering more comprehensive systemic transitions (Smith & Seyfang, 2009). This is in line with the research purpose of this paper. This is in line with the research purpose of this paper. This paper hopes to study the sustainability

of grassroots, innovative rainwater management projects through project analysis and project participant's analysis. It is hoped that the results of the research can promote the construction of future sponge cities. The strategic niche management theory brings about knowledge, skills, and expertise to the users among other actors into the technological development process as well as the generation of interactive learning processes and adaptation of institutions. Therefore, strategic niche management works as a tool for enhancing the success of grassroots innovations since it aims explicitly at learning more about the economic, technological and environmental gains of distinct technologies to ensure that social desirabilities are achieved through providing knowledge and skills to the users among other actors in the development process. Thus, through the SNM element, the researcher will be able to gain in-depth insights into the how the informal housing residents can effectively and efficiently initiate the green roof initiative and ensure success in these settlement areas.

The aspects of SNM theory i.e., vision and expectations, networks and learning, are critical in studying green roof initiative. This is because the implementation of green roof initiative is dictated by the vision and expectations of informal settlements residents towards ensuring rainwater management and the creation of open green space. Vision and expectations are the key drivers of the green roof initiative because the vision and expectations of the residents in informal housing triggers them towards networking with others both informal settlements residents and non-residents to enhance learning of ways through which green roof initiative can be successfully implemented in their settlement areas (Schot & Geels, 2008). Therefore, this will help in answering the study questions by understanding how green roof initiative is incorporated specifically through networking with governments, agencies, NGOs as well as other residents to equip the residents of the informal settlement with knowledge and skills necessary to ensure effective and efficient green roofing in their settlements.

## 2.9 Conceptual Framework

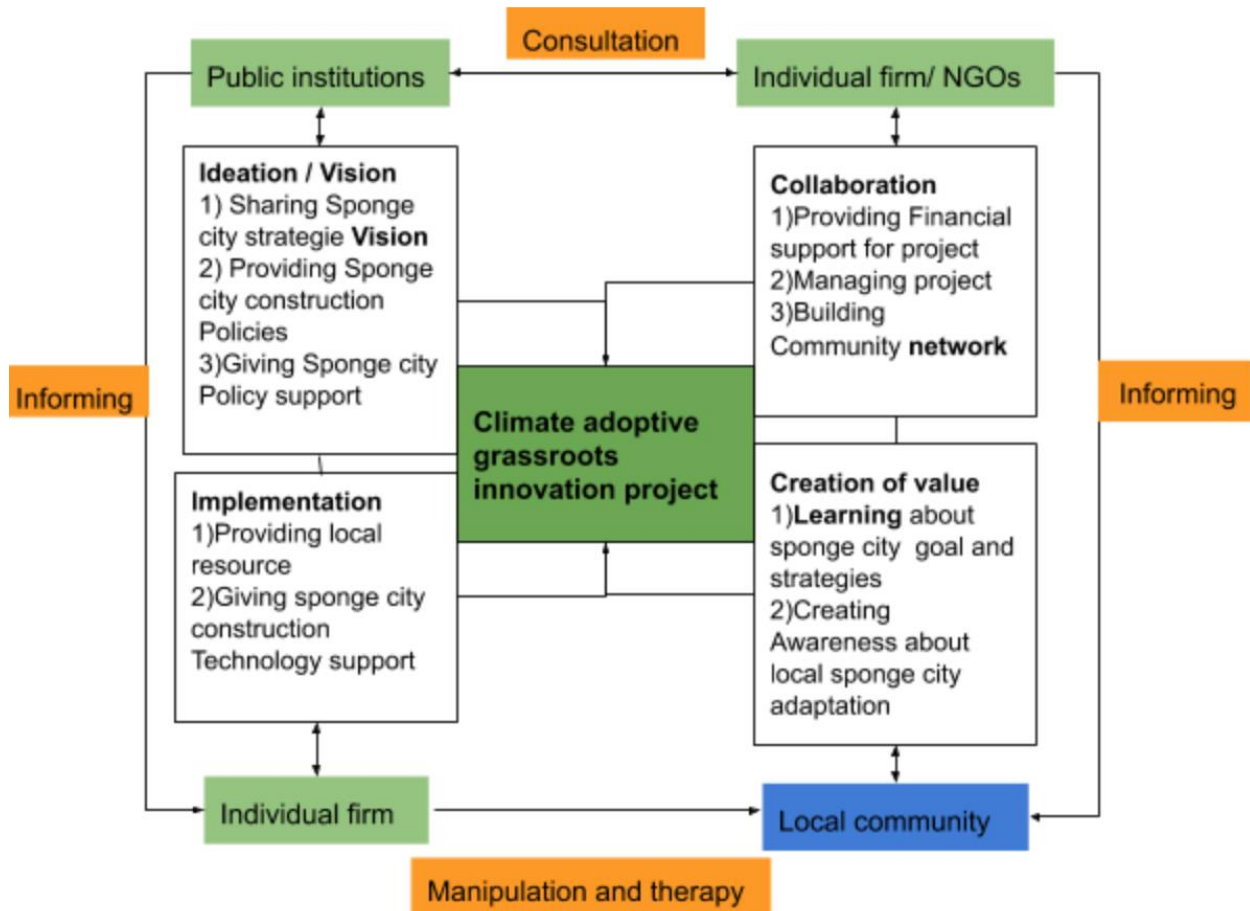


Fig 4: Conceptual Framework

Notably, various institutions inclusive of public institutions, individual forms, NGOs, as well as the local community engage in consultation process through which the challenges facing a community specifically an informal settlement region are discussed in the attempt to provide a remedy to the problems systematically. All the involved agencies i.e., individual firms, local community, NGOs as well as public institution collaborate with each other towards a common goal whereby each agency offers distinct supports aimed at achieving a climatic which would facilitate adoption of grassroots innovation projects in informal settlements such as financial support, project management, creation of awareness through educating the residents on the essence of grassroots projects as well as networking between the community and other relevant institutions necessary to facilitate the implementation of grassroots innovation projects. Through collaboration all the engaged parties or agencies work together towards the ideation of a possible solution. This involves

activities such as the sharing of the Sponge City plans, policies as well as strategies which can assist in attaining the vision of the informal housing areas in relation to food security, clean air and eliminate water scarcity which will in turn results in increased production of foods through the implementation of green spaces due to availability of water.

After the ideation which is achieved through collaboration, the implementation phase is initiated which involves the provision of resources and technologies that supports Sponge City and LID strategies to ensure water security which is a key ingredient in the successful implementation of all grassroots innovation projects such as green roofing initiative. Different institution engage in distinct activities based on their capabilities and functionalities to enhance the implementation of the initiative successfully. This involves Sponge City initiative to ensure storage, maintenance and treatment of rainwater which is used in green space projects. In Addition, low impact development strategy is also enacted as storm water management strategy to tap storm water. Therefore, through the initiation and implementation of the Sponge City and LID strategies water security is enhanced which in turn results in successful implementation of green infrastructure. Additionally, value is created through educating the involved parties specifically the residents on the sponge city strategies as well as low impact development and their significance towards the success of the green infrastructure. Also, the value of implemented initiative is created through benefits attained from the projects to enhance continuity of the projects within the regions by making sure that the resident are aware of the projects value at an individual as well as at community level.

## 2.10 Chapter summary

This chapter offers insights into the sponge city concept, its relevance and application in green roofing. It provided a detailed analysis of the linkage and relationship between green roofing and sponge city as well as the significance of both in enhancing healthy and resilient climate. Different types of green roofing initiatives are addressed fully as well as the advantages of green roof in relation to sustainable climate. In addition, the concepts of grassroots innovation and strategic niche management are addressed and its relevance to green roofing for climate adaptive projects as well how they can foster green roofing initiatives within informal urban settlements. Therefore, the research collected data on how the strategic niche management can be applied to foster the green roof initiative as an example of grassroots innovation to ensure that gaps identified while reviewing literature are filled from which the conclusion of the study is drawn.

## CHAPTER THREE: METHODOLOGY

### 3.0 Overview

This chapter presents the methodology that will be utilized in the study. It outlines the proposed research philosophy, research approach, research strategy, data collection strategy, sampling technique, data collection tools, data analysis, validity and reliability of the collected data and finally ethical considerations. The methodology involves the utilization of logical methods to facilitate the collection of data. The nature of the research guided through the designed approach to ensure that appropriate data within the scope of the study will be obtained to enhance answering the research questions.

### 3.1 Research philosophy

Research philosophy refers to the belief regarding the ways through which the data about a study subject or phenomenon should be gathered, collected, analyzed and utilized for the purpose of the study (Holden & Lynch, 2004). Primarily, research philosophy deals with nature, source and knowledge development in research since the research is actively involved in the collection of primary and secondary data as well as data analysis to provide answers to the research questions which mark the creation and development of new knowledge. There are two main types of research philosophies namely; positivism and interpretivism also referred to as anti-positivist.

This research adopted an anti-positivist research philosophy over positivism, this is because positivism utilizes a qualitative approach while investigating a subject as opposed to anti-positivism which focuses on providing an in-depth exploration and description of the research phenomena from a qualitative perspective. Therefore, the anti-positivism research philosophy will be adopted as it integrates the use of a qualitative perspective which will be adopted as the research approach for the study. The merits of utilizing anti-positivism research philosophy include it's based on natural data collection approaches such as observation and interviews. In addition, the utilization of secondary data is common with this type of research philosophy; thus it doesn't limit research to primary data sources as a result, secondary data will be fully explored.

### 3.2 Research Approach

Maxwell (2012) defines the research approach as the procedure and plan that encompasses the steps of the collection of data, analysis, and interpretation of the findings from which the study conclusion is drawn. There are various kinds of research approach namely; qualitative, quantitative

and mixed methods, this study will adopt a qualitative research approach. The primary reason behind choosing qualitative research approach is because it allows for in-depth analysis and probing of the study participants based on their responses to the questions asked by the researcher which in turn aids the researcher to understand their feeling and motivations. Through understanding the audience's perception and mode of making decisions it can the researcher in drawing conclusions regarding the subject under study. In addition, qualitative research allows for the utilization of various data collection methods such as in-depth interviews, focus groups and case studies which aid in providing critical information for the purpose of the study.

Additionally, through qualitative research approach interviews and secondary data from relevant documents will be used as the main sources of data to enhance the achievement of the research objectives. Secondary data relevant to the topic under study will be gathered through searching for credible and reliable sources from the sources such as journals, publications and government reports related to green roofing adoption and implementation in an urban village in Shenzhen. Further, to facilitate the collection of primary data the researcher will conduct interviews with participants involved with open green space implementation projects in an urban village specifically in Shenzhen.

Qualitative research is subjective in nature as it mainly concentrates on the study subjects' perceptions and opinions rather than data which is measured (Lune & Berg, 2016). Qualitative research seeks to understand the participants' in-depth perception as well as an interpretation of their personal experiences. This will be achieved through the study of social processes in its context to provide the experiences of the subjects under question. Therefore, the proposed study will be researched using a qualitative research approach due to its flexibility in acquiring data from a limited number of participants (Creswell & Creswell, 2017). This will provide a detailed understanding of the green roofing in the community and hence provide rich data for analysis from which the study conclusion will be drawn.

### 3.3 Research Strategy

According to Ritchie et al., (2013), research strategy can be defined as a step-by-step action plan giving direction to researchers' thoughts and efforts and this enables them to conduct the study in a systematic manner, according to the schedule and ensure that quality results are produced. Research strategy can be either single or multiple, this study will adopt a single case study as the research strategy for the purpose of the study. The research adopted a single case study due to its flexibility,

a single case study is highly flexible and provides a highlight of the difference between study subjects in response to the effects of interventions. Primarily, a single case study is significant as it reduces bias in the interpretation of the research findings since the views and perception of the respondents are captured; thus, ensuring reliable and accurate results which are used in answering the research questions and drawing the study conclusion.

Therefore, case study research strategy will be adopted in this study, the researcher finds a case study research strategy appropriate as it allows for a comprehensive study of the subject or problem in question. In addition, the research utilizes desk or secondary research whereby a number of policy documents among other credible and relevant document have been fully utilized including scientific literature. It utilizes secondary data from various credible sources such as policy documents, scholarly journals, reports among other publication relevant to the subject under study. This aided in informing the research on the findings of the previous researches relevant to this particular study.

Policy documents	Document Name
National Policy	The People’s Republic of China. The General Office of the State Council on Promoting the construction of Sponge Cities [Z]. 2015-10-11
Municipal level policy	Shenzhen sponge city construction special planning and implementation plan.2019
	Shenzhen Three-dimensional Greening Implementation Measures. 2019
	Shenzhen three-dimensional greening implementation method. 2019
	Shenzhen Financial Support Sponge City Construction Implementation Plan .2018
	The People’s Republic of China. The General Office of the State Council on Promoting the construction of Sponge Cities [Z]. 2015-10-11
	Shenzhen City Sponge City Construction Fund Reward Implementation Rules (Trial).2019
	Shenzhen Sponge City Construction Fund Reward Declaration Guide. 2019

	Shenzhen sponge city construction special planning and implementation plan.2016
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Table 1: policy document

The merits of utilizing a case study research strategy involve collection and analysis of data within the context of the research phenomenon, it also allows for the integration of qualitative data as well as the ability to capture complexities of real-life situations which ensures that the research subjects are studied in greater levels of depth. The purpose of this case study is to provide a comprehensive understanding of the community-based organization (these are private or public representative of a significant part of a community or an entire community and strikes to meet the needs of the community) in implementation for roof greening.

The overarching question guiding this study will be the role of a community-based organization in open green planning and implementation. To achieve this, data will be collected using interviews in order to meet the research objectives. A case study approach will be used for this study as it will seek to obtain explanations of the factors influencing the implementation of green roofing in the urban villages. The goal of the study is to understand green roofing and explore the factors influencing the adoption and implementation of green roofing in urban villages in Shenzhen. The research questions to be answered for the proposed study approves the case study strategy due to the provision of an in-depth description of the adoption and implementation of green roofing through community-based organizations. This is because all events taking place in a case study approach cannot be controlled or manipulated and the events occur in real-time; thus, eliminating research bias resulting in accurate and credible results.

3.4. Interview and case selection

Four interviews were conducted for the case study, the CEO of the Glocal Company, which owns the Gangxia property, Mr. Xie participate in the Gangxia 1980 project as project cofounder. The manager of TNC, Mr. Yu, participate in the Gangxia 1980 project as project cofounder. The sponge city office in Shenzhen, which is the official planning department for sponge city construction of the city of Shenzhen. An officer from the street office in the Futian street office. The survey was conducted in the researched building with the residents' whose lives in the building, and the resident's lives surround the building and stuff from Glocal who participated in the project. The reason to choose the residents who live in the building is that they are physical lives in the building, they have easy access to the green roof. The reason to choose the residents who live around the

building is because of the structure of the project building is closely next to three other building, for those three buildings they could see the project from their window, they also have access to the green roof, during the construction of the project, they were aware of the project. People who work for the Glocal Company directly participate in the project. Through snowball contacts, three respondents were found, who have participated in the workshop and opening day of the green roof, they have visited and utilized the green roof, even though they are not living in the neighborhood. Therefore, these four groups of people were selected. The total number of 22 surveys were collected. 12 from the building residents, five from the neighborhood building. Three people who did not live in the building or surrounding neighborhood but have participated in the green roof open concert in Gangxia building.

#### **Why this building been selected as the research case.**

1. The location, Gangxia building, is located in one of the biggest urban villages with a considerable amount of informal housing. It is located in the Futian CBD area, where outside the urban village, there are skyscrapers and office buildings. The location of the project visually gets much attention.
2. The building structure, the Gangxia building, is a three-floor residence building built-in 1980. The building has a vast roof between the second and third floors, where it provides a Building difference in floors.
3. Innovation. Gangxia 1980 is the first sponge city green roof project in an urban village in Shenzhen, and the first building uses sponge city technology in informal housing renovation.
4. Collaboration. Gangxia 1980 project is a result of the collaboration between private housing companies and NGOs and foundations. It is a privately initiated sponge city renovation project.

### **3.5 Data collection Strategy**

#### **3.5.1 Sampling Technique**

Sampling techniques relate to the process through which study respondents or participants are selected to represents the target population of the study. In this study, a snowball sampling technique will be employed whereby research participants will recruit other respondents for study purposes. The selection of this sampling technique is due to its usability where participants are hard to find such that the selected participant i.e., shareholders who will comprise of people from different groups of stakeholders involved in green roofing adoption and implementation in the

urban village of Shenzhen, will aid in recruiting other study participants.

Among the advantages of utilizing snowball sampling techniques involves the chain of referrals enables the researcher to reach a certain population which could be difficult to sample while utilizing other sampling techniques. Additionally, the process is simple, affordable as well as time and cost-efficient. It also requires limited workforce and little planning prior to undertaking the research in comparison to other sampling methods (Biernacki, & Waldorf, 2001). On the other contrary, snowball sampling technique has certain limitations which includes lack of cooperation even after referrals making it difficult for the research to complete the study with conclusive findings and results. Biernacki and Waldorf (2001) conceded that, snowball sampling presents an error margin since the referrals are made based on how well a respondents knows the other which can results in similar results and in turn lead to potential sampling or research bias.

### 3.5.2 Data collection tools

The research will utilize semi-structured interviews which will comprise both closed and open-ended questions. It will have two parts whereby the first part will capture the demographic information of the respondents while the second part will capture information related to the implementation and application of green roof initiative. The observations made by the researcher will be dinned and relevant secondary data will be explored fully. The participants will include people from the city, federal government agencies, community residents, and community non-governmental organizations. Four interview participants were considered specifically the higher ranking shareholders in green roof initiatives will be considered for the study whereby each subset was represented. Thus, the four interview participants comprised of shareholder or stakeholder form government agency, NGOs, senior community residents and a representative of the city. This ensured that research bias is eliminated by including a balanced number of participants from all the targets of the study which in turn aid in recruiting or referring other participants for the purpose of the study. The interviews sought perspectives and opinions from the participants with regard to green roofing adoption and implementation in the urban villages of Shenzhen. Each of the interviews will take an average of 20 to 35 minutes to allow for ample time to gather information which aided in answering the research questions.

<b>Respondents Category</b>	<b>Number of Respondents</b>
Property Developer	1

NGO Representative	1
Street Community Staff	1
Government Agency Stakeholder	1
Total	4

Table 2: Interview Respondents

### 3.5.3 Data Analysis

Data analysis relates to the reduction of the gathered and collected data to manageable proportions of the data collected. Data analysis in this study will be based on the research objectives. Content Analysis was utilized in the analysis of the collected data to provide replicable and valid inferences through coding and interpretation of the collected information (Mayring, 2004). The researcher took notes during the interviews to ensure that the information and data provided by the respondent was fully documented. In addition, the interviews were recorded and a professional transcriber was hired to facilitate effective transcription of the interviews from which the respondent's quotes were obtained and included on the study findings. This provided a representation of the collected data providing research findings and results from which the conclusion will be drawn.

The coding logic of qualitative research in this paper is based on the conceptual framework since the research object is a grassroots innovation project and the main research question of the research is the challenge and opportunity of a grassroots innovation project in china. The research question was designed based on the main elements of grassroots innovation. Namely vision, implementation, collaboration and creation of value. Therefore, the coding logic is in line with the four elements. The interviewees involved stakeholders, namely property developer, NGO, public sector, and residents.

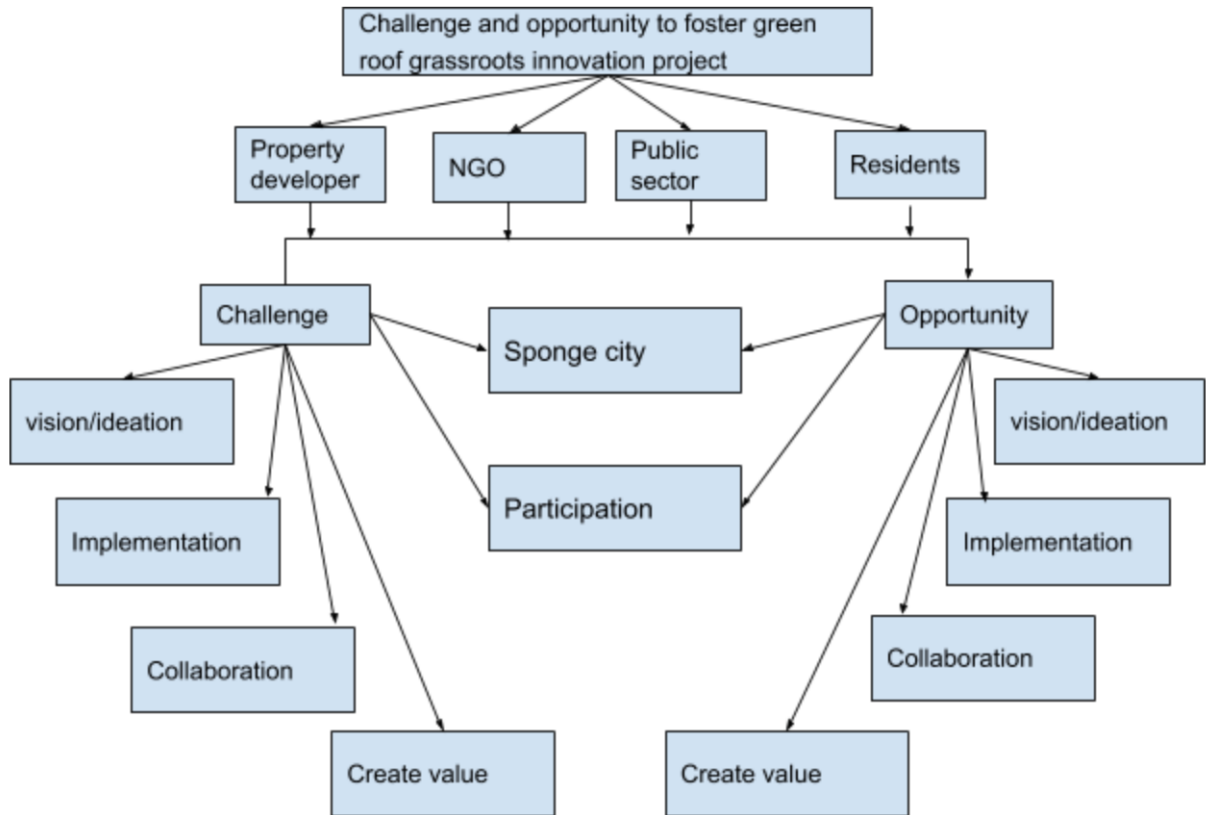


figure 5: Coding tree.

**Codes for interview findings**

Interviewee profile	Challenge	vision/ideation	Implementation	collaboration	Create value
Property developer	CD	CDV	CDI	CDC1	CDC2
NGO	CN	CNV	CNI	CNC1	CNC2
Public sector	CP	CPV	CPI	CPC1	CPC2
Residents	CR	CRV	CRI	CRC1	CRC2

Interviewee profile	Opportunity	vision/ideation	Implementation	collaboration	Create value
Property developer	OD	ODV	ODI	ODC1	ODC2
NGO	ON	ONV	ONI	ONC1	ONC2
Public sector	OP	OPV	OPI	OPC1	OPC2
Residents	OR	ORV	ORI	ORC1	ORC2

Table 3: coding for interview findings

The table represents the challenges faced by the stakeholders; therefore, it starts with the abbreviation C which stands for Challenge, O for Opportunity, and the four grassroots innovations elements V-vision, I- Implementation, C1- Collaboration, C2- Create Value, D-Developer, N-NGOs, P-public Sector and R for Residents. These indicators are also used to analyse interview materials. (See in interview transcripts)

### 3.6 Validity and reliability

Validity concerns the relevance and correctness of the collected data, Mugenda (1999) defines validity as the meaningfulness and accuracy of the inferences based on the research findings and results. It is the degree to which the research findings or results obtained from data analysis represent the subject under study while reliability relates to the degree to which the instruments of research yield consistent results after repeated trials. The designed interviews will be validated by experts in green roofing more precisely by the supervisor of the research to ensure they are veritable tools for the collection of data. During the interviews, the researcher will conduct member checking of the interview responses to ensure that the correct responses are captured. For reliability purposes, the researcher will engage a professional transcriber to help with the transcriptions of the interviews and ensure accuracy.

### 3.7 Ethical Consideration

Ethics refers to a set of guidelines that govern the behaviors of the researcher before, during and after the research (Resnik, 2011). The researcher will seek permission from relevant bodies through drafting letters to the relevant authorities to apprehend the research before the initiation of the data collection process to assure the study participants that the research is purely for academic purposes. The research will ensure that the information provided by the study participants will be treated with

the utmost confidentiality. In addition, the researcher will clarify that the data collection process will be based on voluntary informed consent and the results obtained will be generalized without referring to a specific participant.

### 3.8 Chapter summary

This chapter presents the research methodology adopted in carrying out this particular research with respect to data collection methods and tools whereby interviews were used as the main tool for data collection. In addition, desk or secondary research was utilized such as policy documents, scholarly journals among other relevant and credible resources were fully explored. Case study research design was employed for the purpose of this study. The next chapter documents the case analysis as well as the findings of the research from which the conclusion of the study is based.

## CHAPTER FOUR: CASE STUDY

### 4.0 Overview

This chapter presents the case analysis of Shenzhen urban villages as well as the green roofing initiatives in this particular region. It presents illustrations, figures and locations of the urban villages and the green roofing initiatives in different urban villages within Shenzhen. The findings of the interview are also presented in this chapter.

#### 4.1 Overview of Shenzhen Old Community Sponge Renovation

Shenzhen is a city in China which is located in Guangdong province along the southern tip of the state or nation and lies along the eastern part of the Pearl River. The city population has increased exponentially since it was once a residence for an estimate of 30,000 people in the past which has grown to one of the major metropolises that holds a total population of over 10 million residents in accordance to 2016 statistics. The role of the city as a financial centre as well as a foreign investment centre contributed significantly towards its exponential growth and development transforming it from a market town to a technology and manufacturing hub, the fourth largest and busiest airport and third busiest port in China.



Figure 6: Location map of Shenzhen

Source: Danielewicz-Betz, Anna & Graddol, David. (2014). Varieties of English in the urban

landscapes of Hong Kong and Shenzhen. *English Today*. 30. 30. 10.1017/S0266078414000236.

The tremendous growth and development of Shenzhen City due to the increase in technology and manufacturing activities resulted in migration by a huge number of individual from rural areas to the city in search of employment. The increase in population resulting from increase in the number of immigrants from rural areas resulted in the establishment of urban villages since the immigrants could not afford the rental fees of the residences within the city. As a result of the establishment of urban villages in Shenzhen City, the need to devise measures through which habitable environment would be achieved in the urban villages become a great concern resulting in the enactment of the sponge city initiative in 2014 which was under the support and guidance of Ministry of Housing and Rural-Urban Development (UHURD), Ministry of Water Resources and Ministry of Finance (Li et al., 2017). These ministries were the main actors and were responsible for evaluation, reviewing and selection of candidate or potential cities as recommended by the provincial administrations based on specific criteria concerned with the feasibility and rationality of pilot goals. The main aim of the sponge city program was to retain 70 to 90 percent of the rain water through the application of green infrastructure concept as well as the utilization of the low impact development measures to eliminate water logging as well as prevent of urban floods which, in turn, improve the quality of water and mitigates the effects on the urban ecosystem (Li et al., 2017). In addition, the sponge program was intended to create investment opportunities in engineering products, upgrading of infrastructure as well as the green technology.



Figure 7: Urban Villages in Shenzhen, China

Source:<https://www.thatsmags.com/china/post/19142/exploring-shenzhen-s-urban-villages-baishizhou-hubei-gangxia>

The total land area of the city is 1952.8 km<sup>2</sup>, the terrain is highest in the southeast and lowest in the northwest. The city experiences a southern subtropical maritime monsoon climate. Shenzhen has an abundant rainfall with an average annual rainfall of 1,837 mm (shenzhen municipal.2016). Since 2004, Shenzhen introduced low-impact development concepts. Over the past eight years, Shenzhen has utilised a low-impact development model which has led to rapid development. Through this model, Shenzhen has developed several low-impact development demonstration projects such as buildings and communities, parks and green spaces, roads and plazas. Moreover, in the city's key development areas, old city transformation concentration areas and areas with sponge transformation conditions, have promoted the practice of the sponge city pilot area. In April 2016, Shenzhen officially became one of the second batch of pilot cities for the construction of sponge cities through an extensive and competitive process.(shenzhen municipal.2016)

Construction projects classification is essential as it allows experts and scholars to analyse

construction projects by grouping them in accordance with the similarities. One of the construction projects classification scheme is the Project Definition Rating Index (PDRI), it is utilized in the evaluation of the project scope, definition, completeness specifically during the front-end planning of the project. The classification scheme of Shenzhen construction projects is primarily based on the purpose of the property or land where the construction project takes place since different land are selected for distinguished purposes; hence, the differ in classification of the construction projects. The classification is also based on the design of the sponge city facilities according to the nature of the different land use. The Shenzhen construction projects are divided into seven categories based on the type of construction land. The construction points are clearly defined (Shenzhen sponge city construction special planning and implementation plan.2016).

<b>Construction project classification</b>	<b>Land classification type</b>	<b>Land code</b>	<b>Land type</b>
Building community and	Residential Area Old city transformation, comprehensive renovation area Public building area Industrial warehousing	R1, R2 R3, R4 C, GIC M1.M0,W1,W0	Type 1 .2 residential land. Type 3,4 residential land (large residential area, urban village area) Commercial, service facility land area Public management and service facility land General industrial site, new industrial land, logistics and storage land
Municipal roads and squares	Municipal roads, squares	S, G4	Land for transportation facilities roads, squares, parking plots) and public squares
Park and green space	Park and green space	G1	Park and green space
Urban water body	Waterbody	E1	Waterbody

#### **Table 4: Classification of construction projects**

*Source: Shenzhen sponge city construction special planning and implementation plan.2016*

This table was obtained from the Shenzhen sponge city construction special planning and implementation plan 2016 which presents the classification of construction projects. The first column presents the construction projects with respect to specified classifications under which the construction project can be classified. The construction projects are classified into four categories namely; building and community classification, municipal road and squares, parks and green spaces and urban water bodies. The second column presents the classification of land under the construction project whereby there are classified into residential area, public buildings, old transformation, comprehensive renovation area, municipal road square, park and green space and finally water bodies. There is similarity between the construction project classification and the land classification. The table also presents the code of the lands under which project are constructed, the codes are used to denote the type of land and uses letters from R1 to R4 for residential lands, C, GIC for commercial services and public utility lands, M1, M0, W1, W0 for industrial sites, S, G4 for transport facilities lands, G1 for parks and green spaces and finally E1 for water bodies. The

#### **4.1.2 Urban villages in Shenzhen**

In Shenzhen, 5.02 million people are covering an area of 93.49 million square meters and a building area of 105.61 million square meters (Wang, Wang, & Wu, 2009). There are 320 villages in the city, and the total sum of the area of all the urban villages' accounts for about 1/6 of the total area of the city. There are also 35,000 farmer houses built in the city (Hin & Xin, 2011). However, the residential area of the urban Village accounts for 49% of the city's housing area according to the statistics provided by the "Shenzhen City Village Renovation Master Plan." For example, one of the urban villages Gangxia covers an area of 96,000 square meters, with 881 private buildings and a building area of 395,000 square meters. The Village has a population of 100,000, and it is the leader of the "urban village."

In order to pursue more significant economic benefits, Shenzhen's urban villages are capped continuously, and the floor area ratio and building density are incredibly high (Hao et al., 2012). Such developments have reduced the housing rental costs and allowed tens of millions of Shenzhen residents, especially migrants, college students, and entrepreneurs to have an affordable living. Unfortunately, the high building density and spatial layout make the urban villages in Shenzhen to have less green space and lack rainwater management (Bach, 2010).

Under the prevailing circumstances, if the existing buildings were to be demolished and converted into green spaces, the living costs within the city significantly increase. In addition, the compensatory pressure resulting from the massive demolitions would trickle down to the government. However, if nothing is done, the wastage of land resources and the attendant pressure placed on the environment do not support China's sponge city development path (Hin & Xin, 2011). Therefore, under the guidance of stock planning theory, urban managers advocate for urban villages to consider the flexible transformation channel, and "encourage the comprehensive improvement of the land within the district by carrying out comprehensive renovations of the urban villages" (General Regulations "Shenzhen urban Village (Old Village) Comprehensive Remediation Master Plan (2019-2025).") The transformation mainly includes improving fire protection facilities, improving infrastructure and public service facilities, improving street façades, environmental remediation, and energy-saving renovation of existing buildings. However, this does not change the main structure of the building, the function of the building, does not add auxiliary facilities, but the district government is responsible for organizing and implementing these measures.

The total area of urban Village in Shenzhen is 5510 hectares and the rental population is 11 million( Shenzhen municipal.2016). The area is densely built and this has greatly hardened the surface. At the same time, the function of the rainwater pipe network in the old reformed area is highly degraded, since the construction standard is low, and the internal sputum phenomenon is vital after the summer rain. This forms the key sponge transformation content of Shenzhen. In the planning requirements, the transformation of the urban village area mainly occurs within the residential area, and the low-impact transformation and development are carried out according to the local conditions. The transformation includes permeable paving, roof greening, recessed green space, rainwater pipe network, rainwater tank among many more. (Shenzhen sponge city construction special planning and implementation plan.2016)

The main points of the planning and design of the sponge city for the building and community land state that the use of rainwater in the old city should be based on the infiltration of rainwater in promoting the greening of the roof. The main design consists of four parts. (Shenzhen sponge city construction special planning and implementation plan.2016 and 2019)

Roof of the buildings: Actively promote roof greening, rainwater storage, and reduction of runoff.  
Greenspace: The green space is transformed into a concave type, where the conditions permit, and the limited green space infiltration rainwater fully utilized. According to the

characteristics of the village in the city, the rainwater utilization facilities is included in the green space.

Roads and squares: Pavements and plazas are paved with permeable pavement and permeable bricks.

Drainage system: To improve the rainwater pipe network, analysis of the runoff coefficient background and comprehensive utilization of rainwater is done. These are then used to calculate the drainage system load and after which renovations and optimization are done simultaneously. The rainwater outlet is set in the green space or on the roadside, and the source pollutant removal facilities such as the interception hanging basket are used.

The Renovation technology route shown below refers to the description of a series of technological planned updates and changes which are made to enhance or facilitate the roadmap through which the business or a project is conducted. The renovation technology route refers to the path through which the technological renovation or changes takes place to ensure upgrading or updating of a particular project.

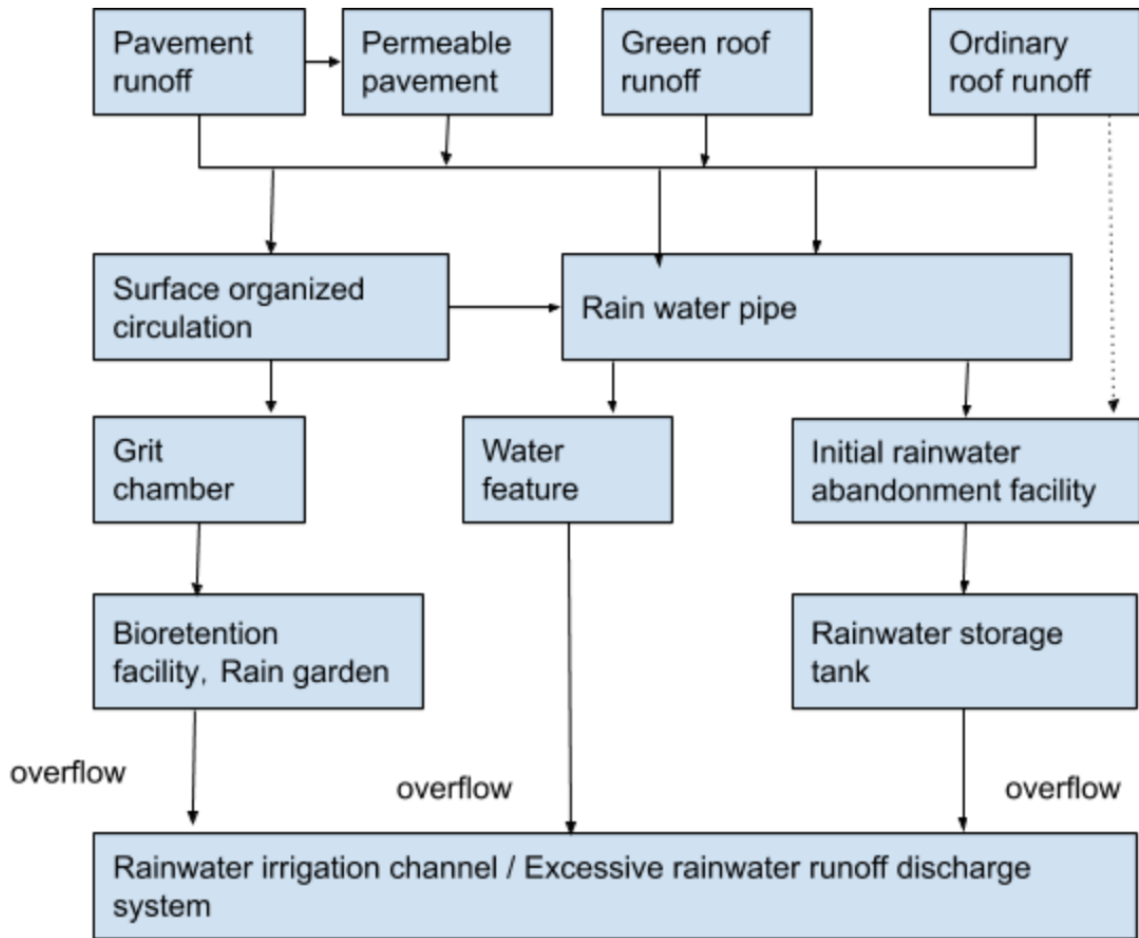


Figure 8: The Renovation technology route. author's creation.

The annual runoff total control rate in the Shenzhen sponge city construction special planning and implementation plan. 2016

Type		Integrated management area (%)	
Control target	Eastern rainwater type	Loam	55
		Soft soil	50
	Central rainwater type	Loam	50

	Central rainwater type	Soft soil	45
		Loam	55
		Soft soil	50

Table 5: Urban Village Comprehensive Remediation Annual Runoff Total Control Rate Target and Control

Source: Shenzhen sponge city construction special planning and implementation plan.2019  
Translated by the author Indicators shows below.

## Gangxia 1980

### 4.2.1 Project background



Figure 9: Gangxia Village in Shenzhen

Source:<https://www.thatsmags.com/china/post/19142/exploring-shenzhen-s-urban-villages-baishizhou-hubei-gangxia>

Gangxia Village is a civic center in Futian District and it is located in the CBD of Shenzhen, one

kilometer to the northwest. The Gangxia village land is approximately 17 ha, whereby each housing lot comprising of 10 ha. It has the characteristics of a village in the city since it is home to hundreds of private buildings which are five to ten stories high, they are close to each other and close enough for neighbors to shake hands in the opposite buildings. The adjacent village provides various goods and services. The village is a home to an estimate of seventy thousand people who are immigrants from other regions in China specifically rural areas in search of employment However, there is almost no tree or any green space in Gangxia village since even the smallest plots have been filled with constructions.

Gangxia 1980 is a long-term apartment located in Gangxia village and was originally built in 1980 by farmers in Gangxia Village. Later on, the Glocal Company obtained the lease of the building in the form of a long-term rental establishment. It was transformed, and the original farmer self-built house became a fully equipped youth apartment. (Interview NI 1.2019). The building contains the green roof project whereby youth residing in the apartment engage in the green infrastructure as a source of income which, which turn, results in the improvement of the air quality in the community.



Figure 10: The location of Gangxia project.

Source: <https://www.goood.cn/green-cloud-china-by-zhubo-ao.htm>

#### 4.2.2 Ownership of the roof

The land ownership of the reconstructed building is by the residents of the urban village, and the development and transformation rights of the building are given to the Glocal Company in the form of a lease agreement. Therefore, the ownership and transformation rights of the renovation project are owned by the Glocal youth apartment, and the right to use is owned by the youth apartment occupants. After the renovation, the roof garden is open to the surrounding residents with the consent of the owner, and the residents around the roof also have the right to use the roof. In the transformation project, the ownership was clear and no problems were encountered. (Interview NI1.2019)

#### 4.2.3 Project organization

In 2017, The Nature Conservation Association (TNC) and Paradise Ecological Protection Foundation joined hands with Glocal youth apartments, Shenzhen Urban Planning and Design Institute, and joint public organizations to launch the “Yugong Plan 2.0 – Gangxia 1980 Sponge City Green Roof Demonstration project”. The project organization shown below.

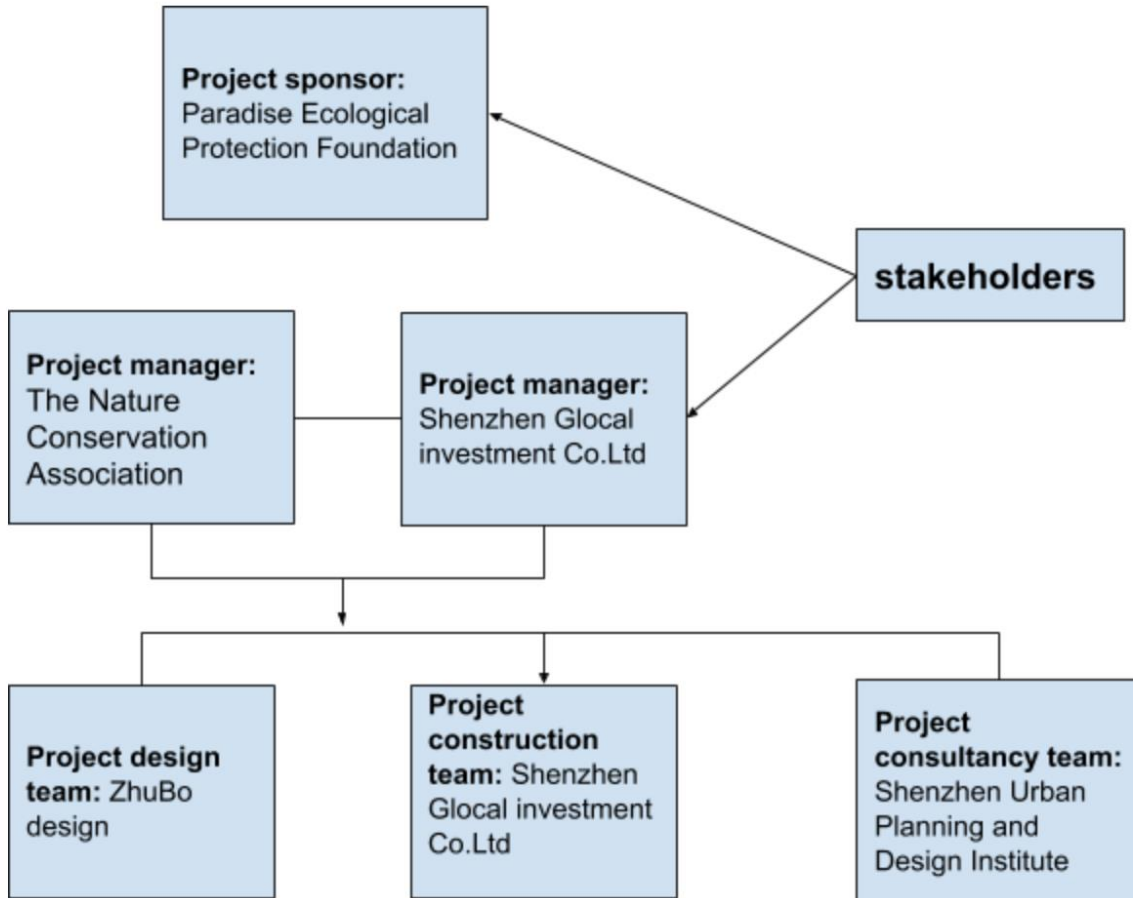


Figure 11: Project organization

Source: Author's own creation

#### 4.2.4 Project Financing

The funds of the project were undertaken by The Paradise Ecological Protection Foundation, The Paradise International Foundation is a nonprofit environmental organization with a focus on nature conservation and the post-maintenance expenses were borne by the youth apartments. This project is a non-profit private financed project.

When it comes to project financing, the property owner had no strong desire to invest, and the community where the project is located did not have a fund for building a roof greening project. (Interview CDI1.2019) (Interview CNI4.2019) The establishment of a green roof would not bring any economic benefits to the property in the short term. However, from the government's perspective, the Shenzhen Municipal Government introduced subsidies for the construction of sponge cities and subsidies for three-dimensional greening in 2018 and 2019. Projects that meet

the requirements can apply for corresponding subsidies. (Official answer from the Shenzhen Sponge City Construction Work Leading Office) This subsidy policy is very new and has not yet been universally practiced. From the perspective of NGOs, investing in such projects can increase public awareness of sponge cities and roof greening. The value of investment projects is even more educational, but NGOs themselves have limited ability to continue promoting such Projects .

#### 4.2.5 Project design

The transformation of urban villages has always been one of the main points of urban development. For the “Gangxia 1980”, a building in the city of Shenzhen, it is even more difficult to meet the construction requirements of the sponge city. This is because the building itself is old, the sponge structure of the building itself is not obvious, and it is located in an area with extremely high building density, so there is no green space around the building. So, the goal of the project is to utilize the roof to create a water sensible green space. Through this project, Gangxia 1980 has a “green hill”, which is based on small green plant blocks. This green hill serves to not only improve the environment but also effectively intercept part of the heavily polluted rainwater and reduce initial runoff.

The structure of “Gangxia 1980” is special, with 4 and a half floors, and half of the 2 floors is a terrace, which makes it a natural test site for the “Yugong Plan”. The rain garden on the 2nd-floor terrace is made up of a steel frame and a planting box embedded in the frame and a leisure seat for the residents. The frame structure surrounds the terrace and forms a green barrier. The hollow steel frame structure is painted with white fluorocarbon paint and is isolated into a lattice of about 33.5 cm in length and 32.5 cm in height. The application of the sponge modification is in the planting box embedded in the grid. There is an aquifer at the bottom of each planting box to trap about 4 litres of rainwater and an overflow at 10 cm where the surplus rainwater can be discharged outside the planting box without causing the roots of the plants to rot due to too much water. After the water in the planting box on the roof overflows, it is collected and discharged into the water storage tank on the second floor. The water storage tank can store up to 400 litres of water. When it is not raining, the water in the water storage tank can be used to water the plants and form the water circulation system of the building itself. (Interview CNI3. .2019)



Figure 12: Green roof in Gangxia 1980

Source: <https://www.goood.cn/green-cloud-china-by-zhubo-ao.htm>

The sponge facility on the roof is even more remarkable. Here, the frame structure extends from the top of the 4th floor to the top of the 5th floor, where more than 300 planting boxes are placed, and there is even a space used to install a swing and a table and chairs for rest. The plants in the planting box are common kidney ferns, green radish, and passion fruit among others. In order to meet the requirements of low maintenance and low energy consumption, many native plants in Shenzhen, such as wild peony, donkey, and grouper, have been selected for vegetation, accounting for more than one-third of the species of green plants. There is a buoy at the corner of each planting box to make it easy to see how much water is in the aquifer. Residents can water the vegetation according to the instructions of the buoy.



Figure 13: Green rooftop in Gangxia 1980

Source: <https://www.goood.cn/green-cloud-china-by-zhubo-aao.htm>

It is estimated that the total water storage capacity of the flower pots and high flower beds on the roof of Gangxia 1980 is 4.79 cubic meters, and the controllable precipitation depth is 26.3 mm. The corresponding annual runoff control rate is about 65%, which far exceeds the construction of the sponge city and the urban village type property requirements for rainwater control (TNC.2019).

#### 4.2.5 Building permission

The building permission in reforming the main body is the legality of the reform. According to the requirements of the renovation of the sponge city in Shenzhen, the Gangxia project meets the requirements for the reconstruction of the urban village. However, since the reconstructed building belongs to the urban village building, in addition to the requirements of the sponge renovation certain legal aspects must be followed. Construction requirements; requirements of the environmental water department, and the requirements of the village collective must be met.

Problems encountered include; during the project, the nearby residents were complaining and when

they saw the construction their first reaction was that they were doing illegal floor construction. (Interview CNI1. Yu.2019) The construction of illegal floors refers to the addition of floors to the roof on the basis of existing buildings. This phenomenon is very common in self-built houses in urban villages. In the face of such complaints, the law enforcement team of the community to which the project belonged was required to show the construction permit, otherwise, the project would be shut down. In the face of this challenge, TNC and Glocal tried to apply for the project permit, and this led to the second problem. Project Licensing Issue: TNC and Glocal applied to multiple official departments for a building permit. After understanding the project situation, the housing construction department believed that the roof greening was not part of the housing construction itself, so the building permit could not be given. The Environmental Water Administration did not have any past experience in such projects, so it was not possible to also grant a building permit. The city management department also said that there is no relevant work experience and it is impossible to issue a building permit after understanding the project situation. (Interview CNI1.2019)

Finally, with the help of the Environmental Water Authority, the project's enforceability was affirmed and the "Red-headed documents" were given. "Red-headed documents" refer specifically to documents issued by administrative agencies against unspecified citizens and organizations. Such documents are binding to the public and involve their rights and obligations, that is, administrative regulations referred to in legal terms. They are universally binding normative documents. (Interview CNI1. Yu.2019)

After obtaining the specification documents, the project leader returned to the community, first communicated with the street community, then communicated with the village collective, and finally obtained permission from the village collective and the project continued. As can be seen from this process, the official procedures for the independent construction of green roofs have previously not been there. Therefore, presently, building green roofs needs to be recognized by the residential construction department, environmental protection department, city management department, as well as street offices, and village collectives. Therefore, there is a lot of government departments associated with a green roof project. These departments have no clear official procedures for building a green roof independently, which leads to the project developers being stuck as they do not know where to begin with obtaining the project licensing.

#### 4.2.6 Sponge technology / Green roof implementation

The project incorporated the sponge technology in the transformation, taking into account the load-bearing capacity of the building's own roof. In the transformation, the construction team carried out the load test of the building for this old building and made a special design according to the test results (interview CNI2. Yu.2019). According to local conditions, it met the technical requirements of Shenzhen sponge renovation. It can be seen that the roof sponge modification has specific requirements for the design of the renovation, especially the sponge transformation on the old building requires a professional team design. Technology is the foundation of the project's success. The technical application and design of the Gangxia project are based on the architectural characteristics and low-impact development technical requirements of the old buildings in the city. The buildings in the city village have terraces, and the designers use the terrace to build a steel roof garden. In the application of low-impact technology, the designer used a plant box, which maximizes the use of limited roof space and can be practised in a village building with a terrace.

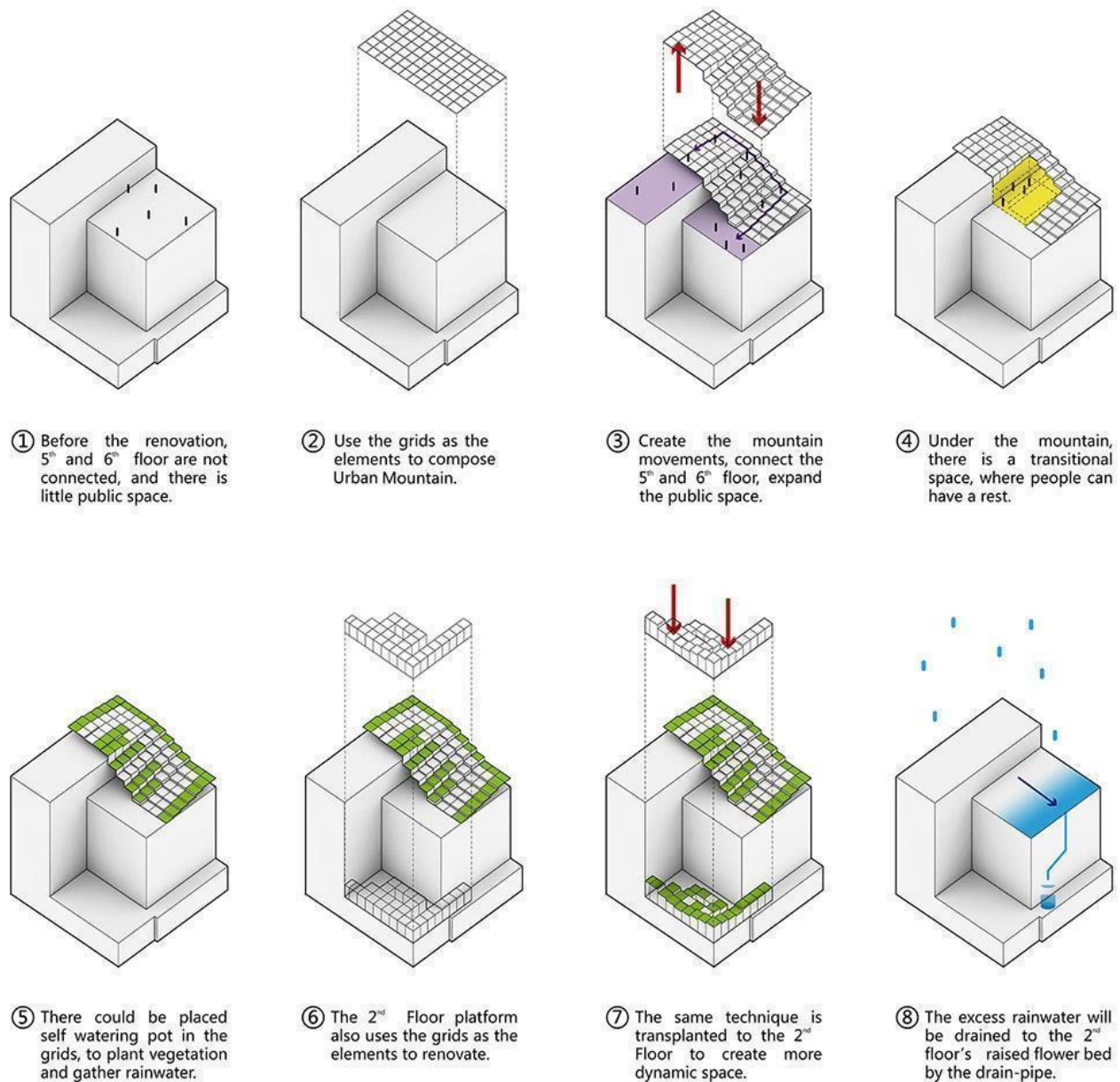


Figure 14: The Sponge technology implemented on the Roof of Gangxia Building.

Source: <https://www.goood.cn/green-cloud-china-by-zhubo-ao.htm>

### 4.3 Sponge City Policy, Three-dimensional Greening Policy

The project itself is the roof greening of existing buildings in the village. Because of the complexity of the project, the connectivity between the project itself and the urban planning should begin with defining the characteristics of the project itself and the urban planning associated with it. From the perspective of the overall urban planning, Shenzhen released “Shenzhen sponge city construction special planning and implementation plan” in year 2016. The special plan is organized by the Shenzhen Planning and Land Resources Committee, in order to meet the The People’s Republic of

China. The General Office of the State Council on Promoting the construction of Sponge Cities [Z]. 2015-10-11. which requires that by 2020, 20% of the urban construction areas should meet the requirements of the sponge city, By the year 2030, 80% of the urban areas should meet the requirements of the sponge city. Among the technical points of the sponge renovation construction project for the construction community, the green roof is recommended for existing buildings.(Shenzhen sponge city construction special planning and implementation plan.2016)

From the perspective of the greening function of the project, the project is as a result of the urban three-dimensional greening plan. The Shenzhen Municipal Bureau of Urban Management's Shenzhen Three-dimensional Greening Implementation Measures was promulgated on January 8, 2019, and it is valid for three years. The three-dimensional greening refers to the construction (structure) as the carrier, the plant as the material, the roof greening, the aerial layer greening, the wall (face) body greening, the scaffolding greening, the bridge greening, the window balcony greening and the hard slope Implementation in the form of greening. The definition of roof greening is based on the top of the building (structure) as a carrier for planting trees, shrubs, lawns, and ground cover plants. This encourages the implementation of three-dimensional greening of existing buildings (constructions), public spaces and slopes that are not public buildings (structures) and suitable for three-dimensional greening. This three-dimensional greening is voluntarily agreed upon by the property owner or management unit of the property through social participation. If multiple owners jointly own the property rights of the property, the three-dimensional greening participation is agreed upon by the owners themselves.(Shenzhen Three-dimensional Greening Implementation Measures.2019)

#### 4.4 Mandatory policy

The mandatory documents for green roof implementation are mainly for new buildings. For existing buildings, the policy tends to spontaneously carry out roof greening according to the existing conditions of the building. For informal housing building there are no specific requirements. In the special plan of sponge city in Shenzhen, there is an overall goal for the construction of a sponge city. According to the location and flow direction of the river system in the nine major river basins in Shenzhen, combined with topographical division, vertical planning and planning drainage network, the watershed is subdivided into twenty-five control zones to decompose and refine the annual runoff total control rate target. Different land use in regional plots is classified by land-use type, and urban villages belong to comprehensive management plots in the type of building community. The indicators and control objectives of different plots are based on

the analysis of the underlying surface and the analysis of the distribution of the soft soil. Then, according to the indicators of the regional plots, the annual runoff total control rate target is completed. There is no clear requirement for the sponge design of the specific urban village. According to the control area classification, Urban Village should cooperate with the completion of the area index. There is no hard indicator for a single urban village, only the overall indicator. (Shenzhen sponge city construction special planning and implementation plan.2016)

In the three-dimensional greening implementation method of Shenzhen, there is no rigid requirement for the existing building to establish a green roof. This is advocated to encourage the existing buildings to construct the green roof on the basis of the construction suitable for the building itself. The type of existing building is not specified. However, after the completion of the roof greening project of the existing building, it has the power to apply for project funding subsidies. ( Shenzhen three-dimensional greening implementation method.2019)

#### 4.5 Incentive policy

Through the Shenzhen Financial Support Sponge City Construction Implementation Plan ,2019, the incentive mechanism for the roof greening project is elaborated for the reconstruction projects for sponge renovation of completed projects, such as non-public private hospitals, schools and other socialized public service organizations, as well as industrial parks, residential quarters, and single buildings that are legally operated and approved by the relevant departments of the district. The design should fully seeks the opinions of the owners before the renovation (the residential quarter should be publicized and reviewed by the industry committee). After the initial review by the District Sponge Office, the third-party organization or expert of the Office of the Sponge Office reviews it and confirms. (Shenzhen Financial Support Sponge City Construction Implementation Plan .2019)

After the completion of the project which is confirmed through the review, it is further reviewed by a third-party organization or expert review by the Municipal Sponge Office and rewarded according to the complete area of the sponge facility and 50% of the average cost of the corresponding type of facility renovation. 5% of the cost is awarded for design and the award funds are arranged from the special funds for municipal water development. The reward criteria for green roofs are shown in the table below.

Name	Budget (Yuan)	Median price	Unit area award (50% of the median cost)	Unit area design fee reward (5% of the median cost)
Green roof	100-300	200	100	10

Table 6: Reward criteria for green roofs

Source: Shenzhen Financial Support Sponge City Construction Implementation Plan 2019

The Shenzhen Municipal Three-dimensional Greening Implementation Measures (2019) pointed out that the use of new construction and reconstruction of existing building space, the construction subsidy standard for three-dimensional greening investment construction and maintenance funding standard for three-dimensional greening projects are all determined by the municipal governments in each district according to their actual conditions and requirements.

**The reference standard for construction funding subsidies includes:**

- Garden-style roof greening is 300 rmb / square meters;
- Simple roof greening is 180 rmb/ square meters;
- Other types of three-dimensional greening are 150 rmb/ square meters;
- The subsidy for the construction of a single three-dimensional greening project shall not exceed 40% of the construction cost.

According to the current effective Shenzhen Garden Building Greening Project Consumption Quota, 50% of the applicable indicators for three-dimensional greening maintenance are subsidized, and the municipal and district greening administrative departments are responsible for payment according to their jurisdiction. (Shenzhen three-dimensional greening implementation method.2019)

With regard to whether the two incentive policies can be applied at the same time, the Shenzhen Municipal Financial Supporting Sponge City Construction Implementation Plan.2018 does not clearly indicate whether the projects that have been subsidized by other projects can apply. The Shenzhen Municipal Three-dimensional Greening Implementation Measures.2019 pointed out that the construction of new project and reconstruction projects including sponge cities, energy conservation and environmental protection, green buildings and other government subsidies will not be included in the scope of construction subsidies in three dimensional greening subsidies, and

only subsidies for maintenance funds can be applied.

#### 4.6 Project management

The management problem is divided into three parts. The pre-project management is jointly undertaken by TNC and the Glocal youth apartment. The project is initiated by the private sector and managed by non-government organizations. The management of the project in the early stage is the responsibility of the TNC. The TNC is responsible for contacting the design unit, coordinating the communication with the relevant government functions of the project, and the Glocal youth apartment cooperates with the TNC to prepare for the project and undertake the work of the construction project.

In the middle of the project, the government function of the specific management project is not clear, and there is no clear management procedure, which is a difficult situation in the project. TNC project sponsors highlight that NGOs, as organizations that promote project development, need the support of relevant government agencies in the medium-term project management, and bottom-up projects need to be integrated with the top-down management system.

In the later stage of the project, the manager of the project is Glocal youth apartment. The main management content is project maintenance and project-based pilot cooperation with TNC and government-related institutions in the sponge city promotion activities. This part of the management is initiated by the private sector.

#### 4.7 Chapter summary

This chapter presents the case analysis of Shenzhen urban villages and the green roof initiatives implemented in these villages. It provides insights into the green roof initiatives in these urban villages, the stakeholder's involved, public participation and the challenges faced in the implementation of these projects.

## CHAPTER FIVE: CASE ANALYSIS

### 5.1 Vision/ Ideation

Vision is one of the key elements of strategic niche management theory, which involves the goals as well as the purpose to be achieved. It revolves around the goals and aims that the stakeholders in strategic niche management strive to attain after the implementation of projects such as

grassroots innovation. Before the development and implementation of the SNM project, a vision is developed, which acts as a guiding tool for the specific project to enhance its achievement in the long-run. All parties or stakeholders involved in the project implementation contribute or rather participate in the development of the vision to ensure that the success of the project can be easily measured through the set vision.

Notably, the sharing of the sponge city strategic vision among involved and interested parties in Shenzhen ensures that the Gangxia project is in line with Shenzhen's planning requirements for urban village renovation, urban greening, and sponge city, and plays a role in promoting the sponge city and community transformation. As a result of the effective sharing of the strategic vision in relation to the Gangxia projects, the government hopes that such projects can be replicated and promoted and that there are corresponding incentive policies for the sponge city renovation project and the three-dimensional greening project. Therefore, this is an indicator that sharing of strategic vision with respect to grassroots innovation projects between the public, private and non-governmental sectors results in the success of the initiatives; hence, sharing aspect cannot be overlooked as it is a key ingredient in the successful implementation of Gangxia green roofing project.

In addition, the need for the provision of construction policies is critical in the implementation of the green roofing initiatives. This is reflected in the Gangxia project as it uses a design concept that suits the local conditions, which in the words of the TNC, is grounded. It uses the existing structure of the old buildings in the village to build a green roof that meets the building's own requirements and technical requirements. (Interview CNI2. 2019). In March 2018, Shenzhen Municipality issued the Implementation Plan for the City's Financial Support for Sponge City Construction, and refined and formulated the (Shenzhen City Sponge City Construction Fund Reward Implementation Rules (Trial).2019) and (Shenzhen Sponge City Construction Fund Reward Declaration Guide. 2019) state 10 categories of awards, and the total amount of annual awards is up to 514 million RMB, of which the "special project of sponge project transformation" is based on the completion area of the sponge facility and the average cost of the corresponding type of facility renovation. 50% is rewarded, and the maximum reward for a single project is up to 10 million RMB. Through the fund reward, efforts are made to mobilize the enthusiasm of the whole society to participate in the construction of the sponge city. These incentive policies theoretically increase the willingness of public and private developers to implement roof sponge renovations, thereby increasing the project's reproducibility. Fund incentives can also help individual developers and people solve the

problem of roof design funding. As result, the provision of construction policies is significant in grassroots innovation project as they contribute tremendously to the success of these innovation through mobilization of funds and public which in turn enhances community participation.

## 5.2 Collaboration

From the perspective of the collaboration of different stakeholders, the Gangxia project is initiated by the private sector and managed by the private sector. However, it involves the housing renovation and transformation permit, so the management process requires the involvement of government agencies. At this stage, Shenzhen has an urban renovation master plan and planning office and sponge city construction office, but Shenzhen does not have a functional agency specializing in the sponge renovation of the informal housing community. That is to say, the functional organization for sponge city construction is at the municipal level, but there is no clear functional organization within the framework of the informal housing community. Therefore, when the project takes place, management problems are encountered, and one must first seek advice from the municipal sponge office. After receiving the opinions, it further goes to the community functional organizations for comments. The community has no relevant management experience in sponge renovation, and there is no relevant management organization. (Interview CNC1.1.2019) as an intermediary between the people and the municipal-level management agencies, the community management agencies have not been able to play a leading role. This makes the project go through some challenges hence becomes complicated. The existence of such management problems increases the challenges in privately initiated projects, and this makes civil organizations and individuals struggle when managing such projects. Communication between different functional agencies creates problems. Because there is no experience in docking sponge city projects. Complex processes can reduce the enthusiasm of developers, which is not good for project promotion.

The planning and management of sponge cities are carried out in the form of region and districts, and there are corresponding indicators in the community and smaller urban units. These indicators are not refined into the informal housing community. Due to the limited energy of the government, the government dominates the projects with large influence and large volume in the promotion of the project. For small projects, such as Gangxia 1980, it is difficult for the government to notice if there is no promotion from civil organizations. Therefore, there is currently no clear project procedure for small-scale individuals or community projects. There are no clear project approval procedures among the many planning policies, which leads to the project not being able to obtain

formal legal permission. The ambiguity of this policy is also a problem that will be encountered by promoters who want to develop such projects in the future.

Additionally, the link between Sponge City and other advanced urban planning is not perfect. Sponge City, as the guiding ideology of current urban planning in China, has not yet fully integrated into other current urban planning, such as in urban renovation plan. So far, there are Rainwater recovery requirements for sponge cities in the informal housing area, but it is an embedded urban renovation plan in the informal housing area. The urban renovation plan is the main area planning guide for the informal housing area, which has Strong execution. Sponge city is the municipal level plan for the city, but it is not integrated in the community or area plan, although the concept is well known, but is Lack of strength. There is currently no clear project procedure for small-scale individuals or community projects. There are no clear project approval procedures among the many planning policies, which leads to the project not being able to obtain formal legal permission. The ambiguity of this policy is also a problem that will be encountered by promoters who want to develop such projects in the future. This shows the need for building a better network between different planning policies and planning agency to ensure effective and efficient management of the initiatives.

In regards to the building community networks, the collaboration of the Gangxia project is built between private firms, NGOs, and the public sector, but the network with the local residents are awake, they are not involved in most of the project phases. Throughout the project, the local community (which means the people live in the building and surrounding buildings) didn't build a connection with other stakeholders before and during the project construction. They later built connections through open workshops and educational programs on the green roof. Some residents have paid attention to TNC and eco-funds on social media through activities on the green roof. Through contact with project personnel, some residents have begun to pay more attention to the construction of sponge cities on social media. Some residents said willing to participate in the follow-up activities of TNC.

### 5.3 Implementation

Provision of the different resources was enhanced, private firms, the Glocal Company, and ecological foundation are interested in the project because they are interested in promoting green infrastructure and participate in the sponge city initiative. Social responsibility is one of the main drives shared by the private companies. "We hope that it will continue to contribute a little to this

community. I also hope to express in our way, what are the things we need to do in the real sense of environmental public welfare” (Interview DV3.2019). The developer, the Glocal Company which participated in the whole process from design to construction to use. In the process, through cooperation with other stakeholders, the developer learned how to practice sponge city construction on his own property. (Interview DV2.2019)

In this process, a platform between developers, construction experts, and sponge city experts was established. For developers, this platform can be used for future development projects. Secondly, the developer learned the approval process of the green roof project during the project process. It is useful for developers who are implementing the green roof project for the first time. Finally, the developer learned the feasibility and construction requirements of such projects through the project. An attempt from zero to one is an exploration and an experience.

For NGOs, the ability to practice green roofs in urban villages is a renewed challenge. Compared to other buildings or areas, Sponge City has little promotion in urban villages, resulting in local residents on sponge cities, rainwater management, and green roofs.

“It is a pilot project we use as a practice sponge city and social participation” (Interview NV1.2019)

The cognition is very shallow. The educational impact of choosing this place to make a green roof is more challenging than that of other regions.

“Residents in the urban village doesn't have a sense of belonging, they don't have a sense of identity about this property. So these tenants, they don't have much enthusiasm for participating in this matter. Because they are also busy, most of them are working class, it is hard to find them to communicate about this type of work in this community.” (interview NPC.2019)

NGOs are also interested in promoting environmental protection and building networks, share vision, provide sponge city education.

“The significance of this project to show the possibility. Then also, for us, to practice this kind of work is at the community level, it requires an understanding of these various links, and this kind of work is a kind of timeliness. Kind of operation. Then the other thing is to make the project itself a successful change from the drawing to the reality, to create the best such display for the media,

other social organizations, and other communities about sponge cities, about development, or green infrastructure, or we sometimes say that this kind of environmental protection in cities, etc” (interview NV2.2019)

Public sector is interested in promoting sponge city initiative, secure the water management and flood risk. “sponge city is an initiative that the whole society should participate in building more resilient city together” (feedback from sponge city office.2019) “sponge city should be jointly building using the power of the society” (feedback from sponge city office.2019)

However, the retrofitting design of the roof requires professional measurements and calculations. The application of the current technology also requires the guidance of a professional team. Presently, the roof greening design of this residential building is expensive, for both private and public developers. From a technical point of view, the Gangxia project is highly reproducible and can be implemented on the roof of similar old buildings. However, the cost of technology is not friendly to private development projects; hence, this the difficulty of promoting such technology. (Interview CDI1 .2019; Interview CNI5.2019) and as a grassroots innovation project, this green roof project is a nonprofit project, the project itself cannot be financially independent, without interests return, it is hard to make such a project financially sustainable. (Interview CNI6.2019)

#### 5.4 Creating value

The local community’s awareness in relation to the Gangxia project is lower than other stakeholders. They are not participating in the initiative proactively. Second, they are not learning about sponge city proactively, most of the local community members agree with the idea of sponge city, they also like to utilize the green roof as open green space in the community, but they think it is the government's job to provide water management services and financial support. Since the property resident is not the initiator of the project, the concept of the project arises after the project is completed. Residents in the building learned about the concept of Sponge City through this project and the Sponge City Small Classroom provided by tnc. In the 14 interviewed residents, they all agreed that it is a kind of sponge city and a green roof continuous development philosophy.

Building residents and residents of the surrounding community learned about sponge city, rainwater management, rainwater utilization, and green roofs by using green roofs and participating in open-day events on green roofs. During the event, professionals from different industries presented the concept of Sponge City, the water circulation system of the green roof installation, the sponge city,

and the community to the local residents who participated in the event through pictures, posters, physical presentations, and communication.



figure 15: The Open day event on Gangxia green roof.

Source: <https://www.gooood.cn/green-cloud-china-by-zhubo-ao.htm>

Residents participating in the event said: "I have learned how green roofs can realize rainwater recycling. I used to think that the green roof is very beautiful. Now I think that this roof is not only beautiful but also collects rainwater and realizes the recycling of rainwater." (Interview 5.residents 1. 2019). The understanding is more vivid than just hearing the green roof. The term used for rainwater is more vivid. This kind of activity is especially popular with families with children.

The residents who participated in the activity said: "I think this kind of activity is very good, very educational for children. We can learn about environmental protection, and it is not boring." (Interview 7.residents 3.2019)

Organizing events on the roof also promoted the establishment of the network. Community residents exchanged ideas and participated in activities with The Nature Conservation (TNC)

Association, sponge city experts, and construction professionals. Through communication, they reached a new platform. The establishment of this network will help residents to learn independently in the later period.

One of the respondents said: “I learned about the Nature Conservancy through participation in the event. I also followed them on the social platform. They shared knowledge and activities about the sponge city on the social platform. I also participated in them. In the activities in Shenzhen, I met some people who are interested in environmental protection at the event. I think this kind of communication platform is very good.” (Interview 8. residents 4.2019). It can be seen that the establishment of the learning platform has promoted the extension of relevant knowledge of community residents gave them away to learn relevant knowledge. Similarly, experience and one of the interviewed children said: "I attended a rooftop concert. I also shared the knowledge of Sponge City in class at the school. I learned this on the roof event.” (Interview 11. participate.2019).

Through the project, the sponge city office learned some ideas on how to build a sponge city in the community. The Gangxia project was jointly developed by a personal developer and NGO. The sponge city office did not directly participate in the construction but participated in the project approval process. For sponge city office, the Gangxia project was also their first contact with similar projects. In the process, they learned the process needed for community residents or individuals to build such projects.

Shenzhen sponge city office states: “ This type of project not only implements the sponge concept but also provides a better living environment for the citizens. This multi-win cooperation model, the experience and practice of cooperation between the government and social forces, can be further summarized. And Promote this type of project.” (Interview OPC2.1.2019).

Through the green roof project, the community and the government also learned about the community residents — the attitude towards the green roof and their attitude towards the construction of the sponge city.

From the perspective of learning, the Gangxia project did not increase the spontaneous participation of community residents in the construction phase of the project at this stage, but it can use the roof as a communication platform to increase the enthusiasm of community residents to participate in educational activities. In the long run, if residents can participate in learning exchanges to improve

their understanding of the construction of sponge cities, and understand the benefits of sponge city construction to their living environment, they can be highly motivated to participate in sponge city construction-related activities in the future.

With respect to the creation of awareness regarding local sponge city adaptation the, NGO involved noted or become aware of two critical aspects. The first is to understand the construction process of the green roof project, especially the process required to build a green roof on informal housing. (Interview CN1 .2019)

Another point is that the local residents' attitude towards the green roof has been learned. The goal of the NGO is to promote the concept of environmental protection and promote the sponge city. “Everyone needs to spend a lot of time understanding the literal meaning of sponge city. But when such a project came out, when you took them to this site to see it, it did n’t really need a lot of languages. Show them how significant the project was, and they would understand it better than just talk to them. ” (interview ONC2.1)

In this project, they have direct contact with the local residents through the activities held on the roof later. By observing their attitude towards the green roof, they can understand how residents like to participate, such as what kind of activities are popular with residents, and what kind of knowledge the residents are interested in.

Through the establishment of a green roof, NGO has summarized some of the experiences related to the grassroots sponge urban project, and these experiences are beneficial for promoting sponge cities and ecological protection related projects in the community. Therefore, the need to enhance the creation of awareness become the initiation and implementation of grassroots innovation project is critical to ensure that the challenges experienced especially with the community are eradicated to ensure the smooth running of the projects which in turn facilitates its success.

## CHAPTER SIX: DISCUSSION AND CONCLUSION

### 6.0 Overview

This chapter presents the discussion of findings, which provides a summary of the results obtained from the study based on the research questions which the research aimed at addressing. It addresses each research question i.e., both the research sub-questions and the specific research question, and provides a linkage with the study findings to facilitate the provision of the answers to this each research question. In addition, the chapter presents a conclusion drawn from the findings of the study. It also provides recommendations based on the practice of green roofing as well as for further research to shed light on the areas that require further exploration based on the current research.

### 6.1 Discussion on research sub-questions

#### **1. What are the sponge city strategies?**

Low Impact Development (LID) is one of the sponge city strategies utilized in the case OF Shenzhen, which has led to tremendous development. Through the implementation and utilization of LID as a sponge city strategy, Shenzhen has developed various demonstration projects such as green spaces, buildings, roads, plazas, and communities. Sponge city involves the strategies which facilitate absorption, cleaning, and utilization of rainfall in an ecologically friendly, which reduces water runoff; hence, LID is among the sponge city strategies as it involves using stormwater to facilitate water quality and habitat aquatic and ecosystem. Therefore, the LID is a critical strategy in the sponge city initiative as it strives towards the achievement of similar goals; hence, its utilization in Shenzhen as a sponge city strategy. Through the utilization of low impact development strategy, Shenzhen became among the pilot cities in relation to sponge city development projects through the competitive and extensive process; thus, justifying LID as a critical strategy for sponge city initiative.

Sponge city initiative involves various activities that aim at enhancing a resilient and healthy ecosystem. As a result, Shenzhen utilizes project classification strategy to facilitate and differentiate the distinct sponge city initiatives depending on the purpose of the goal of a specific project. Shenzhen employs this particular strategy to facilitate the classification of distinct projects based on the intended purpose of the land in relation to sponge city initiative goals. For instance, roof sponge is categorized differently from other sponge city projects in Shenzhen since the design requires a professional team; hence, the utilization of project classification as sponge city strategy as it aided in classifying different projects based on their purpose as well as the resources and expertise required. Therefore, both low impact development and project classification are the

sponge city strategies utilized on the Shenzhen case to facilitate the effectiveness and efficiency of the established projects.

## **2. How can the green-roof initiative be characterized from the perspective of grassroots innovations?**

Notably, the green-roofing initiative in Shenzhen is developed and coordinated by various parties such as government ministries and the private sector as well as the Non-governmental organizations (NGOs). The main aim or objective of NGOs in a global perspective is to provide community-based services mostly voluntary since they do not profit making institutions. Grassroots innovations are characterized by the involvement of collaboration between various stakeholders, whereby each of the collaborating parties contributes towards the success of the project in one way or the other. The Gangxia green roofing project reflects this grassroots innovation attributes as it involves collaboration between various stakeholders from the private, public to the non-governmental sector.

The Glocal Company, which is at the core of the Gangxia project, represents the private stakeholders, which undertakes the development of the project through the provision of financial support and acting as the main developer of the project. Similarly, despite the other two stakeholders i.e., the public represented by the government and the NGO not being involved in the provision of financial resources comparable to the Glocal company, each plays a critical in the development of the Gangxia project. Therefore, Shenzhen green roofing project incorporates the various aspect of green innovation theory, such as vision, collaboration, implementation, and value creation. Vision is evident whereby various parties, i.e., the Glocal Company, NGO, and the public sector come together with a common goal from which they aim at achieving as a group, in this case, effective water management. With respect to collaboration, different agencies such as NGOs, environmental-based institutions, among other no profit-making institutions, join hands to facilitate the implementation of the green roofing project in Shenzhen, Gangxia village. Value is created through the utilization of spaces in buildings that are left unutilized whereby the agencies involved make use of these spaces to facilitate the implementation of this projects, which, in turn, results in a healthy climate and resilient ecosystem in Shenzhen specifically Gangxia urban village despite being a manufacturing hub. Therefore, the utilization of the key elements of grassroots innovation in the Shenzhen green roofing initiative reflects grassroots innovations in the project. Therefore, the Gangxia project can be characterized as a grassroots innovation initiative as it integrates grassroots innovation attributes.

## **3. How do different stakeholders collaborate in the project?**

Different stakeholders collaborate in distinct ways in the Gangxia project whereby the private sector under the Glocal Company collaborates with the public sector through the government to facilitate the issuing of the renovation and transformation permits to facilitate the initiation and implementation of the project. In addition, the Shenzhen urban planning collaborated with the Glocal Company in issuing them with the policies and plans on the sponge city construction in accordance with the region standards. NGOs also collaborated in the project initiation through network building, sharing the vision of the initiative with other stakeholders such as the community to equip them with grassroots innovation education as well as the creation of awareness. As a result, despite the involvement of the Glocal Company in the development of the Gangxia project, other stakeholders such as the public sector, as well as the NGO, also collaborated in different ways, which enhanced the success of the project at large.

#### **4. How can strategic niche management be applied to foster the green-roof initiative as an example of a grassroots innovation?**

Strategic Niche Management is a critical theory in the implementation of any project, not only the green roof and grassroots innovation. This is because, through its elements, namely; vision and expectations, networks, and learning, they enhance effective implementation and development of projects. From findings, the vision and expectations of the different parties, such as the private entities and the NGOs, are aligned since they all aim at providing a sustainable and resilience climate and environment for the community. The presence of a vision portrayed by the involved stakeholders in relation to the green roofing initiative, such as the promotion of environmental protection and building networks and providing adaptive climatic actions by NGO, reflects the SNM theory elements. Sharing the stakeholders' vision to the involved community is a significant endeavor as it contributes towards public acceptance and reduction of resistance by members of the society. For instance, sharing the vision of the stakeholders involved in the Gangxia urban village development resulted in limited resistance and increased participation from the community members since their understanding regarding the essence of the project was raised. In addition, it aided in ensuring that the development of the Gangxia project was in line with the Shenzhen urban planning requirement, such as construction policies were also issued by the local administration.

Network building is another aspect which is fostered through the application of SNM theory whereby the stakeholders involved such as the NGOs and the private based companies such as the Glocal Company collaborate to enhance the success of the project which in turn results in the achievement of their vision. The networking between the private, public, and NGO in the Gangxia

project enhanced the success of the project. This is because each stakeholder participated in the implementation and development of the project in various ways. Each stakeholder plays a critical role in the innovation project since the community, especially in this case, has limited information, knowledge, and expertise in the management and implementation of the green roof initiatives. This is evident in the case whereby the public builds networks with the shareholders through educational and workshops programs in relation to the green roofing initiative despite the lack of involvement of the community in the initial phases of the project, this indicates the recognition of the significance of networking in the success of green roof initiatives reflecting SNM application through the networking element. Different stakeholder's expectations are aired in relation to the project from which the results of the implemented project can be measured as well as the achievement of the underlying vision.

Learning is a critical aspect in the development and implementation of the grass-root innovation projects such as green roofing since it equips the involved parties, especially the community, with adequate knowledge and skills necessary to facilitate project success. This SNM element is reflected in the Ganzxia project whereby the participant who visited the project get in-depth understanding and the importance of these initiatives such that a considerable number is willing to participate in the innovation projects even in the future. Therefore, learning is one of the ways through which green roof initiative can be fostered as it provides the community members with adequate knowledge, which in turn raises their consciousness regarding the green roof innovation project; thus, resulting in public participation and reduced resistance leading to project success.

### **1.How can this initiative engage with the local community?**

Community engagement involves the community-centered and oriented dialogues which enhance the understanding of the societal members' perceptions, viewpoints, opinions towards of the contexts and topics to facilitate a cohesive relationship amongst community members. According to Budiman (2018), community engagement comes in a variety of ways, which involves community building, education, deliberative dialogue, organization, research, and direct services to the society in relation to specific community projects. Community engagement is critical as it ensures that the members of the society are involved in development projects and have access to valued social activities and settings. This results in the development of feeling that they can contribute to distinct social activities as well as develop functional capabilities that enhance full participation in community-based projects. With respect to the Gangxia project, the community was involved in workshops as well as open day forums through which they could learn more about green roofing

projects.

Therefore, community engagement in grassroots innovation projects is critical as it facilitates the collaboration and coordination between community members and third parties such as NGOs, which results in the successful implementation of these projects. Community engagement is central to any public or societal related projects or invention as it involves the creation of awareness of the community at large regarding the risk and benefits of grassroots innovation projects resulting participation and reduction of resistance (O'Meara, Pendergast, & Robinson, 2007). This leads to the mobilization of the community members through raising their understanding regarding the essence of the grassroots innovation projects, which triggers and increases their participation and support of the project in their surroundings, leading to the success of the project. Therefore, community engagement is a key ingredient in ensuring the effectiveness and success of grassroots innovation projects within distinct communities, especially informal urban settlements.

The Gangxia 1980 project is a grassroots innovation project based on the sponge city. The project uses a green roof as a carrier. For the building itself, the green roof is built to recover rainwater, roof leakage, and beautify the roof. For the residents living in the building and surrounding areas, the green roof provides them with an open green space. On this basis, TNC's roof open days and rooftop concerts on the roof provide residents Opportunities to learn more about the sponge city and green roof. A research study conducted by Farmer et al., in 2018 regarding the application of social theory in community-based services, the findings recorded that social innovation theory is a significant and relevant theory as it facilitates understating of what happens in each stage of the development of innovation projects. The participation and engagement of the local community members result in the innovations, which involve the adaptation of the existing ideas and experiences (Warbroek et al., 2019). Social innovation theory integrates various aspect such as social processes and open techniques such as volunteering, distant learning, among other aspects which have a social purpose. Particularly, this theory places more emphasis on the news forms of cooperation, more specifically those that aim at the achievement of the sustainable society, hence reflecting community engagement.

Through the study of residents' participation, the researcher found that residents have their preferences for the participation of this project. Residents are less motivated to participate in the design and construction of the project because residents do not consider themselves to have the technical knowledge and practical knowledge to design and implement green roofs. At the same

time, there is no time and effort to invest in the construction of the project. However, when time permits, residents are interested in using and participating in the presentations and interactive activities on the green roof. Therefore, through the information obtained from the interviews, in this case, community residents are willing to participate in the project in a learning and interactive way, especially community residents with children, which are considered to be very educational for children. By studying this case, the researcher believes that more residents should be involved in such projects. The project should study the way residents like to participate and design the participation model according to the preferences of the residents.

## 6.2 Discussion on the main research question

What are the challenges and opportunities to foster the participatory, green-roof grassroots innovation initiative in Gangxia, China, within the context of the Sponge City program?

### **Challenges**

From the perspective of vision, the link between Sponge City and other advanced urban planning is not perfect. Sponge City, as the guiding ideology of current urban planning in China, has not yet fully integrated into other current urban planning, such as in urban renewal planning. In the case study, in the urban renewal plan of the case area, the construction requirements of the building and the community did not include the sponge city construction measure as an audit requirement. This has made the planning of sponge city construction on the community level weaker. For communities and streets, the sponge city construction is a nuance to the scene rather than a responsibility.

From the perspective of collaboration, the lack of linkage mechanisms in various sectors is critical. For the construction of sponge city, there should be a dedicated lead department, or a coordinating agency to link the various departments. If the two departments are level, they will all be considered from their interests. It is bound to have different opinions. It is difficult for one department to ask another department to meet their own needs. It is naturally challenging to move together. In the case study, there is no lead department between the housing construction department and the sponge city office. During the project implementation, the project team received different feedback in the two departments. The housing construction department considered the green roof to be illegal, and the sponge city office considered the residential project building can implement a green roof. There is no lead department between the two departments, which makes it impossible to communicate, understand, and cooperate. This has increased the difficulty of the sponge city construction project.

From the perspective of implementation, the insufficient conditions for urban village building transformation and the difficulty of transformation is relatively large. The old residential buildings are not perfect for sponge city construction due to extended operating years or defects in the original design, roof anti-leakage. The load function is severely degraded. There are problems such as poor drainage of pipe network and drainage, damage to drainage facilities (Zhong,2017) the selection and implementation of sponge facilities are limited, and the accessibility of sponge construction targets are poor.

The funding conditions limit grassroots sponge renovation, and the owners of residential buildings have reservations about the transformation. At this stage, the sponge renovation of residential buildings needs to be led by the government, and most local governments have not implemented the sponge reconstruction funds in non-pilot areas, which have led to funding problems, have become a bottleneck restricting the grassroots renovation of residential buildings in urban villages.

From the perspective of participation, some residents do not understand the construction and renovation of the sponge city; they are not enthusiastic about participating in grassroots sponge city project. There are many people in the residential area, and the sponge renovation needs a particular public opinion base. At present, the construction of the sponge city is still in the pilot stage, and most citizens still cannot fully understand the purpose and measures of the sponge city transformation, which will have a specific impact on community participation of grassroots sponge city project.

### **Opportunities**

Creation of community-based organization. Grassroots innovation project is hard to push up without solid community support. That is because an individual's effort and energy are limited, as well as the funding ability. Therefore, one way to scale up the grassroots project is to create a community organization. The NGO involved in Gangxia project state that, another project they are working on in Shenzhen involving with community-based organization, this organization have their community foundation, which they collected from each family lives in the community, and they use the money to mobilize the masses or recruit volunteers, and within the community, they are launching some initiatives and activities in the city (interview GO.2019).

The creation of employment opportunities for individuals living within informal urban settlements

through the green roofing initiatives is enhanced. This is because the implementation of the green roofing initiative results in the planting of food crops whereby the involved individual can sell them to others at a profit as well as use them for consumption. As a result, through such programs, the improvement of the informal urban settlement living standards is enhanced, which results in a significant reduction of overreliance on government support.

Additionally, green roofing initiatives present the opportunity of reducing environmental pollution in the implemented regions through controlled storm water to avoid stagnant water, which can lead to health issues. Grassroots innovation, such as planting trees, ensure the fresh circulation of air through the reduction of direct sunlight as well as radiation. Therefore, through green roofing, a healthy and resilient climate which habitable can be fully enhanced.

## 6.3 Recommendations

### 6.3.1 Suggestions for practice

The sponge renovation of existing residential buildings in Shenzhen should have an excellent public opinion foundation. The sponge renovation should be combined with the specific needs of residential buildings, and the transformation plan should be formulated according to local conditions. Through the above research, regarding the further promotion of the construction of sponge cities in existing residential quarters, I believe that the following issues should be taken seriously.

First, the construction of sponge cities should accelerate the implementation of transformation funds, and the government can adopt the method of rewarding for awards. Publicize the existing reward mechanism and give guidance on how to apply for rewards in the community. Encourage the community owners or the property to carry out the sponge renovation spontaneously.

Second, it is necessary to strengthen the citywide publicity and education, popularize the specific practices and purposes of the sponge city, and let the citizens genuinely participate in the construction of the sponge city. As the investors and beneficiaries of the sponge city, the public is obliged to support and supervise the construction of the sponge city. As the promoter of the whole project, the government should actively promote the construction concept, popularize the sponge city incentive policy to residents in a more accessible way, and introduce the complex ecological planning concept to the people in a life-oriented way. Let more people understand, support, maintain and supervise urban construction, and promote the overall concept of the sponge city to

the construction and layout of the house, and improve the overall construction effect of the sponge city. Through cooperation with NGOs, the government can use the promotion advantages of NGOs to promote the sponge city project in the community.

Third, the construction of the sponge city should pay attention to the opinions of urban residents and jointly build a sponge city. Urban residents occupy a dominant position in the city. When constructing a sponge city, the designers and managers of the city occupy a dominant position. The government should increase the publicity of the public and let the urban residents have a profound understanding of the design concept of the sponge city. Take into account the opinions of urban residents, listen to the suggestions of urban residents, and let urban residents participate in the construction of sponge cities, improve the understanding of urban residents on the construction of sponge cities, and mobilize the enthusiasm of urban residents for the construction of sponge cities.

### 6.3.2 Suggestions for further research

This section mainly provides recommendations for future research. First, given the use of a single case study in this paper, the researchers suggest that future research can try to study several different sponge city grassroots innovation cases at the same time and use comparative analysis to explore the advantages and disadvantages of varying project models.

Second, given the low spatial radiation of the case used in this paper, some fewer participants are directly involved and affected by the project. Therefore, future research on grassroots innovation projects can select projects with more participants and projects with more extensive geographical coverage.

Third, the discussion on grassroots innovation projects in this paper focuses on the project itself and the synergy between different stakeholders and projects. Future research can try to study the mechanism of China's grassroots innovation project. Because the results of this study found that the sponge city grassroots innovation project lacks a complete mechanism, resulting in low project sustainability. Therefore, studying the mechanism design of grassroots innovation projects will help future grassroots innovations in China.

### 6.5 Reflection

In this section, I will give a summary reflection on the whole process of completing this paper. It takes a long time to complete this paper, and the process is repeated. Concluding this paper from

thinking to writing is a challenge for me.

Some of the choices I made for research content are due to the content that I want to be close to what graduate students have learned. Some of them are more professional than I think, but in the end, I chose to put down my persistence in the specific research field of urban planning, and decide what I am interested in the topic that is the green roof project of the sponge city and the grassroots innovation.

Curiosity and attraction are the driving force of my research, and how to turn my interest in academic research at the graduate level is the next step. After confirming the research direction, combined with the advice of the instructor and my study of the Gangxia project, the research will focus on how the SNM can promote the grassroots innovative sponge city construction project. To provide theoretical support for the system, I read related literature on sponge city, green roof, grassroots innovation, SNM, and so on. Literature learning has given me a clearer understanding of the direction of research, and I have seen the connection between these concepts.

The study of theory gave me a way to analyze the essence. In the case study, I used this method to interview project stakeholders. By interviews, I can collect the views of stakeholders on the research project in real-life cases, and their opinions are related to their role in the project, which allows me to enrich the overall perception of the project. These cognitions are merely challenging to obtain theoretically. Because the introduction of the research is grassroots innovation, understanding the concept of grassroots innovators can also help the research framework of the full paper.

The interview and questionnaire collection was a long process. I first contacted the Shenzhen Sponge Office. Through them, they reached the developers of the project's NGO and the project's residential building, and they contacted the staff of the street office. The developer contacted the residents who lived in the building and finally reached the residents of the residential building near the residential building where the project was located and the residents who had participated in the green roof project activities. The entire process took about two months. I feel it is very hard, but I hope that all stakeholders can be adjusted because I think this can provide the required perspective for the analysis case.

I am satisfied with the results of the final interview. All interviewees were informed about the meeting and how I would use the discussion and the confidentiality agreement. The interviews with

the project organizers and relevant government departments were very smooth because they also wanted to promote the civil-sponsored sponge city construction project, so the cooperation was very positive. However, interviews with local residents have encountered difficulties. In the process of interviewing local residents, first of all, because Gangxia 1980 is a rental apartment, residents often rent from 6 months to 24 months, when I collect data from others. Residents who have experienced the Okayama 1980 project have moved out of the apartment, so there are not many people who can be interviewed. Secondly, I found that their cooperation is not high. My intuitive feeling is that they think that this project has little to do with them. The existence or non-existence of the project is not very important to them. They said that there is not much throughput on such projects, so there are few views on the project. Finally, the local residents are not very enthusiastic about my appearance and requests for interviews and are unwilling to accept conversations from strangers. I didn't get permission to record all the meetings. I think it was caused by the strangeness and distrust of the residents. Even though they still expressed their willingness to answer questions, they were unwilling to accept the recordings.

For me, my reflection on these problems is that, first of all, as a researcher, I have not fully understood the reality, and I don't know enough about local people's understanding of the domestic situation. Secondly, before I started the interview, I thought that interviews for the purpose of academic research should not be rejected. However, the reality is that local residents do not understand the interviews of my academic research. After the interview, I will explain the purpose of my interview and some related concepts to the residents more clearly. Some residents understand my research, but some residents do not understand. This is something I have not considered between. It is worth noting that some feedback results may be biased. Some residents have new understandings of the project because of my explanation, rather than generating new knowledge through the use of the case project. In the case analysis, I tried to focus on the feedback of the residents with high participation in the project.

The process of interview transcription is quite smooth. Although it takes a long time, however, since the original interview was taken in Chinese, some words cannot be completely translated into English during the translation process, and some meanings will be lost in translations. I chose to translate the sense of the text instead of the exact words the information to ensure the integrity of the interview information.

The discussion of the findings is the most fun part of what I think. In my opinion, the discussion of the research results is the process of using s theoretical detection practice and then using the results

of practice to detect the theory. In this process, I have seen the problems faced by environmentally adaptive grassroots innovation practices in the current Chinese society. Some problems can be suggested through theory. Some issues cannot be attributed to their uniqueness, geographical differences, and cultural differences. According to the method, the book is published. I think this is the ideal answer to my research on this translation.

Looking back at the whole process of writing a paper, I feel like playing a game. The deeper the game is, the more complicated it is, the more difficult the task is, the sense of accomplishment also happens. Although it is easy to make me addicted to writing a thesis, the experience is akin.

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## Appendix 1

### 1. Interview question for community officer

Interview questions:

- 1) What role do you/the organization you represent play in the urban village/old city greening renovation?
- 2) Can you talk about the implementation process of the urban village/old city greening renovation project? The organizational structure of the project?
- 3) Considering the complexity of the greening renovation of the urban village, from your point of view, what is the difficulty of launching the renovation project by the community/street? For example, roof property rights; green infrastructure/sponge technology application; pre-engineering of renovation projects; post-maintenance; transformation project management; development of the main body, power relations between owners and residents; household participation, satisfaction, etc.
- 4) More and more civil organizations, sub-district offices, and communities have joined the projects in the urban village/old city greening renovation, opening up new ideas for greening/low-impact development of urban villages and old towns, in your opinion What are the conditions for such projects to be successful?
- 5) Do you think that the spontaneous greening renovation projects of such urban villages/old city communities can be copied to more urban villages/old towns? If so, is there a project in progress now? If not, what is the reason?
- 6) Is the greening incentive policy currently introduced in Shenzhen applicable to the urban village/old city property?
- 7) Can you recommend me to anyone else involved in the urban renewal of the village/old city to understand the specific project implementation process, organization, and post-operation, public participation, and satisfaction?

## Appendix 2

### 2. Interview for sponge city office

Interview questions:

- 1) Is your work related to sponge city construction?
- 2) What role do you play in the project “Gangsha 1980”?
- 3) Do you know the implementation process of the “Gangsha 1980” project? Alternatively, the implementation process of the roofing greening project/sponge renovation of the village?
- 4) The “Gangsha 1980” project is a project initiated by social capital and citizens. It opens up new ideas for roof greening/low impact development in urban villages. What do you think about this privately-developed sponge city village project?
- 5) Considering the complexity of the sponge renovation in the village, in your opinion, where is the difficulty of developing a green roof/sponge renovation project in Chengzhong Village?
- 6) Do you think that such low-impact development projects in urban villages can be copied to more urban villages?
- 7) Is the green roof incentive policy currently launched in Shenzhen suitable for urban villages?
- 8) What are the sponge city offices that can inspire people and social capital to participate in the transformation of sponges in the village?
- 9) What is the trend of the village in the city of Sponge?
- 10) Can you recommend me to anyone else related to “Gangsha 1980” to understand the specific project implementation process, organization, and postoperative?

## Appendix 3

### 3. Interview for the property owner and NGOs

Interview questions:

- 1) What role do you/the organization you represent play in the project “Gangsha 1980”?
- 2) Do you know the implementation process of the “Gangsha 1980” project? The organizational structure of the project? Stakeholders
- 3) Considering the complexity of sponge renovation in the village property in the city, from your point of view, where is the difficulty of the green roof/sponge renovation project in Gangsha? For example, roof property rights; sponge technology application; pre-engineering of renovation projects; post-maintenance; transformation project management; development of the main body, power relations between owners and residents; household participation, satisfaction, etc.
- 4) The “Gangsha 1980” project is a project initiated by social capital and citizens. It opens up new ideas for roof greening/low impact development in urban villages. In your opinion, what are the main factors for the success of this project?
- 5) Do you think that this kind of urban village property renovation project can be copied to more urban village properties? If so, is there a project in progress now? If not, what is the reason?
- 6) What impact does the Gangxia project have on the organization you represent?
- 7) Is the green roof incentive policy currently launched in Shenzhen applicable to the urban village property?
- 8) Can you recommend me to anyone else related to “Gangsha 1980” to understand the specific project implementation process, organization, and post-operation, public participation, satisfaction?

## Appendix 3

### **Interview guide for residents**

interview questions

On vision/ ideation

- 1) What do you know about the sponge city concept? From where?
- 2) What do you know about the Gangxia 1980 green-roof project?
- 3) Do you have any knowledge about green roof technology?
- 4) Do you have any knowledge about stormwater management?
- 5) Do you think there is a need for this type of green roof in your neighborhood?

### **On implementation**

- 1) Did you feel disturbed during the construction of the project?
- 2) From your personal point of view, what do you think of building this kind of project near your residence?
- 3) Why or Why not you think the project is necessary for this neighborhood?

### **On collaboration**

- 1) During the project, Have you had any communication with the person in charge of the project? For what reason?

### **On creating value**

- 1) After use or visit the green roof do you think you gain knowledge about stormwater management or sponge city initiative?
- 2) Do you think there is a need for sponge city action in your neighborhood?
- 3) After knowing the concept of the roof, did it change your opinion about the project?
- 4) Do you think there is a need for this type of green roof in your neighborhood?

### **On participation**

- 1) When were you informed about the Gangxia project?
  - 1) Before the construction of the project
  - 2) During the construction of the project
- 2) How were you informed about the project?
  - 1) Through a community meeting
  - 2) Through News, media or Post

- 3) Through a survey or questionnaire
- 4) Through a planning community
- 3) In which form did you participate in the gangxia green roof project before implementation?
  - 1) Attending the community meeting
  - 2) Answering survey
  - 3) Attending the project meeting
  - 4) Participating in construction
  - 5) Participating in maintenance
  - 6) None of them
- 4) In which form did you participate in the gangxia green roof project during implementation?
  - 1) Attending the community meeting
  - 2) Answering survey
  - 3) Attending the project meeting
  - 4) Participating in construction
  - 5) Participating in maintenance
  - 6) None of them
- 5) In which form did you participate in the gangxia green roof project after implementation?
  - 1) Attending the community meeting
  - 2) Answering survey
  - 3) Attending the project meeting
  - 4) Participating in construction
  - 5) Participating in maintenance
  - 6) None of them
- 6) How would you like to participate in the green roof project?
- 7) How would you like to participate in spong city construction?