

# Impact and management of rooftop garden - An example from China

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Abstract. Environmental protection in urban areas has already become one of the core issues of city building. Rooftop gardens presented a potential solution to these problems, providing ecological and social benefits. This essay aims to analyze the impact and management of rooftop gardens. Rooftop gardens are not always a suitable green engineering solution; there are different challenges to implementing rooftop gardens. These challenges include the cost of building and maintenance, the lack of support from the public, and policy. The SWOT analysis method is used in analyzing the strengths, weaknesses, opportunities, and threats of a rooftop garden. The combination of four aspects from SWOT can yield different strategies that suggest some advice for the future development of a rooftop garden. There are four strategies concluded by a combination of SWOT factors, including expansionary strategy (strengths and opportunities), reverse strategy (weaknesses and opportunities), diversification strategy (strengths and threats), and defensive strategy (weaknesses and threats).

Keywords: Rooftop Garden; Green Engineering; SWOT analysis method; Policy support

# 1 Introduction

The negative impact of modern urban development on the environment is enormous. Cities as the most densely populated areas and consume 67% of global energy and lead to 75% of the global carbon dioxide emission<sup>[10]</sup>. Cities exacerbate climate problems, for example 80% of greenhouse gases (GHG) are from cities<sup>[11]</sup>, and these GHG will harm the environment such as the ozone layer, in fact, 30% of GHG emission are from building sector of urban area<sup>[11]</sup>. If this vicious trend is not stopped, future environmental problems caused by urban development will be even worse, so it is necessary to take measure to stop this vicious trend.

There are numerous ways to solve this problem, including technological solutions (i.e., enhanced abatement technology), soft measures (i.e., nature-based solutions), and behavior changes through citizen engagement<sup>[11]</sup>. Currently, rooftop gardens provide an effective solution to urban pollution and have become an amenity for city dwellers.

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Rooftop gardens are a surface covered by vegetation on the top of a building; they have a thickness of 0.06–0.12 meters and are able to cool down the surrounding environment (See Figure 1)<sup>[14]</sup>. The leaf area is the most crucial factor when it comes to cooling: the larger the leaf area, the better the effect on cooling and humidification<sup>[16]</sup>. Vegetation on rooftop gardens such as trees, bushes, grass, and shrubs are better at controlling CO2 concentration at certain levels, improving the environment, and maintaining oxygen balance<sup>[16]</sup>. Rooftop gardens still have many other ecological benefits, such as purifying the air and creating habitats for birds. When considering the design of rooftop gardens, the load must be a priority. The design should calculate the weight of the roof garden and the bearing capacity of the building; otherwise, it will cause overload pressure, leading to the collapse of the building<sup>[22]</sup>. In terms of rainwater, drainage is a big issue in a rooftop garden; standing water will rot the roof and plants<sup>[22]</sup>. The material of the rooftop garden should be anticorrosive. The excess rainwater on the rooftop garden can enter through shallow plant trenches and eventually enter the cistern through water pipes<sup>[8]</sup>. There are many other uses for the collected water, as well as alleviating water scarcity. When building rooftop gardens, the plants need to be selected carefully. Firstly, avoid plants with poisonous, thorny, fluttering, or irritating odors<sup>[17]</sup>. Secondly, plants with air-purifying effects and ornamental qualities can be taken into consideration<sup>[17]</sup>. Rooftop gardens, thus, not only do not take up valuable and scarce land space in the city but can improve the greening rate of the city and increase the quality of life for people<sup>[8]</sup>.



Fig. 1. Structure of a rooftop garden

#### Source: Kosareo and Ries, 2007<sup>[7]</sup>

China is a country that has the second-largest population and the highest energy consumption in the world. In the past few decades, urbanization in China has become unstoppable; more buildings are being built, while building energy consumption accounted for 30% of total energy consumption in 2009 and the number is still increasing<sup>[16]</sup>. According to China's National Bureau of Statistics, China's Seventh Population Census in 2021 shows that 63.89% of the Chinese population lives in urban settlements, a 14.21% increase compared to 2010. This means that most Chinese cities share the same identity: high population density and small floor space per capita. According to the relevant document of the State Forestry Administration of China, in 2020, urban green space per capita will reach 14.8 m2. However, the average green space per capita in the world is 18.32 m2, whereas London's average green space per capita is 24.64 m2. Compare the global greening situation: there is not enough greenery to serve everyone and to deal with the high energy emissions from cities in China. So, roof greening has become a potential opportunity to increase the greening area and improve the quality of the ecological environment in China<sup>[16]</sup>.

In recent years, the Chinese government has proposed a policy called carbon neutrality. According to relevant documents from the State Council of China, the Chinese government aims to comprehensively establish a green, low-carbon cycle development of the economic system and a clean, low-carbon, safe, and efficient energy system with energy use efficiency to reach an advanced international level, with the proportion of non-fossil energy consumption reaching 80% or more by the year 2060. The document also mentions the construction of urban ecological and ventilation corridors, improving the level of urban greening, and accelerating the construction of green communities. In this case, a rooftop garden is a feasible method to achieve the carbon neutrality goal<sup>[13]</sup>.

Rooftop gardens are associated with targets 11 and 13 of the United Nations Sustainable Development Goals (SDG). Target 11 (sustainable cities and communities) indicates that by 2030, settlements should provide universal access to safe, inclusive, and accessible green and public spaces (11.7). Rooftop gardens are a great method for providing green space and thus improving the environment in settlements. Target 13 (Climate Action) indicates that authorities should integrate climate change measures into national policies, strategies, and planning (13.2), and whereas a rooftop garden is a measure to enhance the environment, especially in urban areas, it can be considered a strategy to integrate climate change.

The objective of this thesis is to analyze the management of rooftop gardens in China and give recommendations accordingly. The paper is structured as follows: Section 2 introduces international and Chinese experience in the development of rooftop gardens through previous scholarly studies; Section 3 is the introduction of the SWOT analysis method and explains the reason for using this method to analyze; Section 4 is the objective description of the results of rooftop garden development based on experience and current development status; the conclusion and my suggestion will be listed in Section 5.

# 2 Literature Review

#### 2.1 China Section

The development of rooftop gardens in China can be divided into the following two stages: 1. Chinese rooftop garden history; 2. rooftop gardens in different Chinese cities.

#### 2.1.1. Chinese rooftop garden history.

The earliest rooftop garden in China appeared on the roof of Beijing New World No.1 Amusement Park in 1918, and Beijing Xizhu Street Kaiming Theatre in 1922[17]. The trees, flowers, and vegetation that are planted on a residential roof or balcony can be considered the prototype of a rooftop garden (See Figure 2). It has become a common activity all over the nation in the next few decades.



Fig. 2. Residential rooftop garden

#### Source: Author Self-photographed

In the early 21st century, the development of rooftop gardens was encouraged by urban greening development, as a result, several types of rooftop gardens appeared and the number of rooftop gardens increased dramatically<sup>[16]</sup>.

Chengdu city published "Chengdu Rooftop greening and vertical greening technical guidance" in the 2000s; Beijing city published "Beijing Green Roof Specification" and a range of policies around 2005; Shanghai city published "Shanghai Green Roof Technical Specification" in 2008<sup>[17]</sup>. These policies are the proof of a large-scale development of rooftop garden happening in China.

## 2.1.2 Rooftop gardens in different Chinese cities.

#### (1) Guangzhou

Guangzhou cities have the name of "Flower City," because the citizens in Guangzhou like to plant vegetation in gardens, balconies, and rooftop. However, this greenery is not in scale. Most of the proper rooftop garden greenery is located at high-end commercial buildings, government units, pilot buildings<sup>[17]</sup>. Guangzhou is a city that are suitable for developing rooftop garden because of the geographic conditions with high precipitation and warm temperature, but the rooftop garden practice is poor. According to Guangzhou Bureau of Statistics, the area that can develop rooftop garden reaches 77 million m2, but the actual green roof area is only 690 thousand m2, the green roof per capita is very low. Although the "Guangzhou Green Roof Guidance" was issued in 2007, this document has not been improved since its release, many technical and data indicators cannot be updated in a timely manner, guidance and practicality has lagged<sup>[17]</sup>.

Guangzhou, as a densely populated city, has a huge demand for good environmental conditions. Its future goal is to build more effective rooftop gardens that consider the economy's benefit, the daily activities of citizens, and other aspects.

#### (2) Shanghai

As one of the most advanced international metropolises in China, Shanghai has also implemented rooftop garden development. Shanghai has most of its rooftop gardens in triopolies in China, Shanghai has also implemented rooftop garden development. Shanghai has most of its rooftop gardens in the city's center, on buildings such as hotels, superior apartments, and shopping malls. Typical examples are The Peace Hotel, AIA Tower, and Shanghai South Railway Station<sup>[20]</sup>.

The Shanghai government attaches importance to rooftop gardens. In the "Shanghai Green Roof Technical Specification," it is clearly mentioned that for buildings under 50 meters, the green roof area shall not be less than 30% of the building floor space. And the government encourages green roofs for all kinds of buildings.

(3) Chengdu

Chengdu city is located in the Sichuan Basin in the southwest of China. With the subtropical monsoon climate, Chengdu has high precipitation (829.4–1784.3 mm annual precipitation, mostly in summer) and warm temperatures (14–22 °C average temperature), making it suitable for growing plants and the development of rooftop gardens.

Chengdu has a good record in rooftop garden construction. Until 2016, the total roof greening area of Chengdu was 2.65 million m2, which accounted for 2% of the total urban greening area in Chengdu<sup>[21]</sup>. The Chengdu government also strongly encourages the development of rooftop gardens; the government has published a range of supportive policies, such as "Chengdu Green Roof and Vertical Greening Technical Guide-lines," published in 2011<sup>[21]</sup>.

## 2.2 International section

Starting from ancient times, rooftop gardens have always been a popular way of construction, which can be found in buildings from the Middle Ages and Renaissance periods<sup>[17]</sup>. After the Second World War, with the progress of technology, new kinds of techniques and materials were being used in rooftop gardens. Many countries have invested a lot of effort in rooftop garden research and produce advanced rooftop garden technology, relevant rooftop garden policies, and professional management<sup>[17]</sup>.

Rooftop garden development at global a scale will take London and Singapore city as examples.

#### 1. London

London is the capital city of the United Kingdom; it is one of the greatest cities in the world. During the Second World War, many buildings in London were bombed and destroyed, and due to the decline of industry after the war, a lot of sites have been cleared out in London. Since 1980, government policy encouraged the reuse of abandoned sites, this redevelopment in London gives great opportunities to green development such as rooftop garden<sup>[4]</sup>. Also, informed by low-carbon policies, city authorities have considered and implemented measures to promote the development of rooftop gardens and edible roofs<sup>[6]</sup>.

The rooftop garden technology in London is advanced; many diverse types of rooftop gardens were built, and people make full use of them. For example, grass roofs, sedum roofs, and black redstart roofs<sup>[4]</sup>. London even developed rooftop agriculture. About 14% of London citizens are planting food in their gardens. London citizens can produce 18% of the population's nutrition needs<sup>[6]</sup>. In recent years, supermarkets converted their roof space into vegetable gardens. This was partly stimulated by the race to be seen as the UK's greenest supermarket<sup>[6]</sup>.

By studying London, we can see that London people highly value and participate in rooftop gardens. The people of London build rooftop gardens spontaneously, driving the development of rooftop gardens in London from a bottom-up approach. A stark contrast to the top-down way in China.

#### 2. Singapore City

Singapore is famous for its garden city and greenery. The space of Singapore city is exceedingly small and limited for on-ground parks, so vertical greening such as rooftop gardens has become essential. Since the late 1990s, Singapore's national planning authority (Urban Redevelopment Authority) has actively facilitated the usage of unused flat roofs as rooftop gardens<sup>[18]</sup>. Rooftop gardens have also gained the support of the government, as announced by the Prime Minister in June 2001: "To demonstrate the Government's commitment to high-rise greenery, the public sector will take the lead in implementing sky deck gardens in our public housing estates and public buildings" (Singapore Government Press Release, Speech by Prime Minister Goh Chok Tong, 26 June 2001).

Singapore citizens are also engaged with the rooftop garden. According to a survey, people would like to "take children out" to a rooftop garden to "get some exercise" or to "find a peaceful and quiet place" <sup>[18]</sup>. The rooftop garden improves citizens daily lives beyond its ecological benefit. Rooftop farming is popular in Singapore as well. Since ground space is limited, rooftop farming and building integrated agriculture can potentially produce 25% of the vegetables consumed in Singapore<sup>[6]</sup>. These are all positive signs that can encourage the development of rooftop gardens.

#### 2.3 Challenges for the future development of rooftop gardens in China

Although the benefits of rooftop gardens are significant, they are not as widespread in China as they are in other countries. At present, China's rooftop gardens are concentrated in government buildings, corporate office buildings, and hotels. Developments in community rooftop greening are few and far between<sup>[15]</sup>. Many places do not benefit from green roofs.

The following paragraphs will explain some difficulties of developing rooftop garden in China.

### (1) Cost & Maintenance

Building a rooftop garden requires more funding than a normal rooftop; the cost of water-proof material, vegetation, and a weight-bearing design all require extra money. The fund of the rooftop garden is important; according to the "Shanghai Green Roof Post-Assessment", the rooftop garden with more abundant funds has a better effect, while the rooftop garden with no sufficient fund, lack of attention to the preliminary design, and plant selection without taking into account the climatic conditions is less effective<sup>[15]</sup>. The real estate developers in China are not interested in building rooftop gardens because the extra cost is high and there is no subsidy from the government.

Maintenance is essential to keep a rooftop garden effective. Maintenance focuses on two aspects: the maintenance of the facilities and the maintenance of the plants. For plant maintenance, the most basic thing is to water and fertilize the plants regularly to keep them alive. The plants also need pruning, pest control, and cold and wind resistance<sup>[15]</sup>. For facility maintenance, the drainage system needs to ensure that it is not blocked. The rooftop garden needs to be cleaned regularly, especially of dead leaves. The building structure needed to be checked regularly to ensure the safety of the building<sup>[15]</sup>. These maintenance tasks require a lot of effort and money.

In conclusion, rooftop gardens are costly to build and maintain. Planting environments in urban centers are poor; special maintenance is required to keep the plants growing properly; and expensive costs and maintenance fees limit the large-scale development of rooftop gardens<sup>[2]</sup>. A new kind of rooftop garden program, more viable plants, and cheaper maintenance are needed to solve the cost problem.

#### (2) Public Support

People in countries such as the UK, Singapore, and Germany greatly engage with rooftop gardens. As mentioned above, people are keen on activities in rooftop gardens and even turn rooftops into gardens for farming. However, most people in China do not notice the environmental benefit of rooftop gardens, and the lack of activities in rooftop gardens does not attract people. Worse yet, rooftop gardens will drive up house prices<sup>[2]</sup>. As a result, people are not interested in rooftop gardens.

In order to increase the public's support for rooftop gardens, the authorities should popularize the knowledge of greening and make people aware of the environmental benefits of rooftop gardens<sup>[15]</sup>. But this is not enough. The best way is to improve the view of the rooftop garden and develop recreation such as places for sports and places for relaxing in the rooftop garden to attract people to engage with the rooftop garden.

#### (3) Policy Support

The Chinese government has introduced many policies to encourage the development of rooftop gardens, such as "Shanghai Greening Management Regulations" and "Shenzhen rooftop beautification and greening implementation methods"[15]. However, these policies lacked a unified regulatory system and financial subsidy for rooftop gardens. Therefore, without the support of a strong policy, rooftop gardens are exceedingly difficult to develop on a large scale.

The government needs to produce a strong policy in order to promote the development of rooftop gardens, like in Singapore. However, rooftop gardens are not suitable everywhere. Local governments need to consider their own conditions before making any policies.

### **3** SWOT Analysis Method

The SWOT analysis method was originally used for business analysis. SWOT stands for strengths, weaknesses, opportunities, and threats. Strength is the internal capabilities and positive factor for organization establishments. Weaknesses are internal factors or constraints that might impede or hinder the performance of an organization. Opportunities are factors or features that can favor or facilitate the establishment of links outside the organization. Threaten to deal with negative factors external to the company that can hinder or delay the achievement of achievable goals<sup>[9]</sup>.

Former studies have proven that SWOT can also be conducted while analyzing the development of a rooftop garden. For example, SWOT factors for green roofs in European cities with temperate climates were identified based on the analysis of scientific literature and expert interviews<sup>[1]</sup>. Therefore, it can be a framework to integrate and analyze the internal and external factors that influence development in a rooftop garden and as a problem-solving method<sup>[12]</sup>. A combination of distinct factors from SWOT can be used to obtain four strategies and hit the goal of sustainable development of rooftop gardens.

The following part will explain the strengths, weaknesses, opportunities, and threats of rooftop garden development.

#### 3.1 Strengths

Many studies have proven that rooftop gardening has many advantages. Rooftop gardens can enhance the beauty of the city. Creating rooftop gardens on buildings is intended to improve the environment in which people work and live. By opening a green space for rest, communication, and activities in the densely populated buildings, we can improve the life quality of citizens through improved physical and mental health<sup>[17]</sup>.

Scholars have confirmed the widely known fact that green roofs are able to increase urban biodiversity with additional aesthetic value<sup>[5]</sup>. For example, the vegetated area on a rooftop can provide habitat for birds.

Vegetation on rooftop gardens such as trees, bushes, grass, and shrubs are better at controlling CO2 concentration at certain levels, improving the environment, and main-taining oxygen balance<sup>[16]</sup>.

Rooftop gardens are also energy-efficient and alleviate urban heat. Vegetative roof systems in the urban environment show that green roofs help reduce temperatures around buildings by between 0.1 and 6 °C through increasing evapotranspiration and further decreasing building energy consumption<sup>[11]</sup>.

#### 3.2 Weaknesses

Cost is a major weakness of rooftop gardens. Compared to an ordinary roof, the cost of a rooftop garden is higher. The cost includes extra design and construction costs (materials, wages), and the post-construction maintenance costs are high (watering the plants, regular maintenance)<sup>[1]</sup>. The cost of specific plants, vegetation, and soil requires special selection and extra cost.

Then, the structure of rooftop gardens needs to be carefully designed, such as the weight of the roof garden and the bearing capacity of the building; otherwise, it will cause overload pressure, leading to the collapse of the building<sup>[22]</sup>. In terms of rainwater, drainage is a big issue in a rooftop garden; standing water will rot the roof and plants<sup>[22]</sup>.

Another concern is fire; plants in roof gardens are flammable, and they can spread fire very quickly, leading to huge damage to the building. So, the fire prevention measures should be considered carefully when designing and building rooftop gardens.

## 3.3 **Opportunities**

With the improvement of technology, the weaknesses of rooftop gardens can be reduced. For example, if an advanced structure for a rooftop garden is invented, the level of danger associated with rooftop gardens can be greatly decreased, and it can be implemented on more buildings and accepted by the public.

Due to the increasing effect of global warming, rooftop gardens as a suitable method to deal with it have a greater chance of development. In the face of climate change, green roofs may become particularly useful due to their ability to mitigate the urban heat island effect and provide for greater evapotranspiration in cities<sup>[1]</sup>. When global warming is getting worse and attracting more public attention, it can lead to an increase in the social responsibility of firms or the public to protect the environment, which encourages the development of rooftop gardens.

The most important opportunity is the support of policy. Unlike projects which focus on the creation of new parks or urban recreation areas, no additional space is needed when implementing a green roof policy. The aim of rooftop garden policies is to improve service efficiency and urban quality of life by using innovative technology<sup>[1]</sup>. If the government provides subsidies and creates a system for rooftop garden construction, rooftop gardens can be largely developed.

## 3.4 Threats

Natural disasters pose a great threat to rooftop gardens. For example, hurricanes can easily destroy buildings, not to mention the exposed roof gardens. According to the China weather website, hurricanes cause billions of dollars' worth of building damage every year.

The local climate can be a threat as well. Some places, such as the arid and semiarid climate of northwest China, where the precipitation is low and the temperature is not suitable for plants to grow. The lack of technology and experience in building rooftop gardens can hinder their development.

Without a prominent level of public support, a real estate developer will not want to build a rooftop garden since there is no demand for it and no profit to be made from it.

# 4 Discussion

After identifying the four factors for rooftop garden development, different combinations of these factors can yield different strategies for rooftop garden development (See Table 1).

	Strengths	
	1.Enhance the beauty of the city	Weaknesses
	2.Improve life quality of citizens	1.High cost
	3.Increase urban biodiversity	2.Structure challenge
	4.Improve air quality	3.Fire hazards
	5.Energy efficient and alleviate urban heat	
	Expansionary growth strategy	
Opportunities	1. Take advantage of the public's concern	Reverse strategy
1.Innovative technology	about environmental protection to introduce	1.Implement innovative technology
2.Public attention to environmental issues	relevant policies and create a professional	2. Attracting investment through people's in-
3.Policy support	industry chain.	terest in environmental protection
	2.Learn from other countries' experience	
Threats		
1.Natural disaster	Diversification strategy	Defensive strategy
2.Local geographic conditions	1.Create professional industry chain	1.Adaptation to local conditions
3.Lack of technology and experience	2.Meet public expectation and demand	2.Strict audit system
4 Low level of public support		

Table 1. Different factors with different strategies

## 4.1 Strengths & Opportunities

By taking advantage of rooftop gardens and the opportunities offered by external factors, a kind of expansionary growth strategy can be obtained.

Since protecting the environment is a hot topic nowadays, the ecological advantages of rooftop gardens can be strongly promoted. In this trend of protecting the environment, the government can introduce policy with subsidies and promote the establishment of a professional industry chain for rooftop gardens, such as the launch of plantations specializing in rooftop garden plants, factories specializing in the production of materials needed for rooftop gardens, and teams specializing in the construction of rooftop gardens.

Foreign countries such as the UK and Singapore have extensive experience and advanced technology on building rooftop gardens, so domestic real estate developers can learn from them and use that experience to help develop their own rooftop garden.

#### 4.2 Strengths & Threats

Combining strengths and threats can lead to a diversification strategy that uses the advantages to avoid or offset threats.

A professional industry chain can decrease the negative effect of threats; for example, a rooftop garden can be fixed easily and cheaply by a professional team after experiencing a natural disaster like a hurricane.

The development of rooftop garden needs to follow the demand in the market, it should be built to meet public expectations so that more people will accept and support it instead of excluding it. According to a survey mentioned above, people would like to "take children out" to a rooftop garden, to "get some exercise" or to "find a peaceful and quiet place"<sup>[18]</sup>. It can be concluded that people want to have activities on rooftop gardens, so some recreational construction can be built on rooftop gardens (See Figure 3).



Fig. 3. Recreational construction on rooftop garden

Source: Author Self-photographed

## 4.3 Weaknesses & Threats

The combination of weaknesses and threats is a defensive strategy, its' aim is to ensure the weaknesses will not become worse when there is an external threat.

Firstly, building a rooftop garden requires a site-specific approach, so that the potential dangers in the surrounding area can be minimized. For example, China can be divided into 7 zones (See Figure 4), each with their own unique climate conditions. A region such as the northwest of China with a dry climate is not suitable to develop a rooftop garden. On the other hand, the amount of precipitation and average temperature in the east and south regions are higher, which are more suitable for growing plants on rooftops.



Fig. 4. Climate zone in China

#### Source: Dong et al., 2020<sup>[3]</sup>

Secondly, practical guidance and auditing standards for rooftop gardens should be established. Professionals should audit each rooftop garden to ensure that there are no safety hazards and that it meets the standards before it is put into use. Also, the professional staff needs to check regularly whether there is a security risk and record the condition of the roof garden for later repair and maintenance work. This can ensure the quality of each rooftop garden is qualified, effective, and safe, so that the threat of an unsafe structure is minimized.

#### 4.4 Weaknesses & Opportunities

This is a reverse strategy to decrease the negative effect of weaknesses by using external opportunities.

Innovative technologies in various industries can be used in rooftop gardens, so that some disadvantages of rooftop gardens could be solved. For example, the newly developed calcium carbonate fireproof material is a Class A non-combustible material that has outstanding fire and thermal insulation performance. In practical application, it can not only be fireproof but also absorb noise and have a waterproof and moisture-proof effect<sup>[19]</sup>. This material is very suitable for the construction of rooftop gardens.

As public awareness of environmental protection rises because of education and publicity, people will notice the benefits of a rooftop garden and will support the development of rooftop gardens, making them more likely to buy a house with a rooftop garden. With this demand for rooftop gardens, firms will allocate resources to developing rooftop gardens; therefore, many problems can be solved when there is more funding and more resources for the rooftop garden industry.

# 5 Conclusion

Rooftop gardens are a surface covered by vegetation on the top of a building. Rooftop gardens are included in many regional urban development strategies because of their ability to mitigate warming, clean the air and control carbon dioxide, and promote biodiversity, but the development challenges are structural, with drainage issues and erosion problems. When the construction of rooftop gardens in China and some foreign countries is mentioned, it can be clearly seen that the construction of rooftop gardens in China is still lacking behind compared to other countries. The SWOT analysis method is used to analyze the strengths, weaknesses, opportunities, and threats of rooftop garden development. The combination of these four factors is then used to obtain different strategies for the development of a rooftop garden, including an aggressive growth strategy, a defensive strategy, a reverse strategy, and a diversity strategy. After analyzing the four factors of rooftop gardens in China using SWOT, there are serval suggestions given in this article: Policy support is essential for rooftop garden development. With the support and subsidies from the government, real estate developers can be encouraged to build and improve rooftop garden, as well as a specific industry chain for rooftop garden. There are many foreign countries, such as Singapore and UK, have experience of developing rooftop garden, and domestic developer can learn from their past experiences.

# 6 Evaluation

In this project, my plan is to analyze the effects and management of rooftop gardens. The effects are easy to understand, especially the ecological benefits of rooftop gardens. However, the management is very complex because developing a rooftop garden includes economic, construction, and safety concerns, and different places have different ways of managing it. It is hard to draw a conclusion about it. In order to address this issue, I made a new plan for my project, which included a separate discussion of domestic and foreign management styles and development status, so that the features of different places and management would be clear.

After this, I face another challenge. In my essay, I use the SWOT analysis method as a methodology to analyze the development of rooftop gardens. However, after identifying the four aspects of a rooftop garden, I realized I could not give a conclusion or make a suggestion about the future of rooftop gardens. So, I searched for some articles online about SWOT, and eventually I found some articles that use SWOT for rooftop gardens, just like I did. In one of them, I discovered that I could combine the four aspects of SWOT together to obtain four strategies for any development. So, I did the same thing to my own essay, and I got four strategies, and I can make conclusions and suggestions for my analysis.

Talking about something positive, I learned how to manage my time and organize my tasks, and the result is good. Before starting my essay, I did a Gantt chart to make a brief timeline of my project, and it can remind me what I should do at which stage. During the process, there is a conflict between my schoolwork and exams and my project. I had spent a lot of time on my schoolwork and somehow set this project aside for a while. But I squeezed some time out for this project from my weekend free time and leisure time. It was not a big deal for me because my efficiency is relatively high, so I still have my leisure time. Also, I distribute my project time very evenly throughout the entire process so that I won't be in a rush. Overall, I consider this project well organized, and I can deal with the time conflict well.

Before I started this project, I had heard of Google Scholar and CNKI for searching information, but I had no idea how to use them. During the process, while I am researching, I learn how to use them. But I didn't stop there; I continued to study how to use it and found more tips on how to use it. For example, when I need to read more articles related to my topic, I just need to see who else has cited articles that I have previously identified as useful. It is only a basic tip, but it is especially useful. I found it out by myself, and it shows my ability to drill down on things.

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