

# An Analysis on the Sustainability of Green Roofs under Haze

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**Abstract:** Green roofs over limited urban land is sort of relief over its environment pressure, and is developing towards a sustainable future. Bearing the concept of "Ecological Engineering", the Green Roofs are introduced to urban construction, combines human society with environment. Taking into the consideration of spatial arrangement and the relationship between architecture and nature, the Green Roofs transcend universal construction into the arena of aesthetics, enlightening people with a practical way toward a sustainable development. This thesis will provide analyses on the sustainability of Green Roofs, the influence of those on urban development and advice on its application.

**Keywords:** Green roof, Haze, Efficiency

## 1. Introduction

Although this year's economic situation is grim, the trend is positive for the promoting economic development quality. Economic development depends on and affects and changes the environment. In recent years, with the fast growth of economy, environmental problems are worsening. In report on the government work of this year, solving pollution problems to protect the environment falls to taking into account of people's health and sustainable development, which must be promoted seriously with the determination of achieving win-win combination of economic development and environmental improvement.

So far, the environmental problems such as global warming, desertification, energy shortages, air pollution, the greenhouse effect and heat island effect have been threatening human survival. It is bound to deteriorate to be irreversible if these environmental problems attach insufficient attention and solution. Meanwhile, over the past few years, the environmental problems that we all emphasis with is "haze" emergences. Haze is the environmental hazard caused by the combination of dust, sulfuric acid, nitric acid, organic hydrocarbons in the air and other very small and dry dust particles floating in the air that evenly becomes turbidity, blurs vision and leads to the visual deterioration. Being exposed to the haze weather in a long term will threaten human life and health security, lead to a variety of diseases and do harm to human health and security. According to statistics, the annual pollution index, PM2.5, in more than 172 cities in China has exceeded the standard published in "air quality guidelines" in 2015, and only 18 cities meets the guideline standard. Among those 172 cities, the index in a large proportion falls to seriously polluted. In addition, it is found that, on a global scale, about 2.1 million people die

from PM2.5 each year. A brief introduction to Haze is now provided: Haze mainly comes from such industrial emissions as dust, waste incineration and etc., all of which are necessary emissions of industry that sustains economy development and city construction. Therefore, to summarize, green roof on the limited urban land will be the balance between urban development and environmental protection, which is a feasible direction for the sustainable development of cities.

## 2. Current Situations at Home and Abroad

Green roofs abroad mainly exist as roof gardens." The ancient Babylon "sky garden, one of "the seven wonders of the ancient world", is the first true roof garden. Researches were stimulated by emerging industrial civilization as is illustrated as follows. Japan, which always attaches great importance to the greening, and Germany, with the world first-class environmental protection and greening facilities, have reached a quite advanced roof garden facilities. According to the survey, the roof a forestation rate has reached an average of 15% in Germany. Meanwhile in China, the first ones to carry out the roof greening plant is in Sichuan Province. In the early 60s, residents in Chengdu and other cities in Sichuan used flat roof on top of factory workshops and warehouses to plant vegetables and fruits as a way of full utilization of space and interesting pass time. But with social progress, economic development and the change of environment conditions, the demand of green roof is not only to satisfy daily life consuming, but to further its significance with the expectation for a better environment. According to the ecological and environmental research that conducted by an international organization, the best per capita green area shall exceed 60 m<sup>2</sup>, while the United States' urban planning requirement in the regard

shall be 30 to 40 m<sup>2</sup>. In 2014, the per capita green park area in China is 12.6 m<sup>2</sup>, which obviously fail to achieve the standard[1]. In limited urban space, it will benefit a sustainable development with the combination of green environmental protection and economic development, which is exactly the significance of green roof. There is a stated requirement in Chengdu that demands newly constructed buildings in 6 urban districts and counties be in line with the following implementation of green proof: buildings of high, multi-layered and non-slope-bottom-floor type below 12 floors or below 40 meters high in Long Quanyicounty, Qingbai Jiangcounty, Xinjincounty, Wenjiangcounty, Shuangliu county, and Pi county, shall implement roof greening projects. Also in Chengdu main districts and counties, buildings constructed within 20 years with clear property rights, and safe roof construction protocols shall implement roof greening projects. The construction funds shall abide the policy of "Awards as Compensation" to award elite projects by relative government organs at the municipal, district and community level respectively[3].

### **3. An Analysis on Green Roofs' Sustainable Benefits**

By definition, green roof is to plant green plants on the common roof of the building in order to achieve the aim of greening. Green roof introduces the concept of "ecological engineering" is introduced to the urban construction by taking both human society and the natural environment into consideration, by well implementation of principles of ecology and architecture and by rationalizing and organizing the relationship between the building and other factors. Green roof also fully utilizes construction space that is people-oriented, building-oriented and coordinated-nature-social-development-oriented. Carrying social and cultural functions, green roof is the evolution from green planting is furthered to profound significance as one of the "beauties" that human cognizes.

#### **3.1. Characteristics of green roofs**

Nowadays, the more common form of green roof in China is mainly multi-storey, namely: the roof structure layer, a waterproof layer, a protective layer, drainage layer, a barrier layer, layer of soil and vegetation layer. Compared with everyday roofs, green roof is characterized by thicker soil and vegetation layers. The treatment, maintenance and management of soil and vegetation as a result become a key point of building green roofs. Taking into account the roof loadings, landscape beauties, and spatial and functional use of the building, post-processing shall differ under different conditions and different vegetation plant. Because of the increased vegetation layer, required drainage layers of vegetation and grass-roots are different from ordinary roofs. Under normal circumstances, a secondary waterproof of green roofs shall be

taken into consideration[3]. Generally, since the vegetation roots will hinder drainage layer, setting an isolation layer and a protective layer may that hindrance.

Traditional roof is open to any layout while green roofs takes into consideration the concept of space layout that combining garden art and architectural aesthetics to its construction that becomes a spatial artistry. Under normal circumstances, a green roof has several forms, namely, open and semi-open and enclosed[3]. Each form is laid differently according to a people's demand on its function and artistic effect. For example, the combination of vegetation and garden ornaments, or vegetation and vegetation would be different in various conditions. The layout of the space usually considers permeability, integration of the background, and coordination of sensory green, which is a matter of ecological aesthetics.

#### **3.2. the sustainable benefits of green roofs**

With In this knowledge-based society, with the advancement of science and information technology and globalization, the problems of the environment are becoming more and more serious. So, sustainable development is of particular importance. The leaders of the Party and the state have shed light on the sustainable development strategy planning and research or many times, aiming at establishing a good social development process. Green roof, of course are involved in the sustainable development for bringing about advantages and benefits. Benefits of sustainable development generally includes three aspects, i.e., the social benefit, economic benefit and environmental benefit.

Firstly, the social benefits of green roof. Building green roofs to cool building has brought vigour and vitality, and has enabled relaxed and lively vision. Nowadays, a lot of green roofs are presented in the form of open garden who have more resting places, open square or children's playing area, providing a healthy environment for residents. Along with the aging society as well as the second child age, life atmosphere and environment model which residents expect have broken the inherent pattern, and the demands for the environmental health are also increasing. People can make use of green roofs in parent-child park, activity area and communication platform to remove any ice burglary-resisting door model and to improve the family relations as well. Or the Green Roofs can be established combining industry which is similar to the "roof garden restaurant" platform, increasing not only aesthetic value but also building commercial model to add artistic flavor and healthy atmosphere.

Secondly, the economic benefits of green roof. Due to the complexity of green roof's construction and high demands of management, the construction investment in the early stage is huge. And this has become an obstacle of the Green Roof's development. According to research, the initial cost of green roof is about 27% higher than

conventional roof[4], but when it comes to air conditioning facilities and saving of municipal infrastructure investment, reducing fee of drainage and sewage treatment, green roofs can actually bring long-term economic benefits. At the same time, the pollution tax, government subsidies, market barriers of reducing emissions and four main forms of market mechanism tool of tradable permit relieves the problem of relevant financial and market risk, and increase the economic benefits of green roof on certain conditions[5].

Thirdly, the environmental benefits of green roof. According to relevant research, it has shown that temperature of the wall covered with green plants is about 10 degrees Celsius lower than those without green plants covering the surface. Also, the indoor temperature with greening coverage is about 7 degrees Celsius lower than those without greening coverage[1]. Besides, green plants can also increase relative humidity of 3% to 12%, effectively reducing the heat island effect and climate gradient effect. Green roof contributed to keep the temperature and reduce the demands of air conditions. The use of air conditions will not only threaten life and health of human body, but also lead massive energy consumption which will produce environmental pollutants, such as nox, SO<sub>2</sub>, dust, etc. Most of these pollutants are fundamental sources of haze. Now, the haze threatens environment and human health across the country. Green plants can absorb and remove parts of the exhaust gas and suspended solids. The spread of green roof in cities can effectively improve the air quality to a certain extent. In addition, green plants can reduce the loss of part of the rain by plant transpiration and also rainfall interception to reduce the rainwater draining into the sewage system, thus to relieve the pressure of city municipal pipe networks[6]. Also, rainwater drainage can effectively solve the problem of urban rainfall. There is a note to urban pollution---noise pollution. The construction site, automobile noise and so on are the main sources of noise pollution, which cannot be avoided when developing urban areas. Developing green roof can reduce noise pollution to a certain extent. According to the survey, green roof can reduce the noise up to 10 decibels compared to the ordinary gravel roof[7].

#### 4. Application Suggestions

Green roofs are extensions of the green buildings and architectures. In addition to meet the basic requirements of general construction, higher requirements are needed for maintenance and management. Therefore, Green roofs usually apply to residential buildings with high management level and commercial buildings with comprehensive operation and management system.

The development of green roofs relieve environment problems to some extent, but it has its own insufficiency, such as the consumption of urban water resources for

green vegetations managements, which put pressure on the water resources of the city. Green vegetations have their own life cycles, and can produce litters, which will increase management and sanitation pressure, etc. Based on the comprehensive consideration of the green roofs, following suggestions are provided:

(1) While developing green roofs under the policy incentive mechanism, attentions should be paid to the protection of the existing resources (such as water resources), and dynamic balance should be kept. Considering the precious water resources, it is an effective way to use reclaimed water for vegetation maintenance. It will not only reduce the construction requirements of the reclaimed water system, but also add another way to use reclaimed water at the same time.

(2) For green roofs, whole-life-cycle managements should be carried on, from the professional design stage to the stage of maintenance and management. Among which, the maintenance and management stage is of crucial importance. Under the premise of considering the humanitarian spirit, green roofs can be cared with human-oriented management. According to the vegetation's life cycle characteristic, a regular pruning shears blade and basic nursing should be done on time. Also, maintenances of existing green roofs should be record and analyze for the evaluation of green roofs construction..

(3) There might be obstacles in green roofs construction for residential buildings with low property management level and commercial buildings with imperfect operation and management system. For this part, it is suggested that each owner or businesses, who have aspiration to take part in the construction of green roofs, is assigned to carry out green roofs construction in form of "green cultivation".

#### 5. Conclusion

Sustainable is the crucial point to maintain the dynamic equilibrium between economic development and environment construction. Green roofs development in city construction is one direction of sustainable development. Green roofs development do have its sustainable benefits, but also has insufficient. We need to weigh the pros and cons, and to maximize its benefits in developing.

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