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## Urban farming construction model on the vertical building envelope to support the green buildings development in Sleman, Indonesia

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### Abstract

The purpose of this paper is to analyze the construction model of urban farming on vertical building envelopes to support the green building development in Sleman Regency, Special District Yogyakarta Province, Indonesia. The construction of vertical buildings in Sleman district is growing rapidly together with the increasing demand for the provision of housing and public facilities. The rapid physical development in Sleman has caused the reduction of green land such as green open space (RTH), agricultural land and rice fields. These developments potentially threaten food security in Sleman district. Urban farming is a method of agricultural activities to reduce the problems of agricultural land limitation in urban areas, like Sleman district. The construction design model of urban farming on the vertical building envelope is one aspect of green building that will support the efforts in vertical farming processes. This showed that the method did not require any horizontally ground space but effectively used the vertical space on the building envelope, including wall and building roof features and construction. In fact, the urban farming construction method will not only contribute to productive agricultural activities, but also support the greening of the urban area as well as reduce the crisis of agricultural land issues. The urban farming construction model of the vertical building facade includes the urban farming construction on the roof, wall, and balcony.

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## 1. Introduction

Green roofs, walls and facades are turning into common in many cities across the world. The growing numbers of urbanism are realizing the potential of these living systems to increase the quality of their built environment to provide social, aesthetic, environmental and economic benefits [1]. The building envelope constitutes all the building elements that separate the indoors from the outdoors. Building envelopes components include the walls, foundations, roof, windows and doors [2].

### 1.1. Population growth in Sleman and increasing vertical building development

The development of Sleman regency is increasing as shown in the increase of its developmental growth later on triggering the raising quantity of new comers leading to the increase of population growth. In 2008 the quantity of people in Sleman was 31.09%. Until 2010, Yogyakarta's population grew once more to 31,62% population and kept growing in 2013 as noted as 31,76%. The population growth in Sleman was the effect from Yogyakarta province unable to accommodate the population for the increase of economic, social and governmental activities. The increase of population growth in cities every year causes an increasing demand for the needs of residence and facilities, which have to be accommodated [3]. However, as population grown and lands are limited, the land cost is high. Therefore, vertical building is deemed as the most efficient solution for the limited land and the today high land price and it starts to be applied in Sleman.

### 1.2. Sleman agriculture land use issues and food security issues

The way to prevent the productive land such as *urban farming* could really be applied because this method is a farming style in city areas, which is identic to the limited land. The rarely productive land for farming does not affect the farming activities in city [4,5]. Moreover, it can help city urbanization, land crisis and contributes in food problems. Urban farming also holds an important role to improve air quality in the city [1]. The shrinkage of agricultural land occurred due to the effect of growth and uneven population distribution in 2008-2013 [6].

In the period of 2008-2013 the agricultural land in Sleman reduced about 365 Ha. It then brought an effect on the sustainability of regional food. Food production in Sleman during 2010 was 168.158 tons of rice, and then it reduced about 8% from production in 2009 [6]. The phenomenon was caused by the weakness of government regulation that was unable to control the change of agricultural land utilization. The Government of Yogyakarta only could protect land that is appropriate with regulation. It is mentioned that it is only about 35.000 Ha of total productive agricultural land in Yogyakarta that can be protected. Hence, the innovation of development is needed to protect the food security [7].

### 1.3. Lack of implementation of building vertical urban farming

The assembly of vertical greening on the wall and balcony is still limited only in ornamental plant. Fig 1 shows that balcony is equipped of ornamental plant and some walls are just left as an empty space. Meanwhile, the center picture indicates the domination of the wall and minimization of opening does not make any use of vacant land as a growing plant media that can be used to reduce heat and to absorb the air.



Fig. 1. Limited vertical farming and vegetation in most buildings in Yogyakarta

The purpose of this paper is to identify the model of urban farming on the vertical building envelope as a basic of green building design in Sleman. The objective of this study is to analyze the urban farming construction in some building elements including roof and wall. The wall elements cover some parts of wall including wall, balcony/terrace, and window.

## 2. Urban farming construction

The urban farming in the building facade will refer to the green facade approach. A green facade is created by growing climbing plants up and across the facade of a building, either from plants grown in garden beds at its base, or by container planting installed at different levels across the building those are roof and wall elements (see Fig.2) [1].

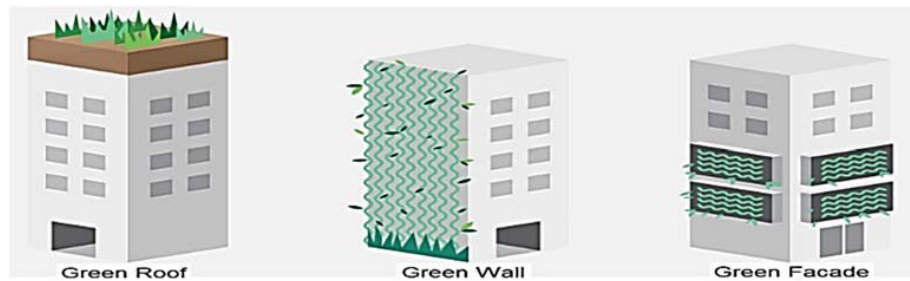
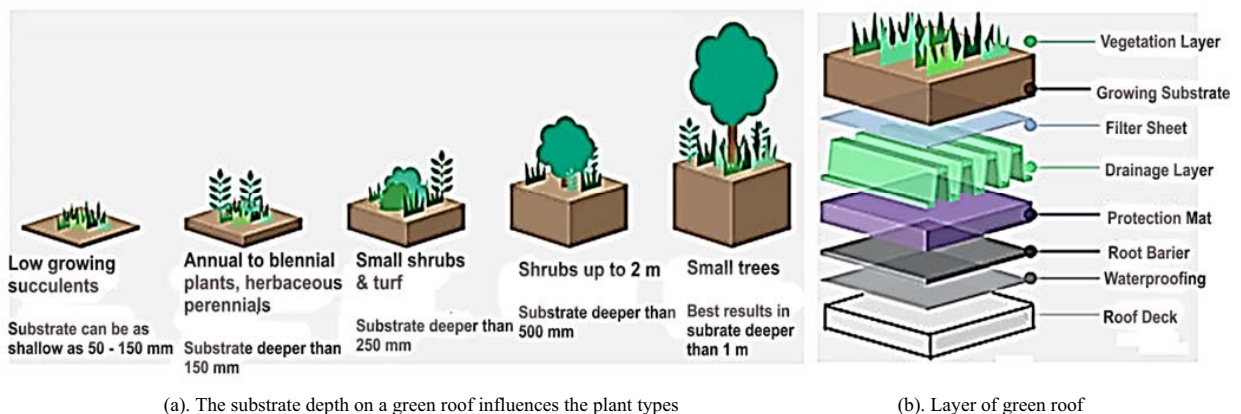


Fig. 2. Schematic model of Green Roof, Green Wall, and Green Facade

### 2.1. Green roof construction

Green roof constitutes a vegetated landscape built up from a series of layers that are installed on a roof surface as 'loose laid' or modular installed layer by layer on the roof or as pre-prepared layers in trays. Vegetation on green roofs is established in a growing medium that may range in depth from 50 mm to more than a meter depending upon the weight capacity of the building's roof and the aims of the design [1][8]. Green roofs are built up as a series of layers, each of which performs a specific function. The most typical build-up is shown in Fig. 3 [1].



(a). The substrate depth on a green roof influences the plant types

(b). Layer of green roof

Fig. 3. Substrate typology and green roof layers

## 2.2. Green wall construction

A green wall is comprised of plants grown in supported vertical systems that are generally attached to an internal or external wall, although in some cases can be freestanding. Like many green roofs, green walls incorporate vegetation, growing medium, irrigation and drainage into a single system [1]. The construction model and scheme of urban farming can be seen on Fig. 4.

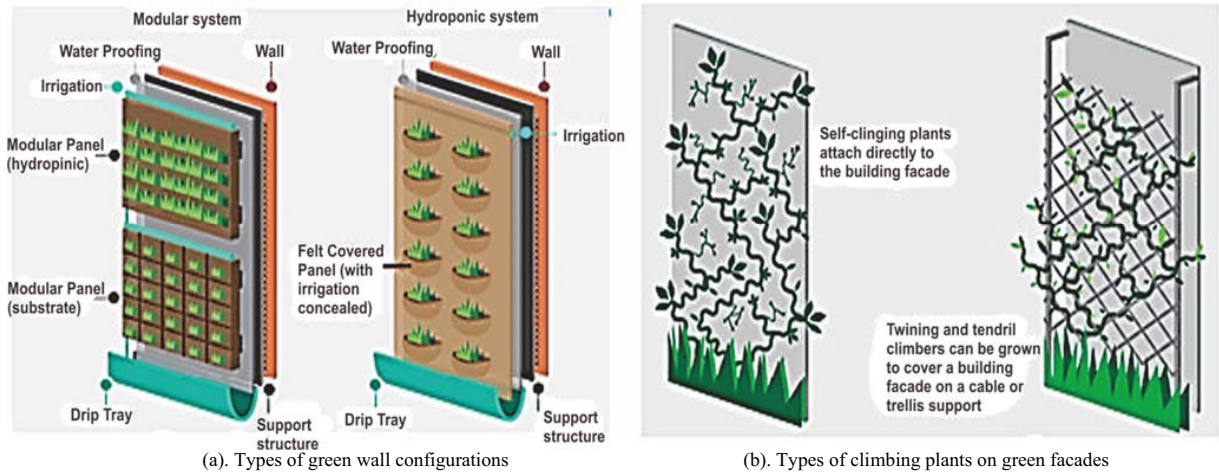


Fig. 4. Typology of green wall and green facades construction schemes

## 2.3. Green facade construction

A green facade is created by growing climbing plants up and across the facade of a building, either from plants grown in garden beds at its base or by container planting installed at different levels across the building. Climbing plants can attach directly to the surface of a building, or they can be supported on an independent structure of the building. The use of climbers that anchor themselves to a structure by twining stems or twining tendrils enables a green facade to be installed in front of solid walls or some other structure, to create a partition, privacy screen or sunshade. The degree of density of the facade coverage can be managed to suit the required function [1, 8, 9].

## 3. Vertical urban farming case study and construction models

Greenhost Boutique Hotel, located on Jalan Prawirotaman II No. 629, Brontokusuman, Mergangsan, Yogyakarta, Special District of Yogyakarta, is optimistic if the social and environmental changes that occur at this time are also accompanied by the emergence of a passion for innovation and better habits. The increasing number of people living in the city requires people to farm in the city. Climate change and environmental degradation make people choose more wisely production methods and reduce energy consumption. In addition, health problems require people to behave and eat healthy foods. All these principles are applied to each element in Greenhost Boutique Hotel, including rooms and the products used, building design, food, and service [10]. The roof utilization as a plant medium can be applied by various methods, such as pot placing on the flat roof as well as on the slopping roof.

The Greenhost hotel is implementing the urban farming that has been installed in constructional manner on the roof, wall, and facade. In this hotel, the application of urban farming mostly uses the Nutrient Film Technique (NFT) system with a number of perforated pipes, and the nutrient is channeled by using pump and timer to manage the time enabling it to run automatically [11]. The planting, treatment until harvesting methods are very easy to be done just like the general way of planting. However, the green roof of the Greenhost hotel is not only constructed on the flat roof but also tilted or slopping roof. As slopping or tilted roof is mostly used in Sleman

and most regions in Indonesia, urban farming on the roof element is better to applicate the urban farming construction for slopping/tilted roof (see Fig. 6). Though the use of tilted roof as a planting medium is less popular in the society nowadays; it can be applied by the following methods. Lettuce is recommended to be planted at a distance of 12.5 cm.

### 3.1. Green roof of urban farming construction

The roof slope is designed to about 150 to make the roof save to be stepped onto and make it easy to do planting, vegetation treatment until harvesting. The simple construction uses the frame as a place to put the plant pots on the roof with fiber cement as roof materials. The space giving to the plant is used to give circulation for the plant harvesting as well as plant treatment (See Fig.7). The irrigation system on the roof uses electrically automatic system by applying the sprinkler [11].

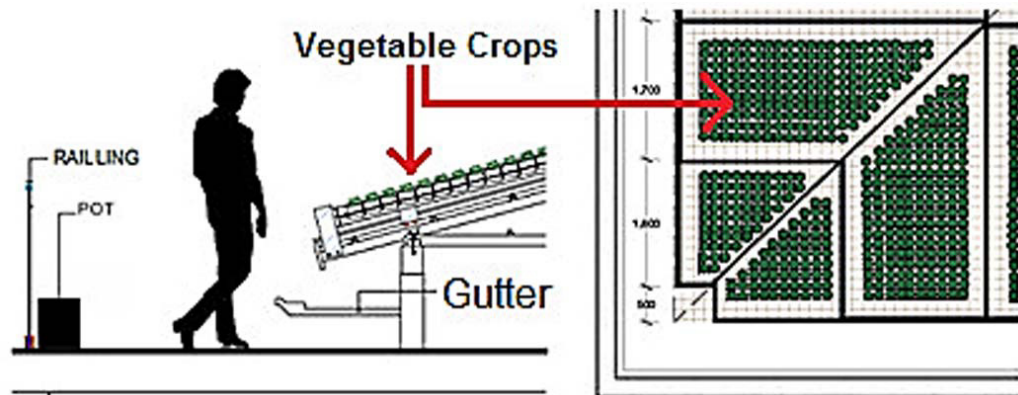


Fig. 5. Urban farming installation construction on the roof.

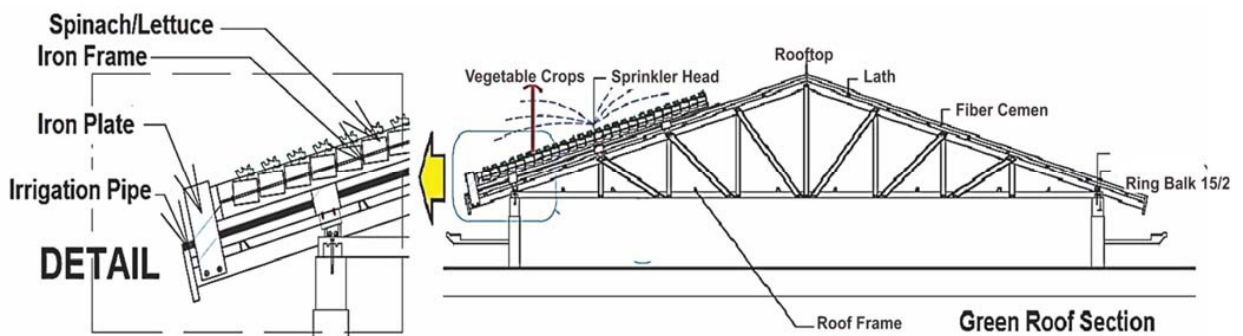


Fig. 6. Urban farming application and the detail construction



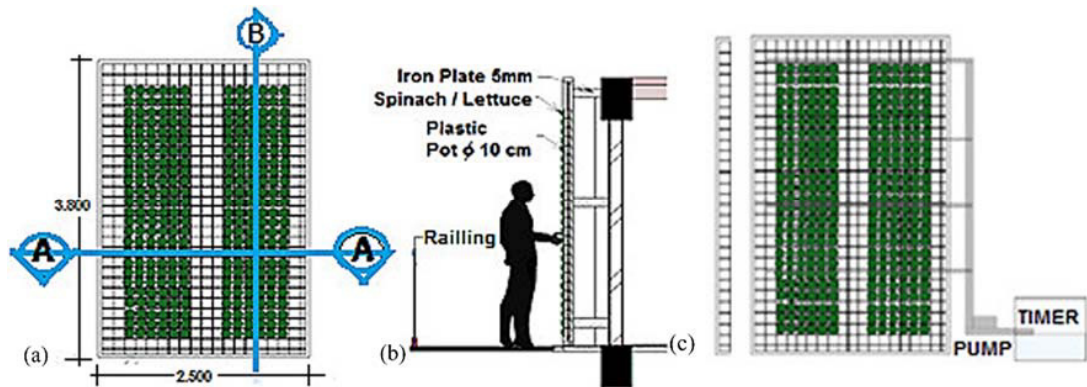


Fig. 7. Urban farming application on the wall: (a) elevation, (b) section, and (c) irrigation system

### 3.2. Urban farming on the wall and facade construction model

The utilization of plain wall can be used as green wall with a simple construction so that it saves the cost and structure. In Greenhost hotel, the wall is used to put the pot by using the welded iron construction. The use of simple construction such as welded iron can be used as cantilever media of the pot (Fig. 8). Here, harvesting and treatment can be done easily. The vegetables planted on the high places can be harvested by using ladder to help. Lettuce and basil in this case are the recommended plants. Moreover, the distance between plants in the construction below can be adjusted to the plant size, which will be used because it is flexible and as needed.

#### a. Irrigation system

The irrigation system in the wall uses an automatic watering with timer and pump. The water is channeled through a pipeline and distributed to every row of the plant. The pot is made of plastic with many small holes to provide a way for water to flow to the rock wool plant media, and to every plant.

#### b. Urban farming on the balcony

The utilization of balcony as a medium for planting as well as for making use of the less productive room is right. Those are the urban farming application on the balcony (Fig. 9). Equal to the planting in the roof, planting in the railing uses NFT irrigation model arranged vertically and horizontally. The size can be adjusted with the building length. While the building facades is planted by decorated vegetation that is *lee kwan yew* plant. The other alternative of balcony utilization is giving crawled plants on the shading. The plants can be *srikaya* or other spreading plants.

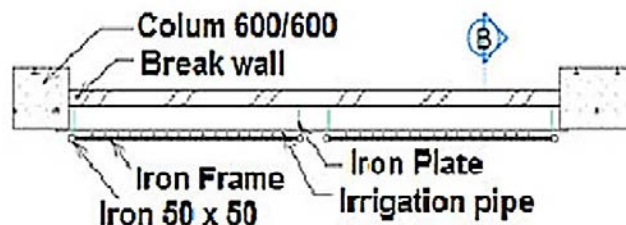


Fig. 8. Urban farming application on the wall plan

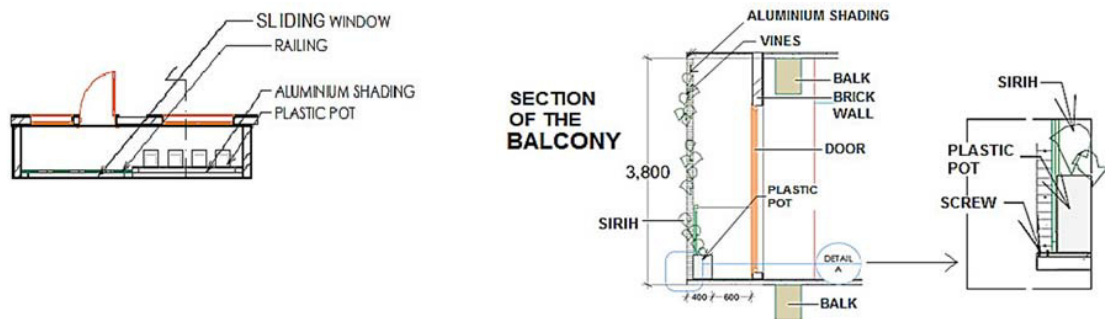


Fig. 9. Balcony plan, balcony section and section of pot placing on the balcony

The harvesting system is very flexible for being located on the balcony and easily to be controlled. Furthermore, the pot is in located lower enabling it to be reached by anyone. The recommended plant is spreading plant like the *srikaya* fruit in which this plant can also be used as sun screen.

#### 4. Conclusion

In Sleman District and Yogyakarta, most buildings are lacking of the implementation of urban farming. The application of urban farming is not limited to the roof or balcony, but it can be done vertically on a wall. The used construction is simple to be applied on building roof, wall, and facade. The model of urban farming are the selected form and materials in accordance to the space provided. More research on urban farming construction models should be conducted not only in university context but also in the government and the agriculture community context. This will encourage more urban agricultures in our cities and regions.

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