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# Sustainable development concept of rain harvesting for public flat in Tamansari Village, Bandung

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# Sustainable development concept of rain harvesting for public flat in Tamansari Village, Bandung

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**Abstract.** Bandung is the capital city of West Java province in Indonesia. The city is located on 768 meters (2,520 feet) above sea level and lies on a river basin surrounded by volcanic mountains. The annual rainfall is considered as high level. The most rain happen on January with total precipitation is 973.0 millimetres, while the less rain happen on August with total precipitation is 70.0 millimetres. In addition, La Nina phenomenon occurs lately to trigger high rainfall level in Bandung city. Based on Meteoblue Bandung City, the average of precipitation in Bandung is 2164mm / year. The potential of this large rainfall later can be utilized as water reserves, in urban settlements with high population density. In line with the Mayor of Bandung city Regulation (Perwal Bandung) no. 1023 year2016 about the Green Building mentioned that any building with area more than 5,000 $m^2$ requires to preserve balance of environment, including concerning social, cultural and ecosystem. Later, this paper aims to explore the sustainable development concept of rainwater harvesting for a public flat in Taman Sari, Bandung. The need for clean water for the residents is as much as 102,200,000 litters/year for 2800 occupants. The design of Tamansari Village public flat then able to accommodate 23,700,993.6 litters/year, which means 23% of the total needs of clean water.

**Keywords**: Concept, Rain Harvesting, Sustainable

## 1. Introduction

West Java province is the most population province in Indonesia. The capital city of West java province, Bandung city, is a fast growing metropolitan city. The city is recently facing environmental problem and rapid urbanization. The most critical environmental issues is related to water resources, including flood, pure water supply crisis, water pollution and ground water level. Flood disaster in Bandung city is a common news topics whenever rainy season. [1]. Conversely, in dry season, the city has problems related to pure water scarcity faced by the residents. Overall, the supply of pure water by Water Supply Company (PDAM) is only available to serve36.5 million $m^3$ per year, including 40% of surface water and 60% ground water (BPS, 2015). As consequences, the new groundwater companies were established because the PDAM cannot provide public demand of water. The decrease of groundwater level has been happened since 1980s. This is related with the rapid development of industrial and residential settlements. The most severe ground water levelling occurred in industrial areas and high density of settlements [2].Meanwhile, rainwater utilization technology as a source of water has not been explored optimally yet. The study and implementation of rainwater harvesting in Indonesia is still less number compared to the drought area. The study in Petra University shows that building able to harvest 100% of rainwater based on WAC (Water Conservation) in GBCI Greenship methods [3]. Rainwater harvesting also conducted in IPB Dramaga Campus, which potentially amounted to 319.734 $m^3$ per year or equal to 52% of the average annual needs.[4]. The study in Novotel Hotel, Yogyakarta, during the rainy season, rain water can supply up to 21% of total water consumption in a month. Annually, the rain water can supply the water consumption of the hotel for about 8.6%.[5]. Meanwhile, rainwater harvesting technology as a source of clean water in households are still not optimal. This paper then explores the concept of sustainable in high density areas such as Tamansari Village for rainwater harvesting of public flat.

The location has been selected based on the Urban Slums Development Plan (RKP-KP) 2015.Those study shows that Tamansari Village is one of urban villages identified as having severe slum conditions (PU, 2015).Public flat here is a plan for the development of vertical housing in densely populated areas.

## 2. Public Flat in Tamansari Village, a Densely Populated Area in Bandung

Bandung was a high density of population in West Java and second city after Jakarta. In line with the strategic plan of Ministry of Public Work and Housing [6], Bandung City Government has planned the location of vertical housing development including on high density population, Tamansari Village.

Bandung was located in 6°54S and 107°3E with elevation on 768m above sea level. Bandung city is famous as a mountainous city with moderate average temperature 26 ℃ on 2017. The precipitation average was 2.164 mm/year. The rate of precipitation was consider decreased 184.74 mm on 2015 198.8 mm on 2016.

### 2.1. Study Area

The area of public flat is 36.508 $m^2$with elevation is 725 to747 m above sea level. The geographical coordinate of area is 6°53'47.01"S and 107°36'24.71"E. The boundary of the site as follow: Cikapundung riverside, Jl. Plesiran, Jl. Kebon Bibit and local settlement (Figure 1). The existing area consist of building (90%) with few open space. The rainfall precipitation average is 10 – 20 mm per days.


**Figure 1**. Area of Tamansari Village in Bandung City
(Source :http://static.panoramio.com/photos/large/41790853.jpg)

Population in this region is about 2.400 people with 1.080 households. The average population aged around 40-60 years, with the number of children in each family is about 2 children. Beside that age, there are also people whose age 60 years old and over.

Cikapundung River is the main river of Bandung City and cross Tamansari Village. The problems in this area is number of people who still throw waste into the river. The water supply for residents who rely on river water cannot be fulfilled. The Water level is reduced due to siltation of the river caused by piles of garbage, other than the potential of flood disaster on rainy season that was also a problem for Tamansari Village district.

## 3. Rainwater Harvesting Concept

Rainwater Harvesting is a rainwater collection system for reuse in daily activities, such as for watering plants, flushing water, drinking water for farm animals, irrigation water, washing, and others. Rainwater is also very suitable to be utilized for drink water resources. The amount of rainwater is abundant and the quality is better than river water. It takes a bit of processing to be able to use it as drinking water.

**Figure 2**. a. Retention pool. Source: images.google.com b. Gutter. (Source: images.google.com)

Rain water harvesting is aimed to take advantage of rain water. There are various methods to do this rainwater harvesting. The most simple and most applicable method is to utilize the roof as a medium of falling rainwater, then channeled through a horizontal gutter which channeled down and combined with retention pool (Figure 2b) [7].

Juliana has studied the rainwater harvesting (RWH) system based on tank capacity and catchment area [8]. The RWH system is capable of replacing up to occupant and 72% for 4 occupants, especially for areas with annual rainfall above 2500 mm / year. The effectiveness of tank storage is 2 $m^3$, but for more efficiency, the capacity can be reduced to 0.5 – 1.0 $m^3$. The extensive catchment area that is effective for capturing rainwater is at least 70 $m^2$.

The buildings such as flats with roof to land area can accommodate large water discharge. The water harvesting system is more appropriate to use for the following reasons (Chris Reardon, 2013):

a. Water harvesting uses a simpler system than recycling water. For example, to utilize waste water, necessary process and more complex systems such as cleaning and sterilizing water.
b. Water recycling can damage / contaminate groundwater reserves because waste water contains chemicals that may be harmful to health. Thus, in addition to the substance is damaging the soil, the substance can also contaminate the wells in the vicinity.

Rainwater collected can be move into the soil so that water reserves in the soil can be maintained. In addition, it also aims to maintain soil fertility so as not to decrease soil. Given the design area in the middle of the city that has a little water absorption

Based on Green Building Council Indonesia (GBCI), the score for Water Conservation (WAC) mention about rainwater harvesting as follow [9]:

1 star = 50% of surface roof area can harvest the water
2 star = 75% of surface roof area can harvest the water
3 star = 100% of surface roof area can harvest the water

The Water conservation method was then adopted by the Government of Bandung City which stated in Mayor of Bandung Regulation (*Perwal Bandung*) no. 1023 of 2016 about the Green Building. [10]

Water Storage can be accommodated in the upper water tank and bottom water tank, depending on design of water tower. The tank will be stored on top so that water distribution can be carried out using gravity (Figure 3). In addition to the above, there is also a tank below which will be discussed at the next point.

**Figure 3.** Left: The example of placing Rainwater storage on a flats. Right: The water storage must be placed in service area. Source: housing-estate.com.b The tank for harvesting water (Source: http://storagetangkindonesia.co.id)

In order to maintain the aquifer (groundwater reserves), the system must consider water percolation so that ground water reserves are maintained. In addition, percolation is aimed to maintain the soil surface height so as not to decrease soil.

Water that was collected, some of which must be collected into the soil so as to maintain soil fertility on the land. In order to take rain water into soil, geo textile was used on shallow soil surface so that water run off can be provoked to enter underground tank storage. The underground tanks storage were intended to add water reserves, as well as to maintain soil fertility because water can be absorbed directly when the soil is dry. The scheme of rainwater harvesting method is explained in Figure 4.

That scheme in Figure 5 shows that the rainwater harvesting is a simple idea. First, the rainwater precipitation which fall on the roof, is collected to the water tank through gutter. Water will be distribute to the tower. Once it filtered, it may consume as a fresh water.

The other method for rain harvesting is collecting from the water runoff which through grill and store at the ground reservoir. After filtered and pumped it is able to consume as a fresh water. This scheme at Figure 6 shows how the rainwater which fall on the asphalt can be collected.

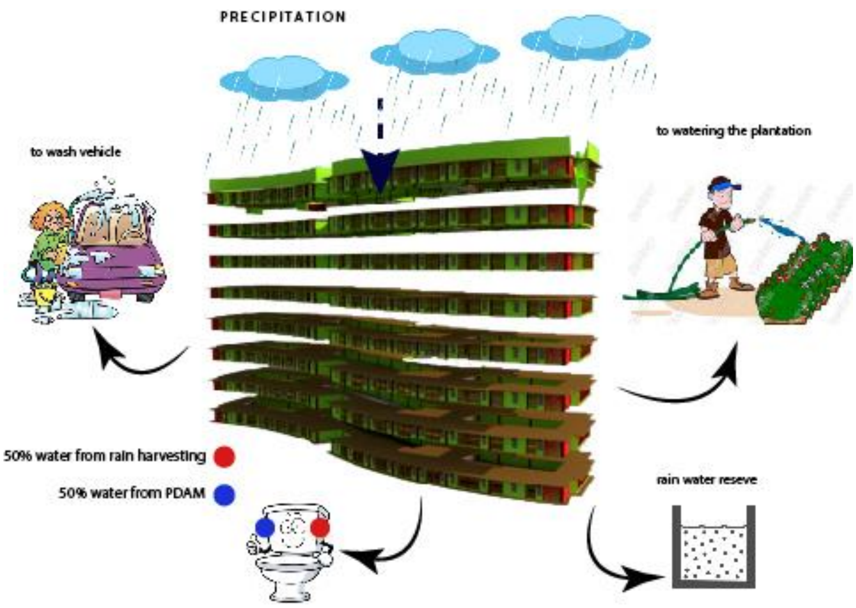


**Figure 4**. Rain harvesting concept in Tamansari Village Flats

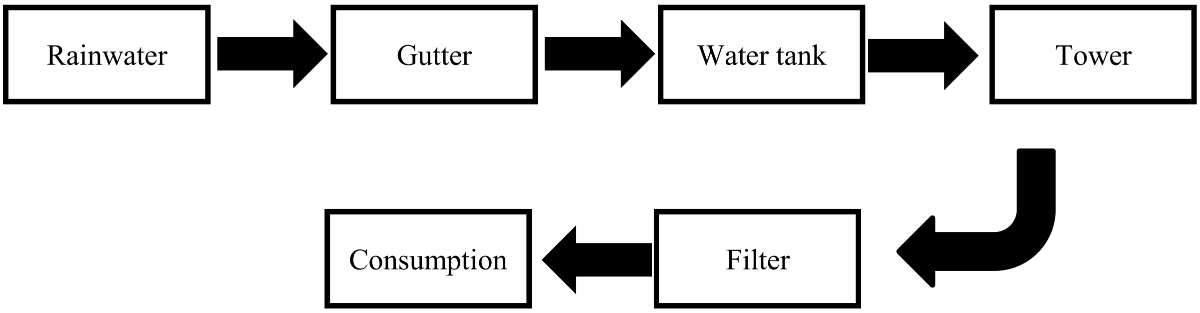


**Figure 5**. Rain harvesting method through gutter and vertical water tank in Tamansari Village Flats

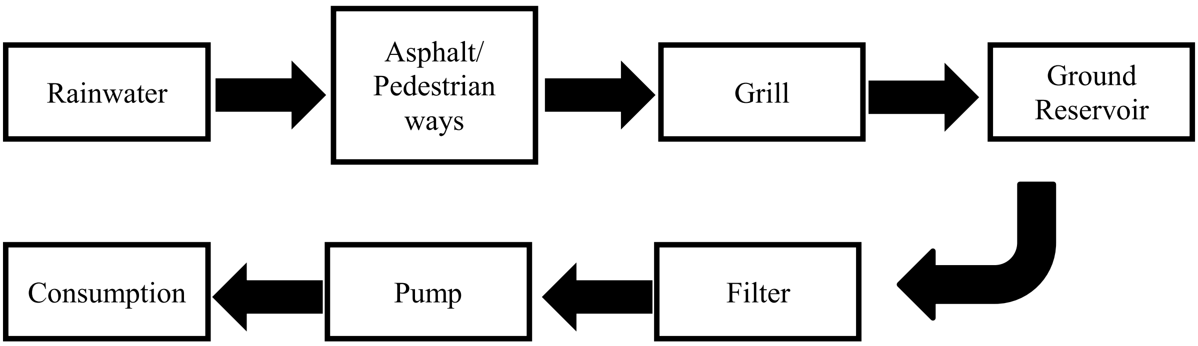


**Figure 6.** Rain harvesting method through grill and stored at ground reservoir in Tamansari Village Flats

Placement of a water tank, this should consider the height of the building. The rate of water velocity due to the force of gravity needs to be considered the slope of the gutter. In addition, design considerations according to dimensions and volume for aesthetic purposes are also important. Thus, as a flat with 8 stories, the flow of rainwater from the roof, will be distributed into 2 directions, the first gutter will serve 5 – 8 stories, while on second gutter will serve 1-4 stories. The scheme of this distribution as seen at Figure 7.

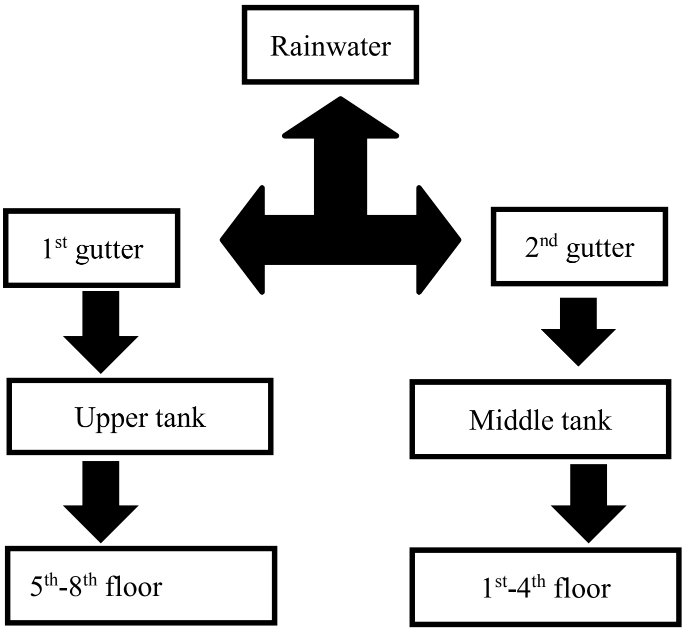


**Figure 7**. Rain harvesting distribution through gutter and floor distribution

The rainwater contents the chemical substance such as $SO_4$ and $H_2S$, especially in urban region which is directed from traffic and industrial pollution. The chemical substance very dangerous and may harm for human health. The layer in the water storage with minimum 20 cm gravel at least able to hold back precipitates containing impurities. For a better filtration, make the addition of fiber, sand, coconut charcoal, fiber and on the top layer covered with brick collision. The layer of water filtration as seen at Figure 8.

**Figure 8**. The filter to remove chemical substance in rainwater

## 4. Rain Water Harvesting Design and Calculation

### 4.1. Flat Design

**Figure 9.** Site Plan of Public Flat

Figure 10 shows the rooftop plan that able to utilize rainwater harvesting, the roof has designed in flat design to collect the water easily than diagonal roof, and meanwhile the system of utilization from the water tank to the building is seen at the flat perspective at Figure 11 and Figure 12.

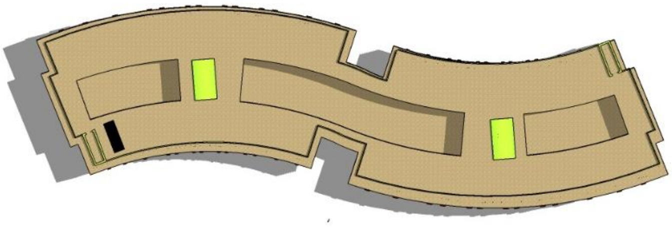

**Figure 10**. Roof Top Plan

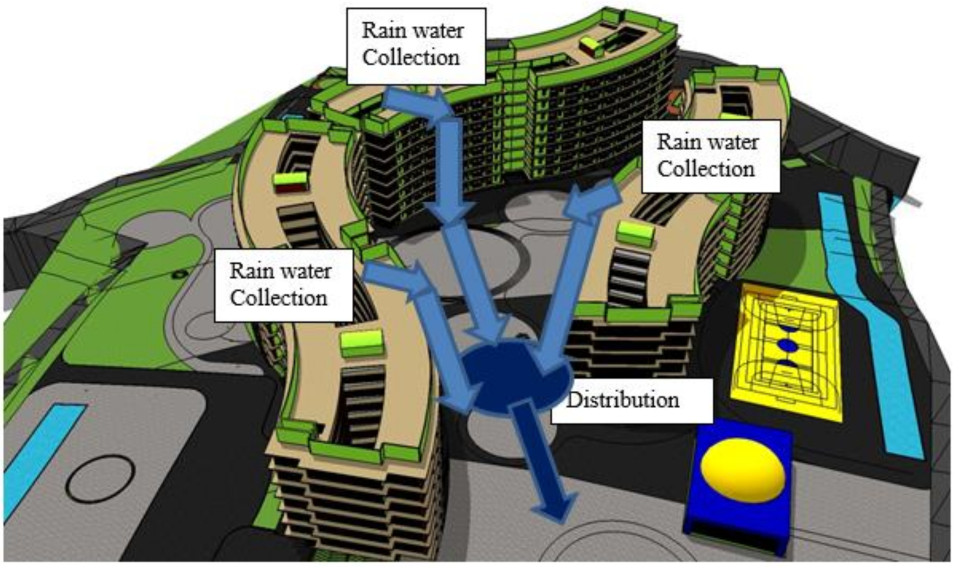


**Figure 11.** Water storage system and distribution

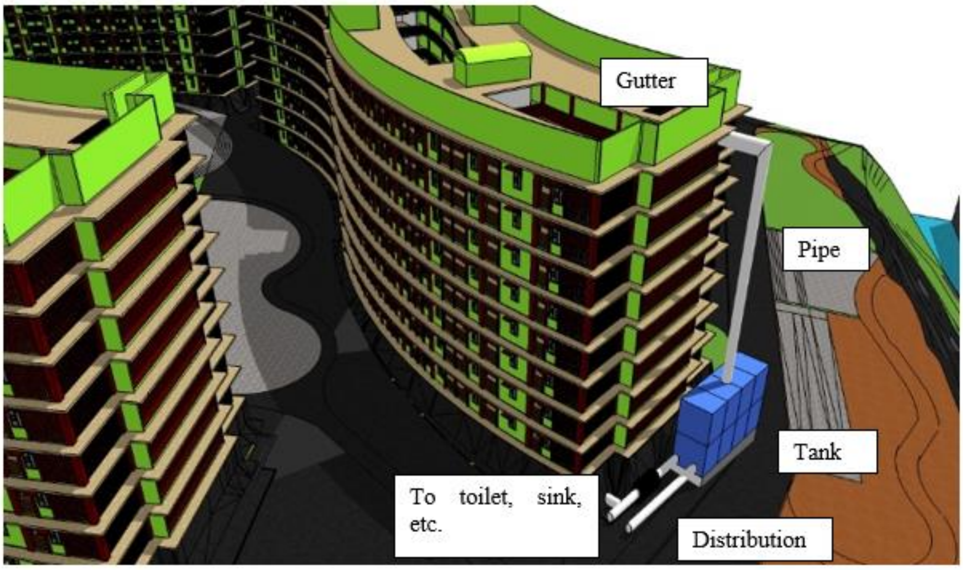


**Figure 12**. Flat RWH system

4.2. Rain Water Harvesting Calculation
The rainwater harvesting will be calculated based on the precipitation data, and the following is the amount of discharge water that can be accommodated:

Roof area that can harvest the water and distributed to the tank:
= 3,650.8 $m^{2}$ / roof
= 3,650.8 $m^{2}$ / roof x 3 towers
= 10,952.4 $m^2$
Rainfall precipitation: 2,164 mm / year

The amount of water that falls to the surface of roof:
= 10,952.4 x 2,164
= 23,700,994 liters of water per year
Which means the maximum (in average) of rainwater in 1 day will be: 64,935 liters

The total needs of clean water for residents: 100 liters/person/day, then in 1 year:
= 100 x 2,800 people x 365 days
= 3,894,200 litters
= 102,200,000 litters
Based on the calculation above, by accommodating the rain water it is about 23% of total water needs will be supplied from the rainwater harvesting.

The number of water tanks required to accommodate this rainwater harvesting will be:
64,935 litters/11,000 liters ≈ 6 water tank.
@tank capacity is 5,500 litters because in one spot, we must to divide the tank into 2 tank.
Figure 6 shows the place of the tank in the site, there are 6 water tank spot that utilized in the site.

The rainwater not only fall on the roof, but it fall on site (asphalt) too. It will be calculated based on the precipitation data, and the following is the amount of discharge water that can be accommodated:

Site area is 36800 $m^2$. Asphalt presentation area that can harvest the water and distributed to the tank:
25% x 36,800 $m^2$ = 9,200 $m^2$
Rainfall precipitation: 2,164 mm / year

The amount of water that falls to the surface of roof:
= 9,200 x 2,164 mm / year
= 19,908,800 liters of water per year

Based on the calculation above, by accommodating the rain water it is about 19% of total water needs will be supplied from the rainwater harvesting.

## 5. Conclusion

The ability of Tamansari Village flat to accommodate rainwater harvesting has performed the possibility to use water storage concept and method that was in line with design and planning. The roof top design is significantly able to influence the method of rainwater harvesting. The flat roof is able to accommodate 80% if the total area of the rooftop. The roof design in Tamansari Village flat shows that the rainwater harvesting is possible to obtain 23% (23,700,993.6 litters) amount of water supply, and by the ground cover (asphalt) is possible to obtain 19% (19,908,800 litters) amount of water supply. Based on Bandung city data, the limitations of PDAM in providing drink water supply in the drought months is possible to be reduced by as much as 60%. The implementation of Concepts and methods of rainwater harvesting will overcome resource of water supply during dry season. The water footprint capacity of more than 50% of the area will also be one of the requirements of the Green Building Council of Indonesia (GBCI).

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