

## DESIGN OF ENVIRONMENTAL FRIENDLY BUILDING BASED ON THE LOCAL WISDOM PHILOSOPHY OF SUMATERA TRADITIONAL HOUSE

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### Graphical design



### Abstract

This study aims to recommend a design of environmental friendly building based on the local wisdom philosophy of the Sumatera traditional house. The house is a combination between modern and traditional house of Sumatera which is a stilt house. The basement of the house is designed as rainwater storage in order to guarantee the availability of household water supply. On the other hand, the upper part of the house is designed as a dwelling. Simulation is undertaken in order to investigate the water volume behavior in the storage due to the variation of rainfall and water uses in the house. The simulation is applied in a house with a roof area of 54 m<sup>2</sup>, 4 residents, and 24 m<sup>3</sup> of storage capacity. Daily rainfall data are obtained from the rainfall station in Bandar Lampung, Indonesia. The result of the simulation indicates that rainwater facility in the house is relatively effective to store rain water and to provide household water supply. For wet year periods, the system is able to supply about 80% to 90% of the total needs. Oppositely, in the dry seasons, the system can support the household water demand up to 60% of total needs.

**Keywords:** Environmental friendly building; local wisdom; traditional house of Sumatera

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## 1.0 INTRODUCTION

The availability of clean water is one of the most talked about issue in the world. Although water is a basic requirement for human life, there are millions of people in many countries which have not been able to access clean water though for the most minimum requirements until now. Such cases usually occur in third world countries or developing countries.

On the other hand, it has been known that in some countries rainwater harvesting can increase people's access to clean water. Rainwater is one of the natural resources that can be renewed and it is suitable to be used as an alternative source of domestic water in the household scale. In a household scale, rainwater harvesting is an easy and inexpensive way to get clean water [1]. Since the beginning of the 20<sup>th</sup> century, rainwater harvesting for domestic water supply has become a popular method in the countries of Africa, Asia, and Latin America [2][3]. The

implementation of rainwater harvesting in these countries varies in kinds, from rainwater harvesting through the roof to the rainwater harvesting to create large reservoirs [4].

Indonesia is a tropical country where the conditions vary from one place to another. East Monsoon winds cause the dry summer months (June to September), while the West Monsoon winds cause wet months with a respectable rainfall (December to March). Rain can occur throughout the year in Indonesia. The temperature of the air with high humidity is also common in Indonesia, especially in coastal areas [5]. Since Indonesia is located around the equator, Indonesia often gets heavy rain, high humidity, high temperature, and calm wind speed. In the rainy season, the lower areas in Indonesia have received an average rainfall of 1,800 mm to 3,200 annually. For the upland areas, rainfall can reach 6,100 mm per year. Especially for the lowlands in Sumatra and Kalimantan,

the average annual rainfall ranges from 3,050 to 3,700 mm [6].

Currently there are approximately 220 million people living in around 11,000 islands in Indonesia. These communities have access to clean water in various ways. The ways are influenced by distance and geographical factors where they are living. Unfortunately, rainwater harvesting has not been massively done in Indonesia. Though Indonesia has adequate rainfall potential to be used [7], the use of rainwater harvesting in Indonesia is only around 2.3% of total Indonesian people.

## 2.0 PROBLEM IDENTIFICATION

Traditional houses in Sumatra, which are often called the *Rumah Panggung* are wooden stilt houses with roofs made from woven reeds. Sumatran people usually build the houses lined up the highway and facing each other, separated by a highway. Due to the geographical conditions and the state of Sumatra as earthquake-prone nature, the traditional houses are made from woods in order to be more robust during the earthquake, and designed on stilts in order to avoid the attacks of wild animals and the flood.

Currently, less people are using the construction of traditional houses due to the modernization era. Nowadays, most Sumatran people make houses using cement and brick materials like other modern houses. In addition, the wooden stilt houses are rarely used by the Sumatran people due to its difficulty in finding good woods and the high price of woods. Efforts to restore the glory of the traditional house of Sumatra have been carried out. But these efforts merely mimic the architecture of houses and not to explore the benefits of local wisdom contained.

This study aims to recommend an environmentally friendly house design that has the characteristics of a Sumatran traditional house. In this house design, part of the house at the bottom of the *Rumah Panggung* is used as rainwater storage (rainwater harvesting) to ensure the availability of water in the house and to reduce the risk of flooding in the region and reduce the risk of home against flood water level.

## 3.0 RAINWATER HARVESTING

Rainwater harvesting is the effort to collect rain water to be used as an alternative source of clean water. Rainwater harvesting is growing rapidly in arid or semi-arid countries. Historically, rainwater harvesting systems have been developed since 2,000 BC in ancient Roman times. In this era, some reservoirs have been constructed to collect rain water for domestic use in urban areas. In Africa, efforts to harvest rain water have been carried out since 2,000 years ago by the people of Egypt. They built reservoirs with size between 200 – 2,000 m<sup>3</sup> to collect rain water. In Istanbul, Turkey, rain water storage ponds in size of 140

m x 170 m with a capacity about 80,000 m<sup>3</sup>, was built in the 6<sup>th</sup> century BC [8]. In India, rainwater harvesting for supplying various needs of water have also been known since about the 3<sup>rd</sup> century BC. In this country the largest rainwater storage called Viranam, a pitcher with a length of 16 km with a capacity of 41.5 million m<sup>3</sup>, has been built around the 12<sup>th</sup> century BC [9]. In modern times, rainwater harvesting for various purposes has been applied in almost all over the world. Rainwater harvesting is not only important to meet the needs of fresh water in dry and salty areas, but can also imply to save water resources such as groundwater from over-exploitation. Figure 1 shows a set of facilities for rainwater harvesting, which are typically used. The facilities are:

1. Catchment area: an area to catch the rainwater that falls. The catchment area is the roof of the house.
2. Conveyance: a facility consists of a channel and pipe for conveying rainwater from the roof into the storage tank.
3. Filter: a facility for filtering out impurities contained in the collected rainwater.
4. Storage: a tank for collecting filtered rainwater. The storage can be on the surface or underground.
5. Delivery System: a facility for distributing rainwater from the storage into the house to be used for various purposes.

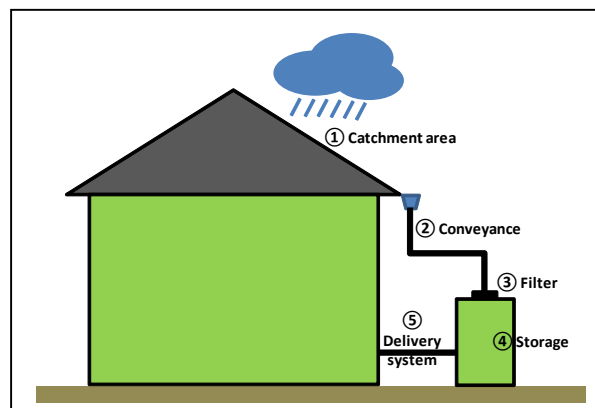


Figure 1 Standard facility for rainwater harvesting

The rainwater harvesting system should be designed well, therefore it can meet the water demand during the rainy season and dry season for the household. Rainwater catchment system or the roof area of the building should ideally be large enough to be able to catch the rain water as efficiently as possible. Furthermore, rain water storage tank should also be planned efficiently in accordance with the roof area and the amount of rainfall that falls.

#### 4.0 SUPPORTING CAPACITY OF RAINWATER HARVESTING

Rainwater harvesting supporting capacity as an alternative source of clean water in the household scale in this study was calculated using the philosophy of water balance models [10]. The calculations in this model were done to investigate the behavior of the volume of water in reservoirs that fluctuate due to changes in inflow and outflow [11]. The equation for the simulation of water balance in the catchment is presented as follows [12]:

$$S_t = S_{t-1} + I_t - O_t \quad (1)$$

$$\text{Whereas } 0 < S_t < S_{max} \quad (2)$$

$S_t$  = storage volume on day  $t$  ( $m^3$ )  
 $S_{t-1}$  = storage volume on day  $t-1$  ( $m^3$ )  
 $I_t$  = total inflow on day  $t$  ( $m^3$ )  
 $O_t$  = total outflow on day  $t$  ( $m^3$ )  
 $S_{max}$  = maximum storage capacity ( $m^3$ )

The maximum storage capacity is a constant and does not change from the beginning to the end of the simulation.  $S_{t-1}$  at the beginning of the simulation assumed to be 0. If  $S_t$  exceeds the maximum storage capacity ( $S_{max}$ ), the excess water will overflow out of the tank. In this condition, the situation in the reservoirs is:

$$S_t = S_{max} \quad (3)$$

Total inflow for day  $t$  is calculated using the formula follows:

$$I_t = c \cdot R_t \cdot A \cdot 1000 \quad (4)$$

Where:

$c$  = runoff coefficient for roofs is assumed to be ranged 0.8 – 1.0 [13] due to evaporation and infiltration on the surface area.  
 $R_t$  = rainfall on day  $t$  (mm)  
 $A$  = catchment or roof area ( $m^2$ ).

Total outflow for day  $t$  is calculated using the formula follows:

$$O_t = nD \quad (5)$$

Where:

$n$  = number of family members  
 $D$  = water demand per person per day

Total water demand per person per day is assumed to be 70 liters per day per capita. This value is taken based on field studies conducted in several places on the Java Island [14]. Other research states that the requirement of water per person per day in Indonesia ranged from 60 to 70 liters per day per capita, with details as follows [15-17]:

- 5 liters for drinking and cooking purposes
- 25 – 30 liters for personal sanitation
- 25 – 30 liters for laundry
- 4 – 6 liters for cleaning of sanitary facilities.

#### 5.0 HOUSE STRUCTURE DESIGN

The house design obtained from this study is basically a modern minimalist house which contains local wisdom philosophy of a traditional house of Sumatran people. On the other word, this house is design with concept of Sumatran people traditional houses. A sample house was taken with the size of 54m<sup>2</sup> with 4-5 inhabitants. This house was made like Sumatran traditional houses which has elevated floor and has stair in the right side of the house. As an alternative, the stair can be built in the front of the house. This house is designed to have 3 bedrooms, 1 living room, 1 family room, 1 kitchen, and 2 bathrooms. The design of the house is supported by columns with a size of 30cm x 30cm with a height of 2 meters under the house. The storage of rainwater is developed in the first floor.

One of the advantages of *Rumah Panggung* design is that it usually has some space that can be used for many purposes. Therefore, in this design the space can be used as a garage. Typically, in a residential area, it is hard to find a parking space. Therefore the vehicles have to be parked on the roadside which only has a width of 3-4 meters. Hence, the concept of *Rumah Panggung* also intended to acquire space that can be used as a parking lot or garage. Another advantage of this house is that there is a space to be a water reservoir that will deposit rainwater that usually wasted away to drain channel and unutilized. In this house design the reservoir is made with a width of 1 meter, 2 meters high, and 12 meters long, with L-shaped around the sides and back of the house. With those dimensions, the total water that can be accommodated is 24 m<sup>3</sup>. The reservoir is completed with manhole which serves as the entrance into the reservoir for cleaning and maintenance. Collected rainwater can be used to meet the needs of domestic water for the residents of the house. The pump is used to deliver water to another tank in this tower for distribution purpose.

#### 6.0 RESULTS OF RAINWATER HARVESTING SIMULATION

The location of this study was in Bandar Lampung City, Lampung Province. Figure 2 shows the fluctuations of daily rainfall from 2004 to 2006 came from a rainfall station Sukarame Bandar Lampung, which is used in the simulation of rain harvesting in house designed. Daily rainfall at the station ranged from 0 to 150 mm with an average annual number of rainy days 106 days of rain. Rainfall in 2004, 2005, and 2006

respectively is 2,861.8 mm, 2,467.0 mm and 1,965.0 mm.

Based on the equation (1) to the equation (4), daily rainfall was applied to the simulation of rainwater with the following conditions:

- The runoff coefficient for the roof ( $c$ ) = 0.85
- Catchment area or roof area ( $A$ ) = 54 m<sup>2</sup>
- The number of members in the house ( $n$ ) = 5
- Total water demand per person per day ( $D$ ) = 70 liters per person per day
- The maximum bin capacity = 24 m<sup>3</sup>

Figure 3 shows the simulation results in the form of the behavior of water in the catchment volume fluctuations. With the data that has been previously

set, obtained a maximum storage volume of 24 m<sup>3</sup>. From the simulation, the annual conditions are known as follows:

- In 2004 there were 305 days from 366 days (83.6%) where water demand can be supplied from rainwater
- In 2005 there were 332 days from 365 days (91%) where water demand can be supplied from rainwater
- In 2006 there were 218 days from 365 days (59.7%) where water demand can be supplied from rainwater.

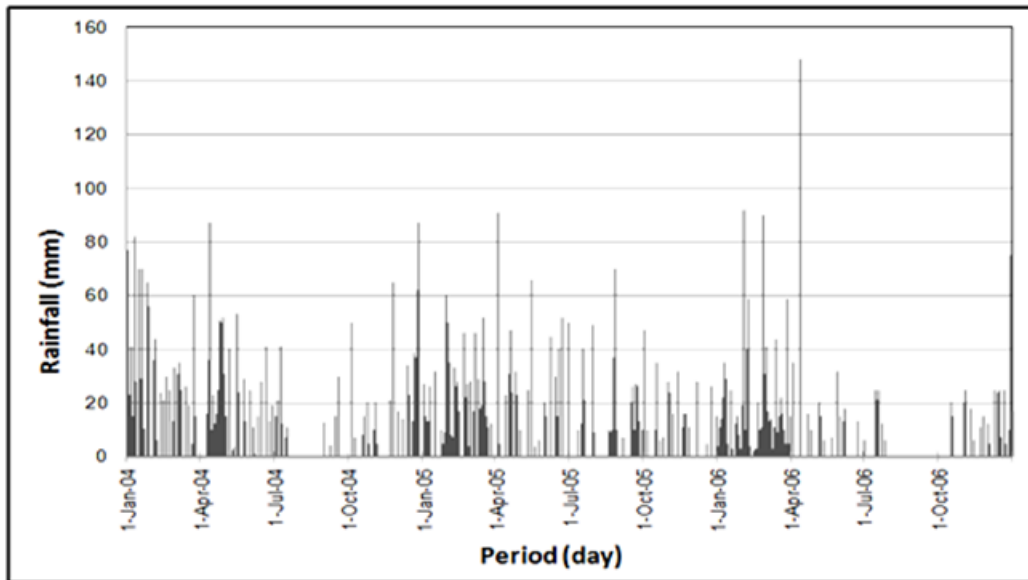


Figure 2 Daily rainfall fluctuation in year 2004 to 2006 derived from Sukarame Bandar Lampung rain station

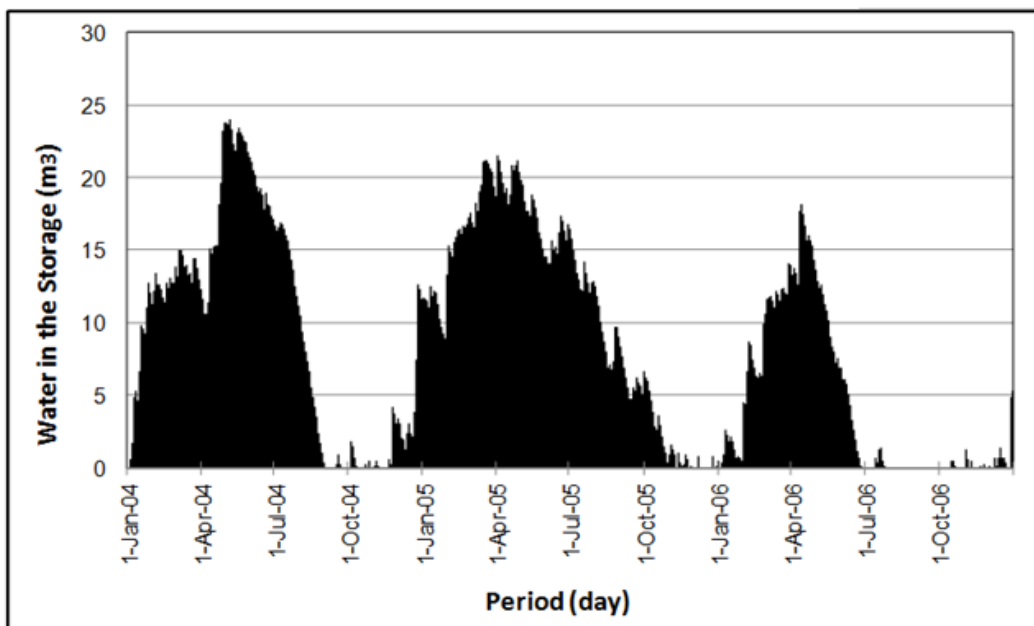


Figure 3 Water volume fluctuation in the storage tank based on simulation

## 7.0 BENEFITS AND POSSIBILITY OF IMPLEMENTATION

There are several advantages that would potentially be obtained by applying the proposed house design in this study. The advantages are:

### 1. Reducing the exploitation of ground water

With the rainwater harvesting system installed at home, household water supply will be supplied mostly from rainwater. Thus the household water supply from wells or groundwater will decrease significantly. This condition will help recharge of groundwater, increase the water table, and may indirectly prevent seawater intrusion.

### 2. Reducing the risk of regional flooding

At this time a lot of flooding happen if an area is experiencing torrential rains. This happen because of water pouring down rain directly flowing to drainage through the roof of the house and yard that has been covered with cement. Water is flowing without the process of absorption into the soil (infiltration) and potentially lead to flooding. The house designed in this study has ability to collect some rain water which is usually directly over flow to drainage. Due to this condition, the surface runoff can be reduced and the regional flood risk can be minimized.

### 3. Reducing the risk of flooding in residences

Other advantage found in the home with the concept of *Rumah Panggung* is the reduction of the risk of flood inside the house. The dwelling area of the house is located 2 meters from the ground. Such condition will avoid the area from the flood water level. Inhabitants and valuable material will be protected from the flood.

### 4. Adding residential building area

Construction of house design in this study allows the increase in residential building area to nearly two fold of the size of the non-stage house. The dwelling area will be the second floor. On the other hand, the first floor of the building can be used as a garage, leisure room, or a small shop.

### 5. Promote local wisdom

The house design produced by this study is the design based on local wisdom philosophy of Sumatran traditional house. Thus, if the house can be applied widely, local wisdom of Sumatera traditional house can be maintained and sustainable.

## 8.0 SUMMARY AND CONCLUSIONS

Research on environmental friendly building design based on local wisdom of Sumatran people custom have been completed. This study concluded that:

1. The house design resulted in this study is a modern house containing philosophy of Sumatera's traditional house.
2. The house designed in this study is a stilt house with size of 54 m<sup>2</sup>, and designed for 4-5 members of family.

3. Rainwater harvesting system at house designed in this study is directed to be an alternative source of household water supply. Based on the simulations, in wet years, the rain water harvesting system is capable for supplying approximately 80% to 90% of annual domestic water demand. In contrast, for the dry years, the rain water harvesting system is capable for supplying approximately 60% of annual domestic water demand.
4. The benefits of the house designed in this study are to reduce the excessive exploitation of ground water, to reduce the risk of regional flooding, to reduce the risk of flooding in residences, to increase the area of residential buildings, and to promote local wisdom of Sumatra people.

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## APPENDIX

### Appendix 1 Illustration of the building

