Experience in Rainwater Harvesting Application at Household Scale in Bandar Lampung, Indonesia

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ABSTRACT

Indonesia is a country that has large rain water availability. However, the implementation of rainwater harvesting in urban areas has not become a popular activity in Indonesia. Instead of the ignorance of the public about the importance of rainwater harvesting as an alternative source of freshwater, information and knowledge about the construction of the installation of rainwater harvesting systems is still very limited. This paper aims to analyze supporting capacity of rainwater harvesting for domestic needs in Bandar Lampung city, Indonesia. This paper also aims to introduce a real experience in rainwater harvesting at household scale in the city. Rainwater harvesting simulation is applied to a family with a roof area of 70 m^2 with number of family members 5 persons and maximum storage capacity 1.2 m^3. Daily rainfall data used in the simulation is obtained from Bandar Lampung Raingauge Station with period of data from 1992 to 1996. The simulation shows that supporting capacity of rainwater harvesting in the area of study is about 53% and 42% for wet year and dry year, respectively. Experience also shows that knowledge about the operation and maintenance of rainwater harvesting facility is important in the application of rainwater harvesting at household scale.

KEYWORDS

Rainwater harvesting application; Household scale; Bandar Lampung

INTRODUCTION

There are three basic problems associated with the condition of the water on Earth. Sometimes the water is too much, too little, or too dirty. These three problems are source of difficulty for most people of the world in using and controlling water. Rainwater harvesting is an alternative source of water supply that has been practiced for centuries in various countries which often experience water shortages such as South Asia countries and some parts of Africa. In these countries, rainwater is harvested for domestic and irrigation water purposes. In some places rainwater harvesting is also used to provide water for consumption. Nowadays, rainwater harvesting is frequently used in the developed countries with purposed of ground water conservation and economizing financial budget for water consumption (Domenech and Sauri, 2011; Basinger et al., 2010). Many cities in Western Europe, Japan, and Korea have utilized rainwater as freshwater source for sanitation use (Villareal et al., 2005).

Indonesia is a country that has large rain water availability, which is about 2,500 mm to 3,500 mm per year. In some areas in eastern Indonesia this amount may be slightly reduced due to geographical location and climate. Overall, Indonesia is a country with huge potential for rainwater utilization. However, in Indonesia, the implementation of rainwater harvesting in urban areas has not become a popular activity. Instead of the ignorance of the public about the importance of rainwater harvesting as an alternative source of freshwater, information and knowledge about the construction of the installation of rainwater harvesting systems for a variety of scales including household level is still very limited. Local governments usually do not put the utilization of rainwater as an alternative water supply both for domestic water and water for other uses such as water for gardening and for firefighters.

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This paper aims to analyze supporting capacity of rainwater harvesting for domestic needs in medium-sized cities in Indonesia. The principle of water balance was used in rainwater harvesting simulations involving the availability of rain water, domestic water needs and the volume of rainwater. The scale of rainwater harvesting application in this study is the rainwater harvesting at household scale. Medium-sized city used as the subject of simulation is the City of Bandar Lampung. This paper also aims to introduce a real experience in rainwater harvesting in household scale in the city.

METHODOLOGY

a. Study location

Bandar Lampung is a district in Lampung Province, Indonesia. It is the capital of the province and a medium city if compared to the other cities in Indonesia. This city is also called the gate of Sumatera due to its geographic position. Facing the Gulf of Lampung, Bandar Lampung is the city in Sumatera which is located closest to Jakarta. With area of population of about 1.5 million, Bandar Lampung is a center of services and trading of Lampung Province (BPS, 2013). Like other cities in Indonesia, Bandar Lampung faces problems in water availability in the future. Sources of freshwater are continuously reduced year by year due to the development of residential areas. On the other hand, the increase in population and industry needs huge amount consumption of water. To cope with this problem, the city government has promoted several methods with purpose to conserve surface water and groundwater in the city. The application of biopory is one of the program undertaken in Bandar Lampung. However, rainwater harvesting for direct use as domestic water or sanitation water never been undertaken or recorded in this area. The location of the application rainwater harvesting for household scale is in a house located in the Natar, a village in Southern Lampung, which is a suburb of Bandar Lampung City.

Figure 1. The location of the application rainwater harvesting at household scale

b. Supporting capacity of rainwater harvesting

Before the installation is applied, the supporting capacity of rainwater harvesting to the water need in the household must be calculated. To predict supporting capacity of rainwater harvesting in this study, simulation using the philosophy of water balance models is employed (Khastagir and Jayasuriya, 2010). 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 (Kahinda et al., 2010). The equation for the simulation of water balance in the catchment is presented as follows (Susilo et al., 2011):

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

$$\text{Where } \; 0 < S_t < S_{max} \qquad (2)$$

Other notations are defined as:

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)

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The maximum storage capacity (S_{max}) is a dimension of storage tank. It is a constant and has never been changed from the beginning to the end of the simulation. S_{t-1} at the beginning of the simulation assumed to be 0 (tank is empty). If S_t exceeds the maximum storage capacity (S_{max}), the excess water will overflow out of the tank. The volume of water in the tank/reservoir at this time is:

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

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

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

Where:

c = runoff coefficient for roofs is assumed to be ranged 0.8 – 1.0 (Fewkes, 1999) due to evaporation and infiltration on the surface area.

R_t = cummulative rainfall on day t (mm)

A = catchment or roof area (m^2).

Total outflow for day t (O_t) as a function of number of family members in the house and water demand per person per day 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 (Washilatur, 2008). Other research found that demand of water per person per day in Indonesia is about 60 to 70 liters, with details as follows (Wulan, 2005):

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

c. Rainwater harvesting system

The system of rainwater harvesting installation applied in the research consists of six components as follows:

1. Roof as catchment area for the rainfall. In this research the effective area of the roof used for collecting rainfall is about 70 m^3. The roof was a combination of asbestos and clay.
2. Gutter as collector of rainwater caught by the roof. The length of the gutter used in this research is about 14 m.
3. Conveyance pipe for sending rainwater collected by the gutter into the rainwater tank. There are one horizontal and two vertical conveyance pipes with diameter of 3 inches. The length of the horizontal and two vertical conveyance pipes are 1 m, 0.5 m, and 1 m, rerspectively.
4. Filter for removing debris from the rainwater. Filter used in this research is the filter usually used for tea filter.
5. Rainwater tank for storing harvested rainwater. The tank is fiberglass tank with maximum capacity of 1.3 m^3. The tank has drainage valve in the bottom, drainage hole in the top, and manhole in the top. Due to the drainage purpose, the effective capacity of the tank is only about 1.2 m^3.
6. Pumping system for regulating the transportation of water in the tank. The pumping system consists of two pumps illustrated in Figure 2. The first pump is called the consumption pump. The pump takes the water from the tank and send it into the consumer of water, which can be bath room or washing machine. The other pump is emergency supply pump. This pump is connected to groundwater pit, takes water from the pit, and supplies rainwater tank if there is no rainwater stock due to long dry season and no rain. If rain happened and rainwater tank is not empty, the pump stops supllying water to the tank and serve only for other storages. By using this kind of system, rainwater tanks can be supplied by hybrid sources of water, groundwater and rainwater.

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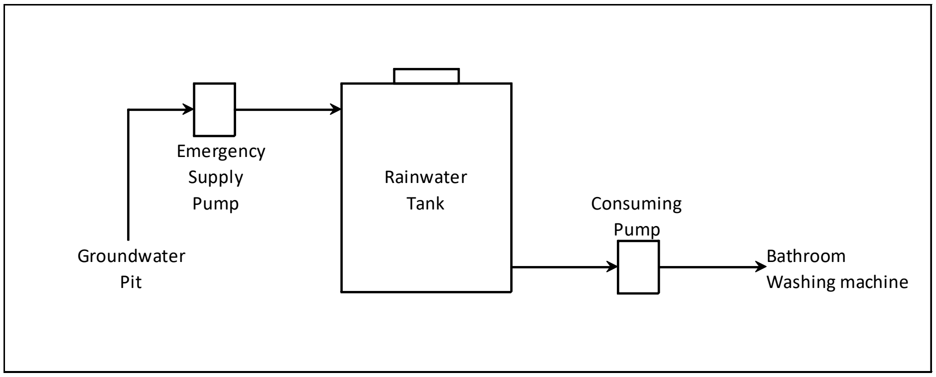

Figure 2. The scheme of pumping system in the rainwater harvesting installation.

RESULTS

a. Simulation results

Rainwater harvesting simulation is applied to a family with a roof area of 70 m^2 with number of family members of 5 persons and maximum storage capacity of 1.2 m^3. Daily rainfall data used in the simulation is obtained from Bandar Lampung Raingauge Station with period of data from 1992 to 1996. The characteristic of the daily rainfall is illustrated below:

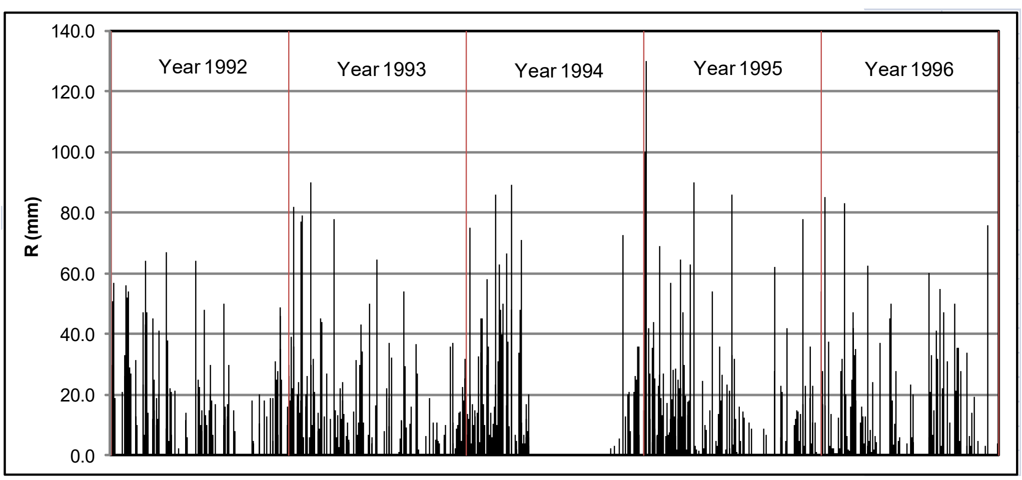

Figure 3. The characteristic of the daily rainfall.

The simulation results indicating supporting capacity of rainwater harvesting in the study area is given in the table below:

Table 1. Supporting capacity of rainwater harvesting in the study area.

Year	Supported days	Non-Supported days	Total Number of day in a year	Percentage
1992	185	181	366	50.5%
1993	194	171	365	53.2%
1994	141	224	365	38.6%
1995	202	163	365	55.3%
1996	165	201	366	45.1%

Source: Calculation

The supported days mean the days of the year that their domestic water needs can be substituted by rainwater. Inversely, the non-supported days mean the days of the year that their domestic water needs

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can not be substitute by rainwater and has to be supplied by pit water or other sources. The table also shows that supporting capacity of rainwater harvesting in the area of study is about 53% and 42% for wet year (year with rain greater than annual average rain) and dry year (year with rain less than annual average rain). In this study, the wet year are the year of 1992, 1993, and 1995. On the other hand, the dry year are the year of 1994 and 1995. In graphical illustration, the supporting capacity of rainwater harvesting in study area is given as:

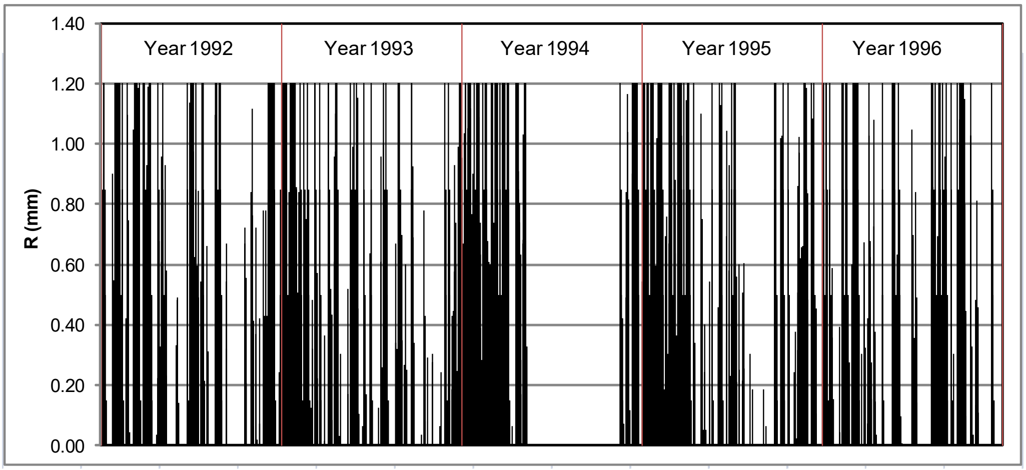

Figure 4. The the supporting capacity of rainwater harvesting in study area.

b. The facility

Below is some components used in the rainwater harvesting facility in the research:

Figure 5. Catchment area (roof), gutter, and conveyance pipe

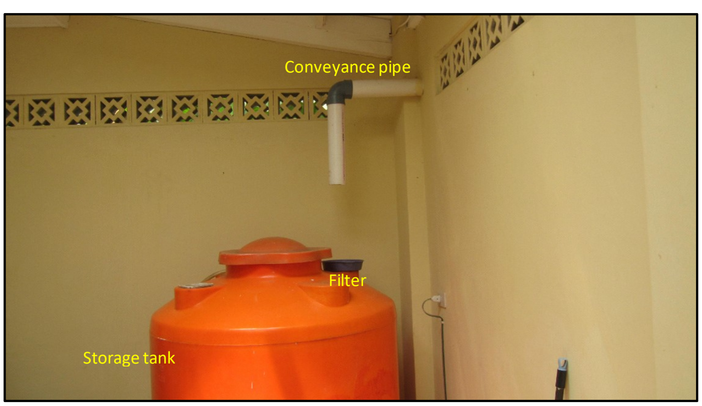

Figure 7. Storage tank, filter, and conveyance pipe

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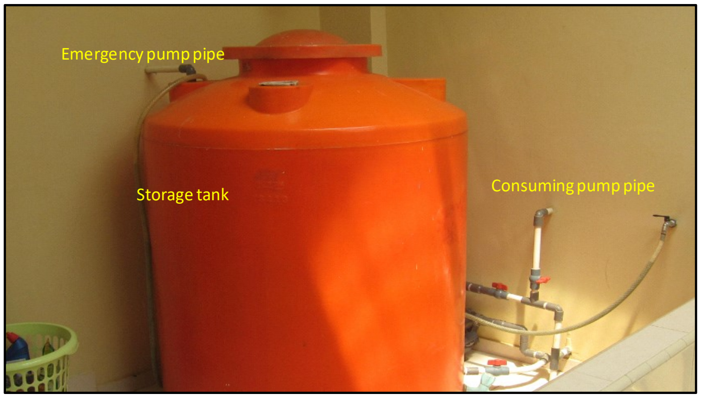

Figure 7. Storage tank, emergency pump pipe, and consuming pump pipe

c. The application

The applications of rainwater harvesting is undertaken with purpose to find an alternative freshwater source for replacing groundwater in providing domestic water needs such as water for washing, bathing, and sanitation. Some important information have been found during the application, such as:

- Quantity of rainwater

  The simulation shows that the maximum tank capacity used in this study is not the most effective size to result in the biggest efficiency of rainwater harvesting capacity. Using 1.2 m^3 of water tank is only resulting in harvesting capacity of averagely 53% and 42% for wet year and dry year, respectively. This condition means there are still too much water drained to the sewerage due to overflowing in the storage tank. The relationship between storage capacity and supporting capacity of rainwater harvesting in study area is given below:

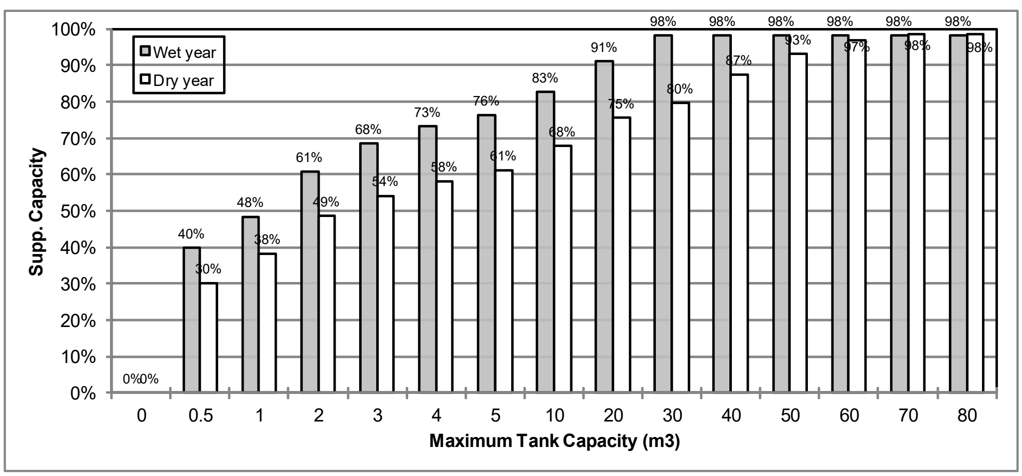

Figure 8. The relationship between storage capacity and supporting capacity of rainwater harvesting in study area.

  The graph shows that maximum supporting capacity of rainwater harvesting in study area is 98% for both wet and dry year. This capacity is reached when the maximum tank capacity is setting into 70 m^3. This tank capacity, definetely, will spend expensive cost for a household. Therefore, for ordinary household, maximum tank capacity of less than 5 m^3 is the most suggested.

- Physical quality of rainwater

  Some studies recommended rainwater in Indonesia as a water with good quality. However, physically rainwater harvested has high turbidity and specific smell due to the characteritics of the roof as the cacthment area. When the first rain comes, it will first sweep all debris and

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dust in the surface of roof. Although the debris will be filtered in the conveyance pipe, only some of them can be filtered. Some dust can not be filtered and goes to rainwater tank. The water in the tank will be turbid and rather smell. To cope with problem, it is necessary to add nylon filter for 0.1 micron particle for filtering debris and carbon active filter for removing the smell. Both types of filter can be found easily in the market. To remove hazardous microorganizm from the water, antiseptic liquid can be applied to the rainwater collected with proper dosage.

- Operation
  The rainwater harvesting facility is operating mostly in the wet season. In the wet season the facility collects rainwater and supplies it to the consumers. In the dry season, the facility only supply water from the to the consumers. When the tank is empty, the tank has to be filled with water from pit or other source. Therefore the operation of the facility is continued. If the facility is not operated using hybrid source, the operation facility will be intermitten and potentially damages the components in it.
- Maintenance
  Experience shows that the roof, gutter, and conveyance pipe are the most sensitive components affecting the operation of rainwater harvesting. When the location of roof is closed to the trees, dry leaves will be fallen and collected on the roof and gutter. The accumulation of these materials will be brought by rainwater and clogg the conveyance pipe. When this condition happened, the operation of rainwater harvesting will be terminated. No water will come to the tank and excess water will overflows through the gutter and potentially damages the gutter. To avoid the clogging in the conveyance pipe, gutter cleaning is necessary to do. The period of cleaning can be once in a month for wet season, and twice in a month for dry season. Dry season need more cleaning because dry leaves is more collected is more in this season. Cleaning for the storage tank is also necessary. Cleaning the tank by flowing through the drainage pipe in the bottom of the tank can be undertaken once in two months. The maintenance for pumping system is undertaken when there is any trouble in the operational. Otherwise, maintenance for pumping system is not necessary to do as long the system is working well.
- Utility
  Rainwater collected can be utilized for various water needs. Most people used rainfall for sanitation purpose such as flushing toilet and for bathing. However, in emergency condition, rainwater can also be used for drinking water after certain treatments. In some coastal and swamp areas in Indonesia, consuming rainwater as drinking water is acommon task. This is because in those areas rainwater is the best quality freshwater if compared to the ones obtained from various sources.

CONCLUSIONS

Benefits of rainwater harvesting has been clearly known by many people in Indonesia. But the application of rainwater harvesting as an alternative provider of fresh water in Indonesia is still rare. Most of the Indonesian people might think that the rain water is dirty water or second-class water inappropriate for use in everyday life. Theory and experience show that the application of rainwater harvesting at household scale can provide many benefits to the conservation of groundwater and further can provide economic benefits. Rain water from rainwater harvesting has also been widely demonstrated can be used for various purposes such as sanitation and even for drinking water. Experience also shows that knowledge about the operation and maintenance of rainwater harvesting facility is important in the application of rainwater harvesting at household.

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REFERENCES

BPS, 2013. *Bandar Lampung dalam Angka (Bandar Lampung in Number)*. Biro Pusat Statistik Bandar Lampung.

Fewkes, A., 1999. The use of rainwater for WC flushing: the field testing of a collection system. *Building and Environment*, 34(6), 765–772.

Kahinda, J.M., Taigbenu, A.E. and Boroto, R.J., 2010. Domestic rainwater harvesting as an adaptation measure to climate change in South Africa. *Physics and Chemistry of the Earth,* 32(15-18), 1050–1057.

Khastagir, A. and Jayasuriya, N, 2010. Optimal sizing of rain water tanks for domestic water conservation. *Journal of Hydrology*, 381(3–4), 181–188

Susilo, G.E., Yamamoto, K. and Imai, T. 2011. The Identification of Rainwater Harvesting Potency in Supporting Freshwater Availability under the Effect of El Nino. Proceeding IWA – ASPIRE International Conference, October 2011, Tokyo – Japan.

Washilatur, R., 2008. *Pola konsumsi air untuk kebutuhan domestik di Sukoharjo bagian Utara (Domestic Water Consumption Pattern in Northern Sukoharjo)*. BSc thesis, Physical Geography Departement, Universitas Muhammadiyah Surakarta, Indonesia.

Wulan, A.I.S., 2005. *Kualitas air bersih untuk pemenuhan kebutuhan rumah tangga di Desa Pesarean Kecamatan Adiwerna Kabupaten Tegal (Evaluation of water quality for domestic water use in Pesarean Village, Adiwerna – Tegal).* B.Sc thesis, Geography Departement, Universitas Negeri Semarang, Indonesia.

Domènech, L. and Saurí, D. 2011. A comparative appraisal of the use of rainwater harvesting in single and ultifamily buildings of the Metropolitan Area of Barcelona (Spain): social experience, drinking water savings and economic costs. *Journal of Cleaner Production*, 19 pp. 598 – 608.

Matt Basinger, M., Montalto, F. and Lall., U. 2010. A rainwater harvesting system reliability model based on nonparametric stochastic rainfall generator. *Journal of Hydrology*, 392 pp 105–118.

Villarreal, E.L. and Andrew Dixon, A. 2005. Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrkoping, Sweden. *Building and Environment*, 40 pp. 1174–1184.

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