Communal Based Flood Mitigation Measures in Bandung City

Elisabeth Rianawati

Resilience Development Initiative, Bandung, Indonesia

Saut Sagala

Institute of Technology Bandung, Bandung Indonesia

Working Paper Series

No. 10 | July 2014

`

WP No : 10

Date : July, 2014

ISSN : 2406 - 7865

Communal Based Flood Mitigation Measures in Bandung City

Elisabeth Rianawati[1] and Saut Sagala[2]

[1]*Resilience Development Initiative, Bandung, Indonesia*

[2]*School of Architecture and Policy Development, Institute of Technology Bandung, Indonesia*

Contact:

Alamat: Jalan Imperial II No. 52, Bandung 40135
Jawa Barat – INDONESIA
Telepon: +62 22 2536574
Email: rdi@rdi.or.id
Website: www.rdi.or.id

`

CONTENTS

`

Disclaimer:

This article presents the draft of original article entitled *"Can Municipal Biophore Program Reduce The Urban Floods? Case Study: Bandung City"* that was presented by authors at 7th ASEAN Environmental Engineering Conference, Palawan 21-22 November 2014

`

Communal Based Flood Mitigation Measures in Bandung City

Elisabeth Rianawati[1] and Saut Sagala[2]

[1]*Resilience Development Initiative, Bandung, Indonesia*

[2]*School of Architecture and Policy Development, Institute of Technology Bandung, Indonesia*

Email: elisabeth.rianawati@rdi.or.id

Abstract

Bandung, the capital of West Java province, is a home to 3.1 million people with density of 16,500/km^2, which put a considerable stress towards the natural resources. The most prominent stress was the conversion of the catchment area of Citarum River into commercial and residential areas. The catchment area, which is located in northern part of Bandung, has lost most of the forest and agriculture areas, leaving only 25% of its 30.000 hectares. The regular rain leads into flooding in city and subsequently the downstream area, which is in the southern part of Bandung. The result is disastrous: transportation paralyzed, housing becomes inundated on regular basis and industrial activities which are located most in southern part were inhibited. The overwhelming flood occurs because 95% of the rainwater cannot be absorbed in the catchment area. This also resulted in the dry up of water springs. Consequently, in the year 2000, Bandung faced a fresh-water deficit and cannot barely supply the water demand of its 3 million residents. Immediate action by Bandung Local Government is by providing Biophore Programs in 2013 arguing that water can infiltrate, run-off diminishes and thus floods will be reduced. This paper main question is to ask the effectiveness of such programs in reducing urban flood. This paper argues that there is limited open space available cause the Biophore Program and thus should be coupled with rainwater harvesting at household levels in order to achieve effective results. The proposed method is now under development of Bandung government to mitigate urban flood. In this paper, the application of the technology in Bandung city is described as well as its application in the household scale. This paper concluded that a small investment in household scale could prevent upsetting but yet avoidable disaster such as urban floods.

Keywords: *urban flood, catchment area, rainwater harvest, biophore, Bandung*

1. Introduction

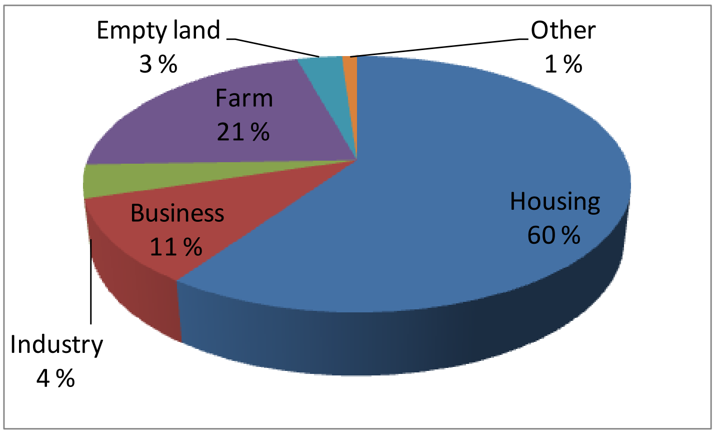
In some areas of Indonesia, floodings are one of the impacts of land use change. In Jabodetabek area, land use change in the upstream region of Bogor, Puncak and Cianjur (Bopuncur) has led to the increase of run-off to the downstream section to Jakarta (Sagala et al 2013a). Similarly, Sagala et al (2013b) observed in Palembang that wetlands conversion to drylands had caused annual inundation in the residences area.

Bandung is part of the Bandung Metropolitan Area (BMA) which experienced significant growth in the last 10 years (Word, 2008). The particularly rapid growth was its economic growth between 2000-2009 with the value of GDP reached USD 70.281.163 (Profile City of Bandung, 2011). As the result, Bandung became the destination of urbanization and thus, making it as the 3rd largest city in Indonesia. Now, it is a home for 3.1 million people with density of 16,500 people /km^2.

This phenomenon put a considerable stress towards the natural resources. The most prominent stress is the conversion of the catchment area of Citarum River into commercial and residential areas. The catchment area, which is located in northern part of Bandung, has lost most of the forest and agriculture areas, leaving only 25% of its 30.000 hectares. This is due the poor and uncontrollable licensing system of residential developers who were eager to produce the highest rents (Firman, 2008). The residential area in northern part of Bandung is highly desirable due to its cool mountainous air and natural environment. This area was expended as hotels, restaurants and exclusive residential area, whereas the southern part was used as industrial area and common housing area (Kepala Bidang Perencanaan Distarcip, 2013).

`

From 1990 to 2008, the built up area in the city of Bandung had covered more than 50%, which comprised most of residential area and commercial purposes (Figure 1). This resulted to the paving of the catchment areas and thus 95% of the rainwater cannot be absorbed in the catchment area. Consequently common rain events could lead into flooding in city and subsequently the downstream area, which is in the southern part of Bandung. The incidents were famously known as *banjir cileuncang*. The term derived from local language that depicted the pools of water that were created because of drainage failure to discharge run off (DBMP Drainage Planning Report, 2012). The result is disastrous: paralyzed transportation, housing becomes inundated on a regular basis and industrial activities are located in southern most part were inhibited.



Source: Tarigan et.al, *draft*
Figure 1. Land use of Bandung

Consequently, in the year 2000, Bandung faced a fresh-water deficit and cannot barely supply the water demand of its 3 million residents. Bandung itself also went into the red zone with declining ground water conditions.

Immediate action by Bandung Local Government was by providing Biophore Programs in 2013 arguing that water could infiltrate and run-off would diminishes and thus floods will be reduced. Biopore was initiated by Dr. Kamir R Brata, (www.biopore.com) one of the researchers from Bogor Agricultural University. The objective is to improve the capacity of soil in absorbing water and hopefully reducing water inundation during rain event. The water absorption of the soil will be improved by making a hole in the ground and filling it with organic waste to produce compost. The waste in the hole feeds the soil fauna, which is capable of creating pores in the soil and thus increasing the absorption capacity (Fig 2). This simple technology is then called by the name *biopore* or biopore.

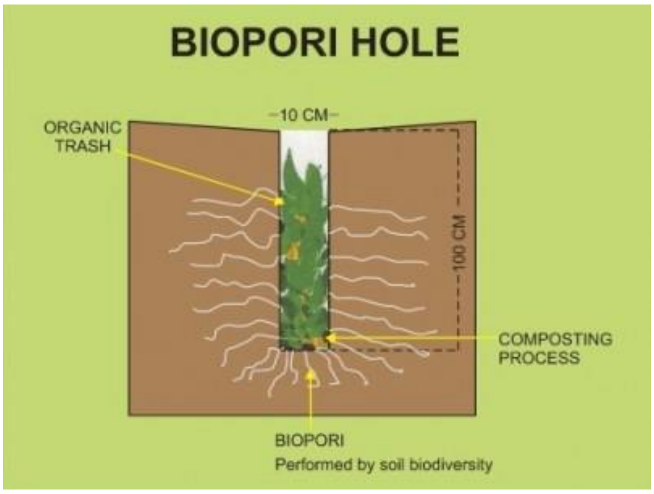


Figure 2. Biopore
Source: biopore.com

`

Biopori is able to enhance the absorption of soil to water (Ibubercahaya, 2014) so that the risk of water flooding (waterlogging) is getting smaller. The stored water could keep the soil moisture even in the dry season (Suara Surabaya, 2014). These advantages are believed to be useful as flood prevention program. The wall of biophore consist of small holes (pores) that are able to absorb water. So a biopore with a diameter of 10 cm and a depth of 100 cm, would have an absorption area around 3,220.13 cm^2. In contrast, without biopore, land area of 10 cm in diameter has an area of only 78 square cm absorption fields. Biopori could serve as an alternative to absorp rain water in the region which has limited space availability (Kompas, 2014).

This paper main question is to ask the effectiveness of such programs in reducing urban flood. This paper argues that there is limited open space available because of the Biophore Program and thus should be coupled with rainwater harvesting at household levels in order to achieve effective results. The proposed method is now under development of Bandung government to mitigate urban flood. In this paper, the application of the technology in Bandung city is described as well as its application in the household scale.

2. Methods

Data collection methods used for this research is done through two methods, namely primary and secondary methods.

- Secondary data collection became the primary method of data collection is done through data collection from the web regarding biopore. Various data and facts contained in the web becomes the raw data were then processed and become the subject of analysis and then triangulated through a primary survey. Hypothesis obtained through the collection of this data is processed through the triangulation mechanism with the primary survey method.
- Primary Survey conducted by interview to the relevant agencies, including: BAPPEDA Bandung, Department of Highways and Water Resources, Department of Spatial Planning and Human Settlement, BPBD of West Java, and Bandung Satlak.
- The rain-harvesting system: infiltration well (diameter of 1 m and 2 m depth) and rainwater tank (1 m wide and 2 m depth) were built in a house and monitored its performance to collect rainwater during rain events.

3. Results

Flood discharge in Bandung area was calculated based on run-off discharged in the catchment area of Citarum river. There have been numerous research estimated the flood discharge in Citarum river. Some of the researches resulted 185.164 m^3/sec of flood discharge, whereas other research reported flood discharge as much as 250 m^3/sec (Maulana, 2012). The one used for assumption in this research is maximum discharge of 140 million liter per rain event, while the average flow of run-off is 37 million liter per rain event.

Biopore ability to absorb water has been studied by many people. According Rasmita (2010) the rate of water infiltration using biopore was affected by differences in the type of soil in each region as shown in the table below.

Tabel 1. Biopore Absorbing Ability

Ground Orders	Biopore Absorbing Velocity (liter/hour)	Location
Entisol Inseptisol Ultisol	147,32 liter/hour 104,56 liter/hour 25,03 liter/hour	Rasmita (2010)
	2.02-6.4 mm/minute	Juliandri et al.,
Sumber Sari Malang	180-300 liter/hour	Malang, East Java (Arifin and Orizanto,(2012)
Sampah kulit buah (14 hari) Sampah 7 hari	1,463 x 10-4 L/ sec/ cm^2 0,224 x 10-4 L/ sec/ cm^2	Surabaya, East Java (Sibarani and Bambang,)

`

Using the assumption of flood discharge by 140 million liters of water per rain event (Kusuma, 2012), the ability of LBR is 180 liters per hour. Then if the inundation should be fully absorbed by the soil within 30 minutes, then there should be approximately 1.555.556 holes of biopore. Whereas out of the 1 million of biopore targeted to be built in Bandung area, there are only 48% which have already made.

However, during rain events, the whole area would be inundated by water and the rain water will saturate the whole area. Consequently the absorption capacity of each biopore hole would not be as much as the one during the experiment. The absorption capacity during the experiment was extremely enhanced due to the surrounding soil of the biopore holes was in dry condition and therefore, the water absorbed by the biopore could be easily absorbed and transfered to a wider area of soil.

3.1. Infiltration well and rainwater harvesting tank

An experiment was conducted using a house. The roof top area of the house was 100 m^2. The rainwater then conserved using rainwater tank coupled with infiltration well. The dimension of the rainwater tank was 1 m in width and length and 2 m depth (2 m^3), while the dimension of the infiltration well was 1 m in diameter and 2m in depth. The infiltration well was filled with big stones and *ijuk* or black-sugar palm fiber without any masonry wall, so the water could effectively infiltrate through the whole area of the well. The method was chosen because the location of the infiltration well was next to the foundation of the house due to limited space.

Two sets of rainwater harvesting tank and infiltration well were built to collect the rainwater. So in one rain event, this rainwater harvesting system could collect and save maximum 4 m^3 of rainwater and infiltrate 0.25 liter/second in the infiltration well. This number was obtained based on the infiltration rate from observation (0.000016 meter/seconds x 15.7 m^2 (the total area of the well)).

There have been many researches who reported the infiltration rate of the infiltration well. Indramaya and Purnama (2013) reported the infiltration rate of the infiltration wellby 0.0000582 m/second, while similar infiltration rate also was reported at Surabaya by Sibarani and Bambang (2014) who reported infiltration rate of 0.000016 meter/seconds.

In daily basis, the infiltration well also receive discharge of the grey water from bathroom and kitchen. The amount of water discharged into rainwater can be seen in table 1 and was calculated based on research reported by Arika (2003). That research calculated the average amount of clean water needed in Cimahi, Western Bandung. Thus the total grey water that must be absorbed is 763 liter/day or 0.76 m^3/day.

The rate of soil water infiltration in the experiment area is 0.0000016 liter/second. With the total area of the infiltration well as much as 15.7 m^2, the total capacity of the well to infiltrate was 0.25 liter/second and thus the time needed to infiltrate the water discharge was between 50 seconds to 34 minutes. This lag time was considered as feasible as the volume of water in retention was less than 0.5 m^3.

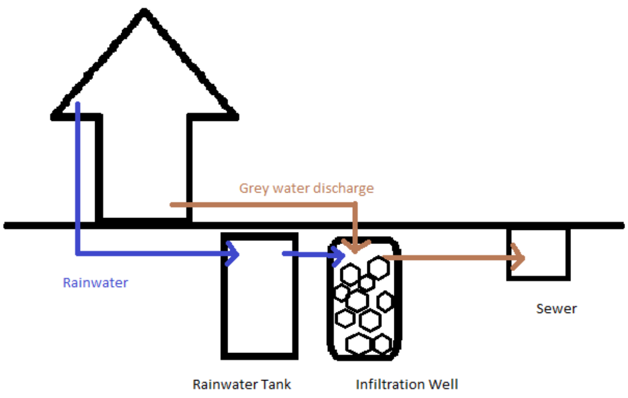


Figure 3. Simplified scheme of rainwater harvesting and infiltration system in household scale

`

(a)

(b)

Figure 4. Infiltration Well (a) and Rainwater harvesting tank (b)

On the other hand, calculation of total water consumption in the house of six people was 936 liter or 0.9 m^3 (Arika, 2003). This implied that the rainwater tank could accommodate the water consumption of the house until 4 days.

Table 2. The average amount of water discharge into infiltration well

Water consumption per person per day (Arika, 2003)			Daily discharge into the well (liter)	Infiltration rate (liter/sec)	Infiltration time
Alocation	**Percentage**	**Liter**			
Bathing and flushing	54.34%	85	510	0.2512	33.84 min
Ablution	13.79%	22	129	0.2512	8.56 min
Laundry	10.55%	17	99	0.2512	6.57 min
Cooking	8.51%	13	13	0.2512	51.75 sec
Gardening	4.09%	6	NA	NA	NA
House cleaning	3.52%	6	NA	NA	NA
Car cleaning	2.32%	4	NA	NA	NA
Fish pond	1.65%	3	NA	NA	NA
Drinking	1.23%	2	12	0.2512	47.77 sec

`

	100%	156	763		50.62 min

4. Discussion

From the calculation, biopori could not able to prevent flooding, but effective in dealing with puddles. This was proven by the flood events three months after the biopore program was launched. Several extreme flooding events were reported on the month of March and April in 2014, whereas the biopore program was launched in December 2013. The failure of biopore to prevent flood might due to the small dimensions of the pores which resulted in the relatively slow of water absorption in contrast to the accumulation of run-off water. The inventor of biopore, R. Kamir Brata himself also mentioned that the main function of biopore was not as water absorption but as an alternative of organic waste treatment, which could accumulate daily (Pikiran Rakyat, 2014)

To handle the flood in Bandung, the mayor of Bandung, Ridwan Kamil proposed a program which comprised of multiple culverts, build a small lake, making infiltration wells, water recycle and lastly creating biopore. The biopore program preceded the other programs because of its low cost. While the other four other programs would be carried out in stages to the next 5 years.

All other methods to catch rainwater in man-made containers, such as infiltration wells, man-made lakes or large containers, can only catch limited amount of lower quality water whereas rainfall is one of the purest sources of water. When the rainfall is fallen in Bandung area, only about 5% rainfall that absorbed by soil, and the rest was become run-off in rivers and impervious area. Thus the attempt to save the water should be focused on harvesting the rainwater. In addition, the next healthiest way to store rainwater is to let the ground absorb it and not to discharge it to the sewer as rainwater absorbed into the soil would likely become underground water.

Moreover, in Bandung, there will be infiltration pond with the size of swimming pool (21x13x3 m^3), with three injection wells with a depth of 12 meters, reaching its maximum capacity of 400 m^3/day. Rain water will be collected, rather than discharged into the drainage channel. So as to create ground water reserves that could be used in the dry season. The infiltration well and rainwater harvesting tank were better than biopore for flood prevention and water saving. The overall construction was designed for a household of 6 people and cost around USD 700. Yet there is also a smaller size which cost USD 300. This number was considerable high for most Indonesian, but, in the longer term, the investment was well worth with perspective of sustainable and green development, in particular in comparison with losses suffer from flood events which reached the number of USD 383.000 in a year (Kacamatasejati, 2014).

Meanwhile, to cope with the drought, reforestation efforts should be made in the mountains surrounding Bandung basin. This is because that the mountain area is the main source of groundwater for people in Bandung. In addition, the construction of residential area in catchment area should be limited.

References

Adhitama, P. & Sagala, S., Sitinjak. E and Pratama, A. (2014) Green Infrastructure Implementation in Flood Mitigation Context (Case Study: Flood Canals in Semarang), Sustainability Science Symposium, University of Padjajaran, 8-10 September 2014, Bandung (*accepted*)

Arifin, S. and Orizanto, K. (2012) Menjaga Kelestarian Lingkungan dengan Biopori. Prosiding the 4th International Conference on Indonesian Studies;"Unity, Diversity and Future."

Arika, D.M. (2003) Kajian Pola Konsumsi Air Bersih Rumah Tangga di Keluarah Setiamanah, Kota Cimahi sebagai masukan bagi Upaya Konservasi. Undergraduate Theses, Regional and City Planning Study Programme, Institute Technology of Bandung.

Sagala, S., Lassa, J., Yasaditama, H. and Hudalah, D. (2013) The evolution of risk and vulnerability in Greater Jakarta: contesting government policy. Working Paper, Institute for Resource Governance and Social Change.

Ibubercahaya (2014) "Biopori, Kecil Lubangnya Besar Manfaatnya". Ibubercahaya.com.

`

Indramaya, E.A. and Purnama, I.L.S. (2013) Rancangan Sumur Resapan Air Hujan sebagai Salah Satu Usaha Konservasi Air Tanah di Perumahan Dayu Baru Kabupaten Sleman Daerah Istimewa Yogyakarta.

Juliandari, M. (2013) Efektivitas Lubang Resapan Biopori terhadap Laju Resapan (Infiltrasi). Jurnal Mahasiswa Teknik Lingkungan UNTAN . Vol 1, No 1 (2013): Jurnal S1 Teknik Lingkungan

Kacamatasejati (2014) Kerugian Banjir di Kabupaten Bandung capai 46 miliar URL http://www.kacamatasejati.com/headline-news/kerugian-banjir-di-kabupaten-bandung-capai-rp46-miliar

Kesuma, R.W. (2012) Studi Pemaksimalan Resapan Air Hujan Menggunakan Lubang Resapan Biopori untuk Mengatasi Banjir. Bachelor Thesis, Program Studi Meteorologi, Fakultas Ilmu dan Teknologi Kebumian, Institut Teknologi Bandung.

Kompas (2014) "Hari Bumi, 100.000 Lubang Biopori Dibuat di Lima Kecamatan". Kompas. 23 April 2014.

Maulana, R. (2012) Prediksi Curah Hujan dan Debit Menggunakan Metode Adaptive Neuro-Fuzzy Inference System (ANFIS). Program Studi Meteorologi, Fakultas Ilmu dan Teknologi Kebumian, Institut Teknologi Bandung.

Pikiran Rakyat (2014) "Biopori Atasi Genangan, Bukan Banjir". Pikiran Rakyat. 13 Januari 2014.

Sagala, S., Dodon, Wimbardana, R. and Lutfiana, D. (2013): Alih Fungsi Lahan Rawa dan Kebijakan Pengurangan Risiko Bencana Banjir: Studi Kasus Kota Palembang. Edited by Herryal Anwar, LIPI.

Sagala, S., Wimbardana, R. and Pratama, F. (2014): Perilaku Dan Kesiapsiagaan Terkait Kebakaran Pada Penghuni Permukiman Padat Kota Bandung. J. Forum Geografi. Vol 28 (1). July 2014.

Sibarani and Bambang (2014) Research Of Biopores To Determine The Rate Of Water Absorption Based On Variation In Age And Types Of Solid Waste R.T. Sibarani dan Ir. Didik Bambang S., MT Jurusan Teknik Lingkungan FTSP-ITS Surabaya

Sitinjak, E., Sagala, S. and Rianawati, E. (2014) "Promoting Sister City Concept for Urban Resilience and Sustainability: Case Studies of Jakarta and Bandung", Sustainability Science Symposium, University of Padjajaran, 8-10 September 2014, Bandung

Suara Surabaya (2014) "Kemarau, Lubang Resapan Biopori Punya Manfaat Ganda". Suara Surabaya. 16 Juli 2014.

Yamin, D., Sagala, S., Situngkir, F. and Lubis, W. (2014) "Household Adaptive Capacity to Flood in Palembang", Sustainability Science Symposium, University of Padjajaran, 8-10 September 2014, Bandung (*accepted*)

Resilience
Development
Initiative

research.knowledge.resilience

Office: Jalan Imperial II No. 52 Bandung, West Java, Indonesia 40135
Phone: +622 225 36574 | **Email:** rdi@rdi.or.id | **Website:** www.rdi.or.id

9 772406 786000