Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 227 (2016) 617 – 622

Procedia Social and Behavioral Sciences

CITIES 2015 International Conference, Intelligent Planning Towards Smart Cities, CITIES 2015, 3-4 November 2015, Surabaya, Indonesia

Green infrastructure development in Cisangkuy Subwatershed, Bandung Regency: potential and problems

Sri Maryati[a]*, An Nisaa Siti Humaira[a], Putri Adianti[a]

[a]*Research Cluster for Regional and City Infrastructure System, School of Architecture, Planning and Policy Development, Institute of Technology Bandung, Jalan Ganesha 10, Bandung 40132, Indonesia*

Abstract

Green infrastructure (GI) development is able to deliver multiple benefits to economic, social, and especially environment. Nevertheless adoption of GI measures faces some problems. The objective of this paper is to explore the potential and problems of GI development in Cisangkuy Subwatershed, Bandung Regency. The methods used in this research are modeling and stakeholder interview. The result of analysis shows that there are four kind of green infrastructure to be developed, which are infiltration basin (7,037.22 ha), vegetated filter strip (1,511.12 ha), dry pond (839.57 ha) and bioretention (418,58 ha). Based on stakeholder interview, the development of green infrastructure is limited only to bioretention (43.75 ha) and infiltration basin (5,930.58 ha) due to the problem of land ownership. Another problem is such measures have not been stated in spatial plan.

Peer-review under responsibility of the organizing committee of CITIES 2015

Keywords: Bandung Regency; Cisangkuy Subwatershed; Green infrastructure; Potential; Problems

1. Introduction

Green infrastructure (GI) is defined as a set of techniques, technologies, management approaches, and practices that can be used to eliminate or reduce amount of storm water and nonpoint source runoff including water and pollutants that run into combined sewer overflow system (CWAA, 2011). Green infrastructure mimics the natural process. This process is more difficult to take place naturally in urbanized area, hence GI is needed.

* Corresponding author. Tel.: +62-22-2509171; fax: +62-22-2504735.
E-mail address: smaryati@pl.itb.ac.id

Peer-review under responsibility of the organizing committee of CITIES 2015
doi:10.1016/j.sbspro.2016.06.123

Adoption of GI gives direct and indirect benefit. Baptiste, et al (2015) stated that application of GI can reduce the amount of storm water runoff, reduce pollution, and increase urban green spaces, thus improving microclimate, as well as neighborhood quality of life. GI provides essential ecological, social, and economic services for functioning healthy urban ecosystems (McWilliam, et al., 2015).

Idea and concept of GI are not new. However the implementation of the idea and concept is still limited (Carlet, 2015). There are some reasons for this condition, among others are institutional, technological, and perceptual (NRC Study, 2008). In order to adopt the concept, study to explore the potential and problems of GI implementation is needed.

The objective of this study is to explore the potential and problems of GI implementation in Cisangkuy Subwatershed, Bandung Regency. The region is one of regions in Indonesia that experiences flood. Adoption GI concept could be a solution for the problem. Potential and problems of GI implementation in this study is based on the perception of stakeholder, in this case the Government. Some studies related to perception of stakeholder in GI implementation are focused on perception of household or community (Baptiste, et al.(2015), Barau (2015). These studies argued that exploring perceptions, values, and preferences is fundamental in achieving desired goals and objectives.

According to Tzoulas, et al. (2007), GI are all natural, semi-natural, and artificial networks of multifunctional ecological systems within, around, and between urban areas at all spatial scales. It means that GI can be implemented in various scales which can be either household, neighborhood, or city scale. At city or county scale, green infrastructure refers to interconnected network of green space that conserves natural systems and provides assorted benefits to human populations (Benedict and McMahon, 2006). In this study, the scale of GI explored is city or county scale.

2. Method

GI is a relatively new concept in Indonesia so that the implementation of the concept is still limited. It is therefore this research cannot apply direct questions to the stakeholders in order to get information related to the potential and problems of GI implementation. In this research, at the first stage modeling is done in order to get information related to the type and location of GI measures that can be implemented in Cisangkuy Subwatershed. The modeling is done by using suitability analysis method. Suitability analysis method is done by using SUSTAIN Model. This model refers to Low Impact Development (LID) application with using Best Management Practice (BMP) Sitting Tool to choose and decide both suitable type and location for green infrastructure. There are some criteria related to land suitability that are considered in this research such as drainage area, drainage slope, imperviousness, hydrological soil group, water table depth, road buffer, stream buffer, and building buffer. Furthermore, narrative analysis method is used to analyze the perception of the government concerning potential and problems of applying the green infrastructure development in the area of study based on the model. By using those methods, the possibility to develop GI can be analyzed. Moreover, the problems as the obstacles notably in implementing green infrastructure can be identified.

The data used for analysis consist of primary and secondary data. Primary data based on interview with the Government Officers of Bandung Regency, West Java Province and the Ministry of Public Works and Public Housing. The respondents for interview were determined based on their institutions. The institutions were chosen based on the scope of works, which should have relationship with the implementation of GI.

3. Result and Discussions

3.1. Ccase study area

Bandung Regency, West Java Province. The area of the subwatershed is 3,3360.78 ha. As a part of Citarum River Watershed, this subwatershed is one of the main areas that supply the need of raw water for Bandung City and Bandug Regency.

The environmental condition of this area is already at a critical level which is shown by the level of erosion, sedimentation, and fluctuating discharge. The erosion level for this area has roughly reached 163 ton/ha/year. Fluctuating discharge ranged from 49 to 394 m3/second. These lead to the seasonal flood in the south part of Bandung

that particularly occurs in rainy season. Annual rainfall in this area varies from 2,000 to 3,000 mm/year with the dry and rainy season occur respectively in July to September and November to April.

From spatial perspective, the land use in this area is classified into 9 categories. The percentage of each use as shown in Fig. 1. Rice field is the largest area in Cisangkuy Subwatershed (28%) followed by Plantation/Field/Farm (22%) and Bushes (21%). Within 20 years from 1994 to 2014, there was significant increase in the category of Housing/Settlement in the amount of 1,186.38 ha (49.60%) from 2,392.07 ha in 1994 to be 3,578.45 ha in 2004.

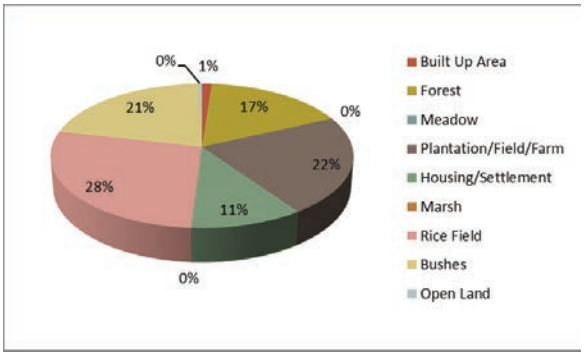


Fig. 1. Land use percentage of Cisangkuy Subwatershed in 2014.

3.2. Potential of green infrastructure development

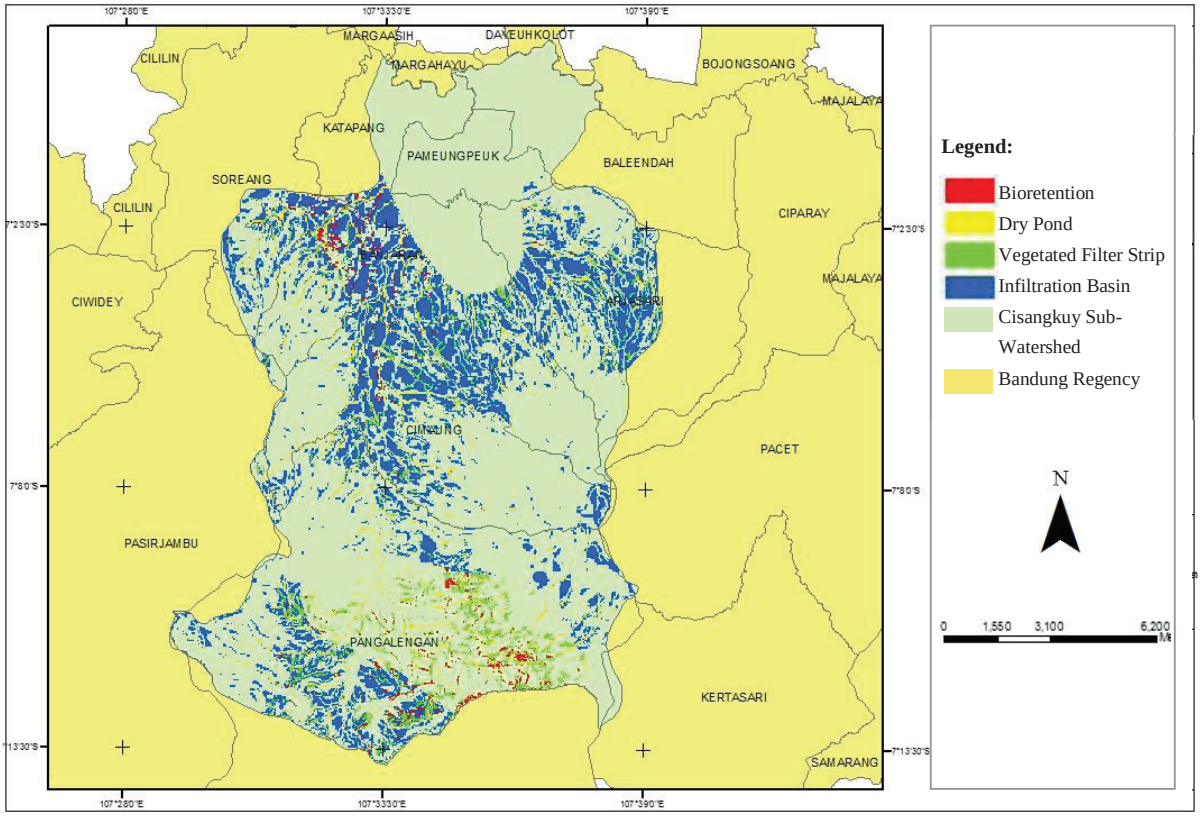
Based on the analysis using input data and criteria processed by BMP Sitting Tool in SUSTAIN Model, it results four types of green infrastructure that can be developed in accordance with the physical condition in Cisangkuy Subwatershed. Those types are as folows: (1) Bioretention; (2) Dry Pond; (3) Infiltration Basin; and (4) Vegetated Filter Strip. As we can see in Table. 1., infiltration basin has the largest percentage with the total area of 7,037.22 ha or 21.09% from the total area of Cisangkuy Subwatershed, followed by vegetated filter strip (1,511.12 ha or 4.53%), dry pond (839.57 ha or 2.52%), and bioretention (418.58 ha or 1.25%). If all these types are accumulated, thus total area covered by green infrastructures is 9,806.49 ha or 29.40% from the total area of Cisangkuy Subwatershed (33,360.78 ha). The distribution of green infrastructures in Cisangkuy Subwatershed based on SUSTAIN Model is shown in Fig. 2.

Table 1. Potential of green infrastructure in Cisangkuy Subwatershed.

	Dry Pond	Bioretention	Vegetated Filter Strip	Infiltration Basin	Total (ha)
Total Area (ha)	839.57	418.58	1,511.12	7,037.22	9,806.49
Percentage (%)	2.52	1.25	4.35	21.09	29.04
Total Area of Cisangkuy Subwatershed					33,360.78

3.3. Problems in developing green infrastructure

Besides the potential of green infrastructure development, there are some obstacles faced in developing it. These problems encompass some issues related to land use and land ownership, natural hazard, and spatial planning which are discussed as follows.



.Fig. 2. Distribution of green infrastructure in Cisangkuy Subwatershed based on SUSTAIN Model

3.3.1. Land ownership.

To know the existing land use of green infrastructure that will be developed, the land use map and the map of green infrastructure distribution are overlaid resulting the overlay map. From this map, it shows that green infrastructure that will be developed is located at rice field (44%), plantation/field/farm (22%), and bushes (13%) (see Fig. 3.).

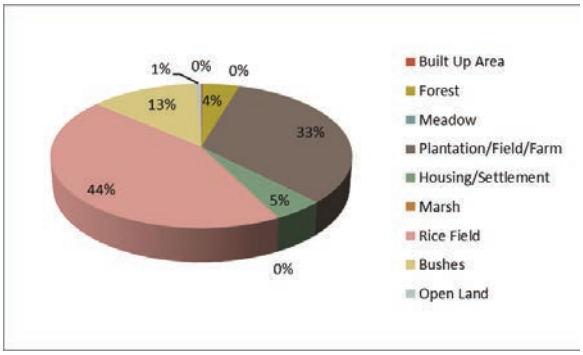


Fig. 3. Percentage of Green Infrastructure Area based on the Land Use

Based on the distribution of existing land use shown in Fig. 3., the constrain is found in the matter of the land ownership. Most of the land is not owned by the Government (private ownership) so it will require participation of

private landowners in implementing GI measures especially in the first or initiation stage. Some big efforts will be needed and have to be done in the context of either land acquisition, negotiating, or encouraging the landowners to consider green infrastructure and allow their property or asset to be used.

3.3.2. Natural hazard.

Based on interview with several Government Officers of Bandung Regency, West Java Province, and the Ministry of Public Work and Public Housing regarding their perception of GI potential and problems to be implemented in the study area, they stated that there is some limitation to develop the GI concerning the natural hazard. The study area is the landslide prone area; hence this aspect is one of the problems in implementing the GI concept. They suggested encompassing this natural hazard particularly to the concept.

Soil erosion and landslides as the results of the ground motion are important factors that have to be considered in view of the physical characteristic of the study area which is located on a plateau dominated with steep slope ranged from 15o to more than 40o. In accordance with the statement of EPA (2014), it is important to consider site slopes in the design of any storm water management system, particularly in the design of green infrastructure systems for sites with steep slopes. It is also said that soil erosion and landslides are concerns whenever construction occurs on or near slopes, but become even more of a concern when slopes are saturated with water. Since many green infrastructure practices enhance infiltration of water into the soil, care must be taken when designing green infrastructure (EPA, 2014). EPA (2014) suggested to minimize the risk of erosion on steep slopes with simply protecting the slope from development and set aside for preservation.

One of the weaknesses using the BMP module in SUSTAIN model is it does not consider the hazard map in the process resulting the potential map of GI. In this case, the hazard map in the study area is the ground motion map. This map identifies the landslide prone areas. In consequence, the overlay between the map of distribution of GI in Cisangkuy Subwatershed based on SUSTAIN Model and the map of ground motion in the study area has to be made to find out the exact information regarding the distribution and total area of GI development considering the hazard possibility that will occur anytime.

3.3.3. Spatial planning.

Incorporating green infrastructure into spatial planning will result in more resilient environment and service. It can provide the unifying framework for creating a continuum between the green elements of rural and urban landscapes (United Nation, 2015). Unfortunately, this GI element has not been accommodated yet in spatial planning system in Indonesia. In the Law Number 26 of 2007 on Spatial Planning, it only emphasizes that utility and infrastructure as a part of the spatial structure plan is solely addressed in order to fulfill the goals of economic and social concern, regardless of the environmental concern.

In this context, the GI is not accommodated yet in the Regional Spatial Plan of Bandung Regency 2007-2027 that is legalized with the Local Regulation of Bandung Regency Number 3 of 2008. This is one of the biggest obstacles to combat the implementation of GI in the study area. The Government Officers of Bandung Regency themselves argue that GI development should be embedded first in the Regional Spatial Plan of Bandung Regency. So far conventional drainage system is used to reduce runoff and to control the flood during large and infrequent storms. The evaluation concerning the use of only conventional drainage which is no longer effective should be done considering the seasonal flood occurring in some areas. Therefore, new concept such as GI development is needed to be listed in the document of regional spatial plan.

4. Conclusions

Based on the modeling result, the types of GI that can be implemented in Bandung Regency are infiltration basin (7,037.22 ha), vegetated filter strip (1,511.12 ha), dry pond (839.57 ha) and bioretention (418,58 ha). The respondents that were interviewed in this research believe that GI can be implemented in order to reduce flood problem in Bandung Regency. Nevertheless, they also stated that some problems will arise in the stage of implementation. The problems

are related to the land ownership and possibility of natural hazard that will occur anytime, hence there are only two types of GI that can be implemented, those are bioretention (43.75 ha) and infiltration basin (5,930.58 ha). Other problems in implementing GI are it has not been stated in spatial plan document.

It is recommended that GI concept should be included as a component of utility and/or infrastructure in spatial plan. According to the planning document, the government can allocate land for GI implementation. The government is also able applying multiple use concepts in implementing the GI.

Acknowledgements

The research, on which this article is based, is funded by the Institute of Technology Bandung under the scheme of *Riset Inovasi Kelompok Keahlian* in FY 2015. The title of the research is Integration Model of Green Infrastructure Measures into Planning Document, contract number PN-6-06-2015. The authors would like to thank all the stakeholders involved in this program. However, the authors alone are responsible for any mistakes and shortcomings.

References

Bandung Regency. (2008). Local Regulation of Bandung Regency Number 3/2008 regarding Regional Spatial Planning of Bandung regency 2007-2027.

Baptiste, A.K., Foley, C., & Smardon, R. (2015). Understanding urban neighborhood differences in willingness to implement GI measures: a casestudy of Syracuse, NY. *Landscape and Urban Planning, 136*, 1-12.

Barau, A.S. (2015). Perceptions and contributions of households towards sustainable green infrastructure in Malaysia. *Habitat International, 47*, 285-297.

Benedict, M.A, & McMahon, E.T. (2006). *Green infrastructure: linking landscapes and communities.* Washington, DC: Island Press.

Carlet, F. (2015). Understanding attitudes toward adoption of green infrastructure: A case study of US municipal officials. *Environmenta Science & Policy, 51,* 65-76.

Clean Water America Alliance [CWAA]. (2011). Barriers and gateways to green infrastructure. Retrieved from http://www.uswateralliance.org/pdfs/ gireport.pdf

Indonesia Government. (2007). Law Number 26/2007 regarding Spatial Planning.

McWilliam, W., Brown, R., Eagles, P., & Seasons, M. (2015). Evaluation of planning policy for protecting green infrastructure from loss and degradation due to residential encroachment. *Land Use Policy, 47,* 459-467.

National Research Council [NRC]. (2008). *Urban Stormwater Management in the United States*. Washington, DC: National Academy Press. Retrieved from http://books.nap.edu/openbook.php?record id = 12465.

Tzoulasa, K., Korpelab, K., Vennc, S., Yli-Pelkonenc, V., Kaźmierczaka, A., Niemelac, J., & Jamesa, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and Urban Planning, 81*, 167-178.

United Nation. (2015). Issue Papers and Policy Units of the Habitat III Conference. Retrieved from http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Papers-and-Policy-Units_11-April.pdf.

United States Environmental Protection Agency [EPA]. (2012). Addressing Green infrastructure design challenges in the Pittsburgh Region: Steep Slopes. Retrieved from http://water.epa.gov/infrastructure/greeninfrastructure/upload/Pittsburgh-United-Steep-Slopes-508.pdf.