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by Stefanus, Robby Yussac Tallar

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THE SUSTAINABLE CONCEPT DESIGN CONCERNING THE IMPLEMENTATION OF LOW IMPACT DEVELOPMENT IN URBAN AREA

Stefanus[1] and Robby Yussac Tallar[2]

[1] Mercubuana University, Dept. of Civil Engineering, Indonesia
[1] Universitas Kristen Maranatha, Dept. of Civil Engineering, Indonesia
e-mail: robbyyussac@yahoo.com

ABSTRACT

The relationship between water quantity and water quality status in the framework of water resources management was complex and likely to be site-specific, thus the cause-effect relationships between pollutant sources (affluents) and water quality condition remain unclear. The primary principle of Low Impact Development (LID) concept design is to detain and/or hold stormwater for as long as possible and to limit stormwater pollution before it enters major waterbodies. LID methods aim to preserve as much water on-site as feasible while also protecting water quality through the use of natural landscape elements. We also highlighted the results of preliminary data to design for the implementation of LID. The water quantity and water quality status relationship in the framework of water resources management was complex and likely to be site-specific, therefore the cause-effect relationships between pollutant sources (affluents) and water quality condition still need to be clearly quantified. The core concept of Low Impact Development (LID) is to detain and/or retain stormwater as long as possible and to reduce the stormwater runoff pollutions before flowing into main waterbodies. LID components seek to keep water onsite as much as possible and protect water quality using landscape natural features. Therefore, the main objective of this paper was to offer the opportunities of applying LID components in urban area. We also summarized the performances of LID components including the improvement of water quality from previous studies.

KEYWORDS: Sustainable Design; LID components; Sustainable water resources management

1 INTRODUCTION

Nowadays, the paradigm of sustainable development is a significant topic that has gained global attention (Deakin and Reid 2014, Puig, Wooldridge and Darbra , Foo 2013, Xing, Liang and Xu 2013). The primary purpose of this paradigm is to develop better ways of doing things in the future and in the present, particularly in relation to environmental challenges. It can be interpreted in many different ways and implemented in many sectors of civil engineering products (Oyedepo 2014, Deakin and Reid 2014, Suduc, Bîzoi and Gorghiu 2014). Nowadays, this paradigm has derived to similar terms such as green design, ecological sustainability or others (Diwekar and Shastri 2010). The general focus of this concept is to improve the quality of environment through several appropriate technologies (Sianipar et al. 2013, Lee and Shih 2011).

In the context of sustainable water resource management, there is also a need to implement sustainable components to increase the ecological aptitude in specific waterbodies and to resolve water problems that are becoming increasingly interconnected with other development-related issues such as social, economic, environmental, legal, and political factors at local and regional levels, and sometimes even at national and international levels. The unsustainability and degradation of water quality condition are an issue of growing concern around the world (Oney et al., 2011; Bezlepkina et al. 2014; Davies and Wright 2014). Rapid economic growth and the forces of urbanization and industrialization are considered as the main causes of increased water pollution (Sim and Balamurugan, 1991; Tsuzuki, 2006; Keenleyside et al., 2009; Wu and Tan, 2012; Abdel-Dayem, 2011; Nursey-Bray et al., 2014). Thus, the water quantity and water quality status relationship was complex and likely to be site-specific, therefore the cause-effect relationships between pollutant sources (affluents) and water quality condition still need to be clearly quantified.

The concept of Low Impact Development (LID) was offered by several studies recently (Dietz and Clausen 2008; Bowman et al. 2012; Gilroy and McCuen 2009; Ahiablame et al. 2012). The core concept of Low Impact Development (LID) is to detain and/or retain stormwater as long as possible and to reduce the stormwater runoff pollutions before flowing into main waterbodies. The investigation of effectiveness of LID components and their implementation in many areas also have been disseminated by previous papers (Qin et al. 2013; Ahiablame et al. 2013; Sin et al. 2014). However, few studies have been conducted the implementations of LID in urban area of Indonesia. Therefore, the main objective of this paper was to offer the opportunities of implementing LID components in urban area of Indonesia. We also summarized the performances of LID components including the improvement of water quality from previous studies.

2 THE CONCEPT OF LID

LID was initially established in 1999 by the Department of Environmental Resources in Prince George's County, Maryland, USA. LID provided an alternative method to conventional stormwater management by improving surface and ground water quality, preserving the integrity of aquatic life resources and ecosystems, and preserving the physical integrity of receiving streams. It is a land development (or redevelopment) method that works with nature to manage stormwater as close to its source as possible. It aims to keep as much water on-site as feasible while also protecting water quality through the use of natural landscape elements. LID incorporates five concepts or key aspects, as seen in Figure 1. This method encompasses all components (conservation, small-scale controls, specialized site design, channeling runoff to natural areas and maintenance, pollution, prevention, and education). The development in a specific area or watershed should be held accountable for the effluents and/or runoff from the incoming rainfall. By emulating natural hydrologic processes, the installation of LID components can reduce or eliminate the quantity of wastewater created from a site in the first place (Figure 2).

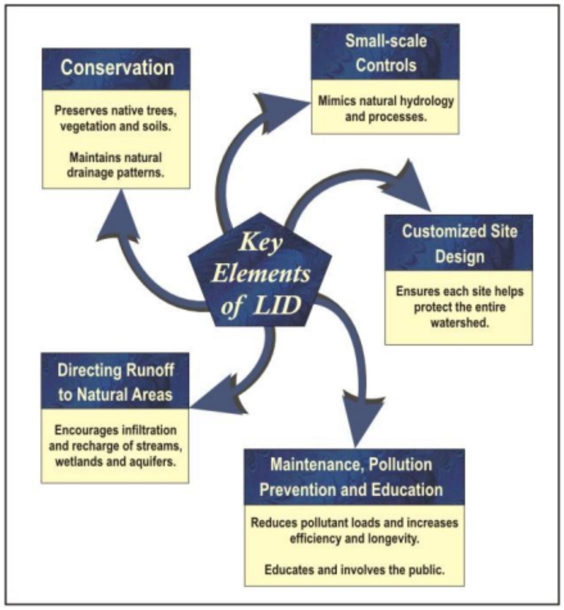

Figure 1: Key elements of LID
(*Source: http://www.lowimpactdevelopment.org*)

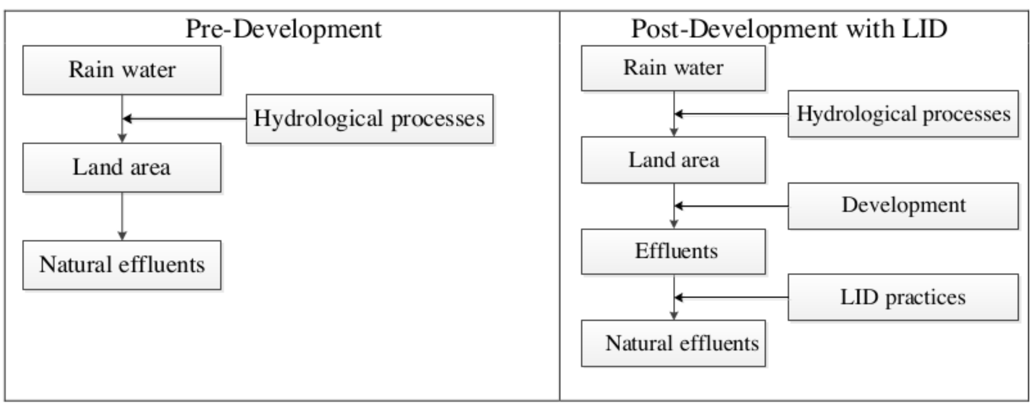

Figure 2: Basic concept of LID

2.1 LID components

The examples of LID components are bioretention or rain garden, green roof, rain barrels or cisterns, infiltration wells and permeable pavement. Bioretention, or variations such as bioinfiltration and rain gardens, has become one of the most frequently used stormwater management tools in urbanized watersheds (Davies et al., 2009). Bioretention is a plant and soil-based component that removes pollutants and debris from stormwater runoff. Stormwater is collected and sent to a treatment area that includes a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants.

Meanwhile, green roof is a planted roof top that provides advantages of water harvesting, stormwater management, pollutions control and aesthetic value. It varies in depth of growing media, types of plants, infrastructures and intended use. It is generally categorized into two types: extensive and intensive. Both bioretention and green roof are considered aesthetic value into its system as one of the advantages.

Rain barrels or cisterns, infiltration wells and permeable pavement are the most common and simple LID components to minimizing stormwater impacts and providing runoff storage measures in the watershed. Rain barrels are low-cost, effective, and easily maintainable retention devices applicable to target area. Infiltration wells are shallow wells which put water into a natural aquifer. They can be used to either drain a catchment area or recharge groundwater. Meanwhile, permeable pavement, also known as porous pavement, is a range of sustainable materials with a base and sub-base that allow the movement of stormwater through the surface.

2.2 LID components in Indonesia

In Indonesia, some of LID components are already implement with slight different terms but similar functions such as biopore, rain barrels or cisterns, infiltration wells and permeable pavement. Biopore is a derivative component of bioretention. Some studies also classified this component into rainwater harvesting technology. It is simpler in design compare than bioretention (Figure 3). It is a hole contained with organic waste such as dead-leaves that serves to trap the flowing water as a groundwater recharge. This component is simple and relatively cheap.

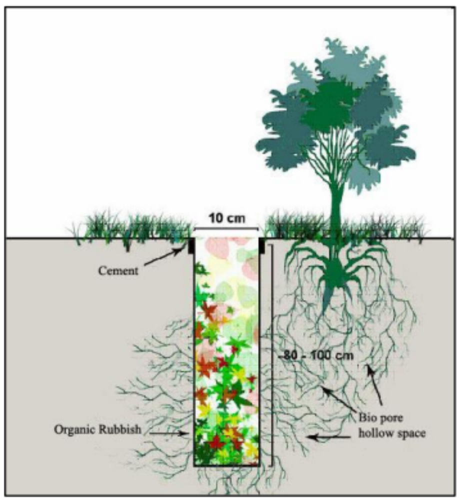

Figure 3: Typical design of biopore
(Source: http://wctngcmfng.canalblog.com)

Infiltration wells also the most common LID component in Indonesia. It is an excavated well that has been back-filled with stone to form a subsurface basin. Stormwater runoff is diverted into the well and is stored until it can be infiltrated into the soil, usually over a period of several days. Infiltration wells are very adaptable in Indonesia, and the availability of many practical configurations. The typical design of infiltration wells can be seen on Figure 4. Meanwhile, the typical design of permeable pavement can be seen on Figure 5.

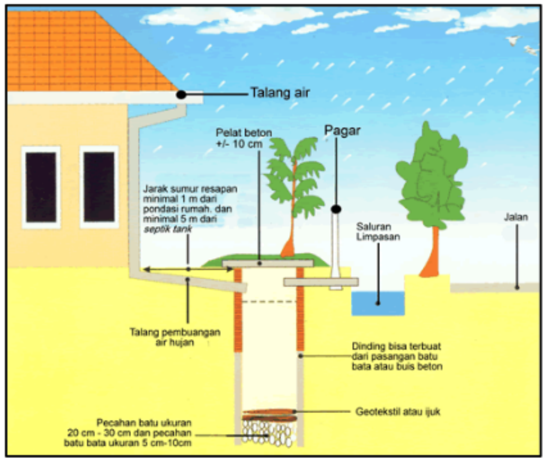

Figure 4: Typical design of biopore
(Source: Indonesia Ministry of Environment)

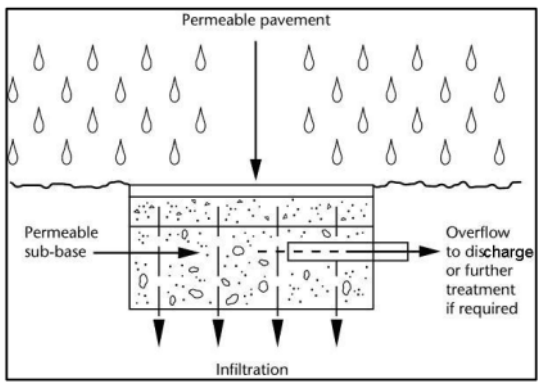

Figure 5: Typical design of permeable pavement
(Source: http://www.millermicro.com/porpave.html)

3 THE EXAMPLE OF CASE STUDY

Indonesia has a long history of water pollution in many waterbodies. In this study, we selected Depok Area, Indonesia as the example of case study. The location of study area can be seen on Figure 6. As a hinterland and buffer area of Jakarta City, Depok Area has designed by the central government to retain and/or detain the water flowing through Jakarta City.

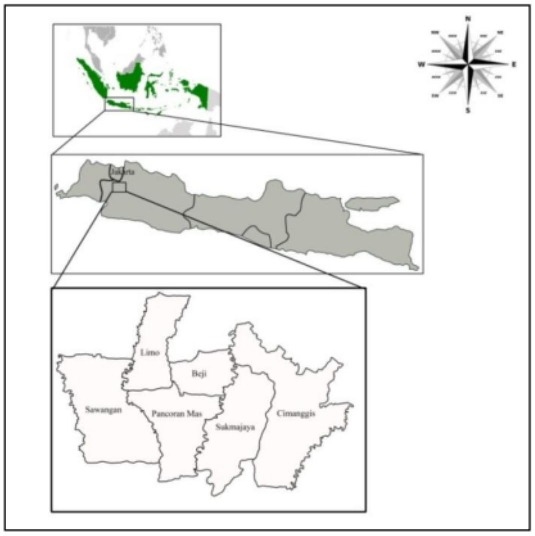

Figure 6: Location of study area

3.1 The review of water quality status

Status of waterbody especially rivers in study area are categorized as moderate to high pulluted. There are some efforts from the central and local governenment through environmental agency in order to restore the water quality in several waterbodies.

3.2 The integrated adaptive LID components

Indonesia is facing the inundation problems due to increased direct runoff combined with water quality degradation. These facts were stirring up the efforts to implement the adaptive design of Low Impact Development (LID) components in the context of initiating the sustainable water resources. As described earlier, some of Low Impact Development (LID) components are already implement with slight different terms but similar functions such as biopore, rain barrels or cisterns, infiltration wells and permeable pavement. The existing Low Impact Development (LID) components need to be combined each other to get maximize results. We offered the integrated adaptive design Low Impact Development (LID) components in types of areas, including in modest residential area (Figure 7). The other alternatives of adaptive design Low Impact Development (LID) components can be modified depend on their purposes.

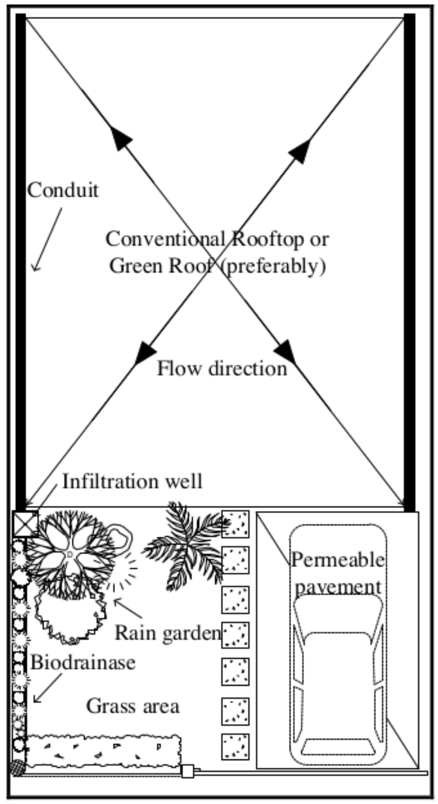

Figure 7: The typical design of sustainable design LID components for modest residential area (not in scale)

The fundamental hydrologic processes are considered throughout the site planning process in Low Impact Development (LID) concept design. By comparing pre- and post-development conditions, the preservation of the pre-development hydrology is assessed. The comparison is aided by taking four key measures into account: runoff volume, peak runoff rate, flow frequency/duration, and water quality. The runoff volume for a given storm grows as the impermeable area of the site increases. The runoff coefficient is the ratio of the associated runoff volume to the overall rainfall event. The runoff curve number (CN) will also be determined in order to complete a hydrologic study for a Low Impact Development (LID) site. Previous literature evaluations can provide more explanation.

4 DISCUSSION

Some catchment areas are categorized as areas with highly polluted status in waterbody. Understanding this fact, SWOT analysis was performed to provide some useful insights for further research (Table 1).

Table 1: The summary of SWOT analysis

SWOT components	Descriptions
Strengths	• There are some indexes to measure water status of waterbodies. • The public awareness about degradation of water status is increased recently.
Weaknesses	• A lack of detailed data on the quality and quantity of waterbodies in the Depok Area, including daily or monthly recorded data on water quality. • Due to an undefined water function in Depok Area waterbodies, the water purposes were mixed together. • Most bodies of water lacked precise blue print design planning, and rivers and lakes should have different and particular laws.
Opportunities	• Some of the water purposes of waterbodies in Depok Area were categorized into moderate level pollution. • Several parameters can affected the water quality index.
Threats	• Some parameters in Depok Area waterbodies, such as fecal coliform and total coliform, exceed prescribed limits. • Effluents from anthropogenic activities increase. • Monitoring and management programs are dependent on local government decisions and are inextricably linked to budget arrangements at all times. • A few waterbodies in the Depok Area have multiple local government agents with no defined authority (management issue).

According to the SWOT analysis, water consumption is intricately related to land use. This suggests that, more often than not, in order to handle water resource management issues correctly, land management issues must also be addressed. Changes in land use also affect watershed features, which have a significant impact on surface runoff, infiltration, and subsurface flows, and hence access and sustainability. Existing water resource management policies are deemed insufficient for conserving and improving the status of waterbodies in the research area. Land and water conservation regulations must be translated into local policies based on their own local characteristics. In other cases, more stringent criteria and policies are required to achieve long-term watershed and water resource management.

5 CONCLUSION

Water-related issues, particularly in metropolitan settings, have raised awareness of the significance of managing water resources holistically. Despite significant investment in the LID concept design, implementation appears to have been elusive and difficult because managing water resources crosses so many boundaries, such as the theory-component boundary, the ecological-societal boundary, and the administrative-hydrological boundary. This study provided the adaptive design of LID components for Indonesia.

LID is an ecological and sustainable technique that reduces or eliminates the amount of effluents/runoff produced by a site in the first place. Certain adaptive LID components have been investigated and the ecological water-purpose within has been underlined. By improving water quality of the waterbodies, it will certainly protect the aquatic life from undesirable contaminants. The supported policies are needed to guard the implementation of LID components.

6 ACKNOWLEDGEMENTS

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