

Riparian landscape management in the midstream of Ciliwung River as supporting Water Sensitive Cities program with priority of productive landscape

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Abstract. Nowadays, Ciliwung River is facing problem of the settlement occupation in its riparian zones. This phenomenon caused ecological damage in riparian, so it can aggravate the disaster of annual flooding in Jakarta. As an effort to control this catastrophe, riparian landscape management of Ciliwung River is needed. Based on its topography, Ciliwung River is divided into three segments, there are the upstream, the midstream, and the downstream. Data shows that riparian in the midstream is the largest area, it covers more than 60% of the total riparian area. This segment is very important to be managed in order to reduce runoff towards the downstream. The method used was comparing many standards to get the ideal riparian width in the midstream, which is 50 m for urban areas and 100 m for outside the urban areas. Next method was analyzing spatially to get riparian landscape characteristic of Ciliwung River. The result showed that 37.11% of riparian zones in the midstream had occupied by settlement. Analysis of riparian function and utilization had held by using Analytical Hierarchy Process. Priority of riparian function in the midstream of Ciliwung River is production. This can be realized with the plan of community garden or inland fisheries. Riparian landscape management in the midstream aims to support the food consumption diversification, and maximize the function of water catchment and water retention in order to support the program of Water Sensitive Cities.

1. Introduction

Ciliwung River flows from the upstream in Puncak, Bogor District, and ends at the Bay of Jakarta. From the total length of 117 km, Ciliwung River is divided into three segments, there are the upstream, the midstream, and the downstream. During rainy season, this river is often blamed as the cause of the flooding in Jakarta. Flooding actually occurs due to reduced of water catchment area, that can be achieved with the existence of green open space, one of which is riparian zones [6] [24].

The phenomenon of settlement occupation in Ciliwung River may destroy land and vegetation formation [16]. As a result, water retention capability in the riparian was diminished, and lead to increase runoff volume that can be cause floods in downstream [2] [5]. Because of the problems in riparian of Ciliwung River, many strategies to protect riparian zones is needed. The strategy must be integrated from the upstream to downstream of Ciliwung River. But in this study, the focus of study



site is on the midstream riparian of Ciliwung River. Based on the area of riparian zones, the midstream is the largest riparian zones, and it covers more than 60% of the total riparian area. Ciliwung River in the midstream through Bogor City, Bogor District, Depok City, and part of South Jakarta. With a declivious slope, this segment is very important location to be managed as water catchment and water basin area. The cover of vegetation, both natural and cultivated, are still dominating in this segment. This potential is very important to be developed for community around riparian.

Several approaches had been done to achieve the goal of riparian landscape management. Analysis of the width and landscape characteristics of riparian is necessary to know the general condition of the Ciliwung River riparian in the midstream. Determining the function and use of riparian landscapes had obtained by Analytical Hierarchy Process (AHP). The approach to get riparian landscape management in the midstream of Ciliwung River is the river restoration concept, which aims to restore the river and riparian zones in natural conditions and protection after the restoration [12] [15] [23] [26]. This concept is also an effort to support the program of Water Sensitive Cities (WSC), where the WSC program aims to realize a city or region to be adaptive with climate change and population pressure on urban water [25].

2. Method

2.1. Study site

The research was conducted from April until September 2015 in the midstream riparian of Ciliwung River along 67.52 km of the total Ciliwung River length 117 km (Figure 1), with the distance between the two river valleys is 35.83 km. The midstream riparian of Ciliwung River is bordered by Bendung Katulampa in Bogor City to Rawajati in South Jakarta.

2.2. Analysis of riparian width and landscape characteristic in the midstream of Ciliwung River

Analysis of the Ciliwung River riparian width in midstream was conducted by comparing the riparian width standards. There are three standards of riparian width that compared (Table 1), that is (1) the standard of riparian width with flood protection function, (2) the standard of riparian width based on the Decree of the Minister of Public Works No 28 of 2015 and the Indonesian Government Regulation No. 38 of 2011, and (3) the standard of riparian width based on morphology, ecology, and hydraulic of river flood [17].

Table 1. Comparison of the riparian width standard

Function	Sources	Explanation	Riparian width
Review of Literature and International Journals			
Flood protection	[11]	Improve meanders	Two canopy trees
	[7] [9]	100-year flood protection	50 - 90 m
	[14]	Reducing the water level increase	30 m
Regulation regarding Riparian Width Standard			
Flood protection and slope stabilization	Decree of the Minister of Public Works No 28 of 2015; Indonesian Government Regulation No. 38 of 2011	Embankment; urban area	3 m
		No embankment; urban area	10 - 30 m
		Embankment; outside urban area	5 m
		No embankment; outside urban area	50 - 100 m
Standard of riparian width based on morphology, ecology, and hydraulic of river flood			
Flood protection	[17]	Urban area	10 - 50 m
		Urban fringe	30 - 75 m
		Outside urban area	50 - 100 m

Riparian land cover analysis was carried out spatially. The method used was to classify the land cover of riparian landscape into two categories: developed and undeveloped land (Figure 2). The developed land on the riparian includes settlements, public facilities, and public space with non-permeable materials domination. The undeveloped land on the riparian includes riparian vegetation, either natural or cultivated vegetation. Field observation and ground truth check are performed to find out existing land cover in the riparian area of Ciliwung River. Field observation conducted at several locations, such as (1) Sempur, (2) Kedung Halang, (3) Bojong Gede (4) Tirta Jaya (5) Tugu (6) Lenteng Agung and (7) Tanjung Barat.

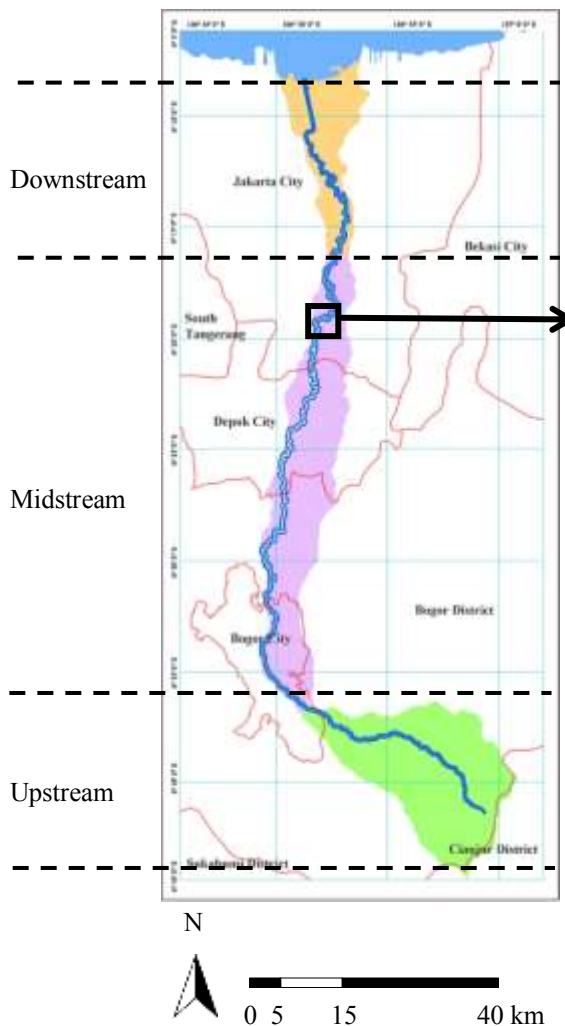


Figure 1. Study site in the riparian midstream of Ciliwung River

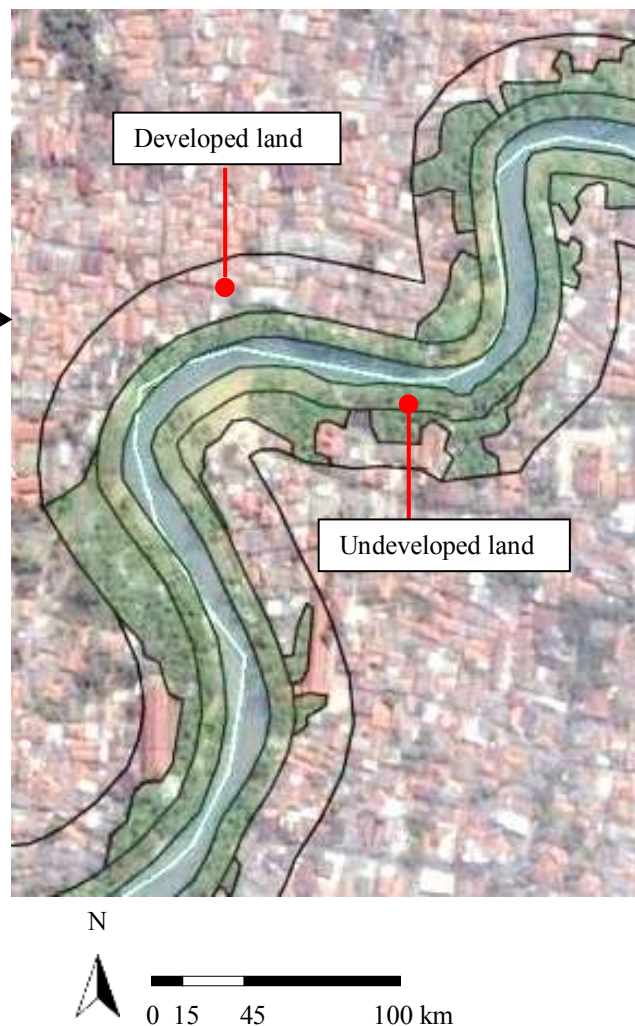


Figure 2. Analysis of riparian land cover at Lenteng Agung, South Jakarta

2.3. Analysis of riparian landscape function and utilization in the midstream of Ciliwung River

The process to determine the function and utilization of riparian used Analytical Hierarchy Process (AHP). This method is a structural technique to analyze complex decisions [21]. Experts who were respondents in this study consisted of (1) experts on Civil Engineering and Water Resources Management, (2) experts on Social and Community-based Management of Riparian Landscape, and (3) experts on Watershed. The experts faced with priority choices of functions and utilization for all segments of the Ciliwung River riparian. The function of riparian is adjusted based on ecosystem services by Arifin and Nakagoshi [3], which is function of (1) water resources management (WRM),

(2) production (Pr), (3) biodiversity conservation (BC), (4) carbon sequestration and stock (CSS), and (5) landscape aesthetic (LA). Utilization of riparian is obtained from the derivative function of the riparian landscape.

2.4. Riparian landscape management in the midstream of Ciliwung River

Riparian landscape management in the midstream was conducted from the result of riparian width and landscape characteristics analysis were combined with the results of the riparian landscape function and utilization. Research approach that used in arrangement of the riparian landscape management was the concept of river restoration with application of eco-engineering [18] as an alternative to the river bank reinforcement with natural materials that not to damage riparian ecosystems. Restoration of river systems is centred on increasing the biodiversity of the system. These results as well as a supporter of the WSC program, that aimed to realize the city become more adaptive to water, both during the rainy season and dry season.

3. Results

3.1. Riparian width determination in the midstream of Ciliwung River Riparian

Based on the region, Ciliwung River riparian is divided into two kinds, that is riparian in urban areas (Bogor City, Depok City, and South Jakarta) and in the outside of urban areas (Bogor District). The width of riparian Ciliwung River in the midstream were determined by considering the three standards, that is (1) the standard width of riparian river with flood protection function, (2) the standard width of riparian based on the Decree of the Minister of Public Works No 28 of 2015 and the Government Regulation No. 38 of 2011, and (3) the standard width of riparian based on morphology, ecology, and hydraulic of river flood [17]. In consideration on runoff during the rainy season and erosion risk on the riverbank or riparian, the determination of the riparian width refers to the analysis, which is 50 m for riparian in the urban areas and 100 m for riparian in the outside of urban areas. This determination are not much different to riparian width standard by Maryono [17]. Riparian width in urban areas is still narrower than in the outside of urban areas, because land demands for development in the urban areas are relatively higher than in the outside of urban areas.

3.2. Riparian landscape characteristic in the midstream of Ciliwung River

The land use of Ciliwung River riparian in the midstream quite varied. Riparian that had been occupied by settlement dominantly can be found in urban areas, like Bogor City (Figure 3), Depok city and South Jakarta. Whereas, riparian land use in form of productive landscape, such as inland fisheries, community garden, and bamboo formation (Figure 4), can be found a little bit in urban areas and dominantly in the outside of urban areas.



Figure 3. Settlement occupation in the midstream riparian of Ciliwung River



Figure 4. Bamboo formation in the midstream riparian of Ciliwung River

Developed land occupation in this segment is 312.41 ha, or 37.11% of total riparian area in the midstream. The remaining area of 529.55 ha is still vegetate area, either natural vegetation such as bamboo, or cultivated vegetation such as mixed graden. Ciliwung River in this segment also has a quite high sinuosity value of 1.88 and in the category of meander river. The river that classified as

meander indicates that the slope of the riverbed in this segment is also relatively ramps and water velocity in this segment is 5 m/s averagely.

3.3. Riparian landscape function and utilization priority in the midstream of Ciliwung River

Based on sensitivity analysis of AHP, in the midstream riparian of Ciliwung River, the function priority is Production (Pr), with a value of 30.6% (Figure 5). The next priority in midstream are Carbon Sequestration and Stock (CSS) 27.7%, Biodiversity Conservation (BC) 25.7%, Water Resource Management (WRM) 23.1%, and Landscape Aesthetics (LA) 21.6%. Although the function of production is a priority in the midstream riparian of Ciliwung River, other functions can also be applied to this segment because the value of priorities were not too significant. The utilization priority in the midstream riparian of Ciliwung River was obtained from the function of production. The utilization for production that already exists in this segment are inland fisheries and community garden. So these utilization will be managed and develop to make sustainable landscape riparian in the midstream of Ciliwung River.

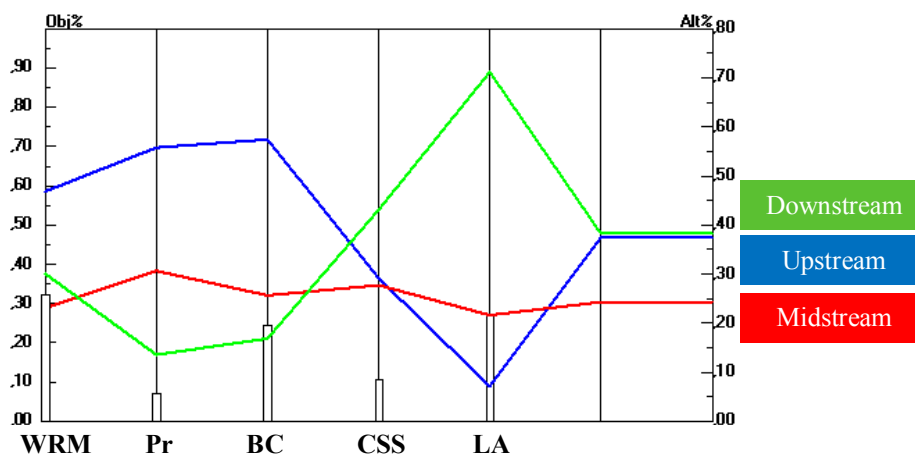


Figure 5. Sensitivity graph of AHP to determine the function of Ciliwung River riparian

3.4. Riparian landscape management in the midstream of Ciliwung River

The approach that used in the concept of Ciliwung River riparian landscape management is the river restoration concept, which is a concept that aims to restore the river in its natural condition. Therefore, developed land such as settlement in the riparian zone must be released and returned as a buffer zone. Strengthening the river banks must no longer with retaining wall or concrete, but by using natural materials (eco-engineering), such as formation of rock, soil and vegetation on the riparian.

Function of production can be realized by making productive community garden and inland fisheries. This garden can be managed by community and the harvest can be used for daily purposes or resold to generate income. Function of water resources management (WRM) is also a very important function, especially in reducing runoff. In the midstream, WRM function is directed at water retention, with the initiation of water retention pond on the outer curved edge of the river (Figure 6). The pond can hold excess water during rainy season and utilized for specific needs, like inland fisheries or waterfront landscape recreation.

4. Discussion

Riparian is a transition zone between terrestrial and aquatic ecosystem which the condition of biotic and abiotic strongly influenced by stream water and ground water [4] [10] [20]. Rapid development that occupies riparian zones had caused damage the ecological function [13] [16] [22]. Therefore, this zones should be protected and free from any massive development (Decree of Minister of Public Works No. 28 of 2015 and Government Regulation No. 38 of 2011). The phenomenon of developed

land occupation in riparian zone is exacerbating the impact of floods in Jakarta and it is one of environmental damage indicator [1] [8].

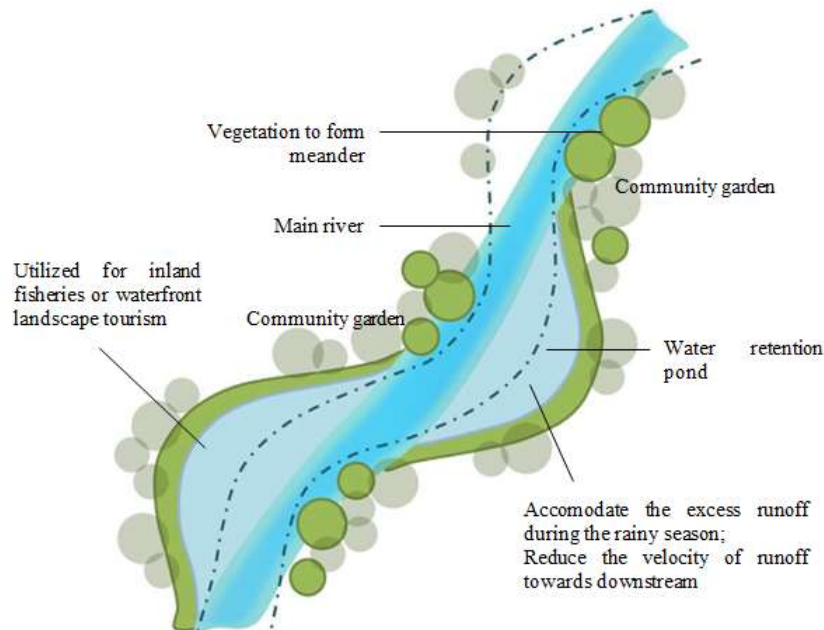


Figure 6. Water retention pond concept on the midstream of Ciliwung River

River management concepts currently applied in Indonesia are still oriented to conventional hydraulic that seeks to discharge water as quickly as possible as toward downstream. Conventional hydraulic concept can even lead to worse flooding effect, because the runoff can not infiltrate to the riparian effectively, then flows even faster and finally accumulated as flooding in the downstream. The bad impact of the conventional hydraulics concept, brings new concepts of river restoration. River restoration aims to restore the river and its riparian zone to its natural conditions, including protection and ecological restoration in areas that have been disturbed by anthropogenic activities [12] [15] [23] [26].

Ciliwung River restoration concept can be combined with a kind of different utilization on each segment. In the midstream, the priority of production function is quite appropriate because there are existing riparian utilization for productive community garden and inland fisheries. However, the existence of productive community garden and inland fisheries have not been well managed and is found only in a few villages. Furthermore, the concept of riparian landscape management for water retention is the initiation of riverside pond. This concept aims to capture the excess runoff during the rainy season. All the concept that had been generated in this study, are the effort to support the Water Sensitive Cities (WSC) program. Water sensitive cities is a road map of a cities to be adaptive for climate and population pressure on urban water [25]. Three principles set the foundation for this vision of a Water Sensitive City, that is (1) cities as water supply catchment, (2) cities providing ecosystem services, and (3) cities comprising water sensitive communities [19].

5. Conclusion

The width of Ciliwung River riparian in the midstream that aims to control the flood, are 50 m for riparian in urban areas and 100 m for riparian in the outside of urban areas. Developed land has occupied 37.11% of Ciliwung River riparian in the midstream, and the rest is undeveloped area that covered 62.89% of total riparian zones in the midstream of Ciliwung River.

The function priority of Ciliwung River riparian in the midstream that was obtained from AHP is for production. The priority utilization for production are productive community garden and inland

fisheries. Concept of riparian landscape management in the midstream would be directed as water retention with the initiation of water retention pond on the river bank to increase water storage volume, so it can reduce runoff during rainy season.

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