A study of cisadane riverside on riverbank development towards urban sustainability

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Abstract. Rivers have immense benefits for the environment and community. They become one of the water resources for the community and an option for community recreation area. Rivers also provide habitat and balance the ecosystem for the environment. Currently, the community is neglecting many rivers in that their water becomes polluted and unusable. This is the reason behind the existence of riverbank development, including in Cisadane Riverside located in Tangerang, Indonesia. This study was carried out in Cisadane Riverside to observe and analyse the elements that constructed the riverbank as public facilities toward sustainable pillars: environment, social and economy for urban sustainability. Observation and interview were conducted in six zones along the Cisadane Riverside. Regarding the riverbank development, it is important to pay attention to the environmental aspect to maintain the urban ecology while achieving the social and economic aspects. In conclusion, the riverbank development that considered the integrated environment, social and economic aspects would create the activity and interaction space for supporting both the urban sustainability particularly for the riverbank itself. The result of this study would be used as the reference for riverfront development towards urban sustainability in Indonesia.

Keywords: riverbank, urban sustainability, ecology, public facilities

1. Introduction
A river is a water flow that forms naturally. The urban river splits and gives impacts to the communities around. The benefits of river for the community and environment include water supply, transportation, water container and biodiversity of flora fauna.

A border area where river meets the city is called riverfront [1]. Riverfront, as one of city’s elements that has been developed, affects urban sustainability. Nowadays, many rivers have been polluted so that they cannot be used by the community anymore and affect the urban ecology adversely. Riverbank is an area that lies between river edge and main lane of the city or minimum six metres from nearest mainland to the river’s edge [2]. It often becomes a neglected area that harms the environment and its community. Some efforts are carried out by the government to improve both the riverbank and the river itself. Those efforts are activating the riverbank and improving the environment quality that can affect the community activities. The sustainability can be reached only if environment, social and economy aspects are well integrated [3].

According to Breen and Rigby [4], environmental aspects, the biodiversity of flora fauna along with the cleanliness of water and environment, affect the human’s health and water resources for the
community. Social aspect is in the form of recreation, physical activities, tourism and entertainment from commercial area, such as café, restaurant or shopping area [5]. Meanwhile, economic equality comes from opportunity in economic development, such as local business or tourism [6].

The riverbank development in Cisadane Riverside was selected to be the case study in this research. The study was carried out in a city where riverbank development was conducted with positive impacts for public space users along the Cisadane Riverside. Besides that, it was chosen as the case study because of its location between the river edge and city’s main road. The purpose of the study is to review and analyse the element and its impacts on riverbank, which is part of a riverfront development as public facility towards the environmental, social and economic aspects so that it affects urban sustainability.

2. Methods
This study employed quantitative approach. Observation and interview were methods used in the case study of riverbank as part of riverfront development. The study duration was three weeks between April to May 2019. The case study location was the riverbank along Cisadane Riverside area in Tangerang, Indonesia. This study was conducted partially within five-kilometre-long and divided into six zones as shown in ‘Figure 1’ below.

![Figure 1. Cisadane Riverside maps and the existing condition](source: Google Maps and personal documentation)

The observation was carried out based on parameter of elements that supported its sustainability [5]. Other than observation, interview was done to fifteen respondents from each zone between 14 to 60-year-old, as they were highly active users of this public space. The questionnaire was administered to observe the impacts of riverbank development from the users’ perspectives and to enhance the observation result. The aspects for the parameter were as follows:

- Accessibility: physical and visual accesses to the riverbank, along the riverbank, to the water and vehicle access;
- Recreation area: activities, tourism, access to the water and culinary area; and
- Natural and built environment: vegetation, surface and supporting facilities.
3. Discussion
Based on the study of riverbank in Cisadane Riverside, six zones attracted the surrounding community and became the spaces for their activities. The users’ occupations in each zone were diverse as shown in the picture below.

![Figure 2. The graph of users’ occupations in Cisadane Riverside areas](image)

The ‘Figure 2’ above shows that the land use context around riverbank area affected the kinds of users in the riverbank. Zone A, Zone B, Zone C and Zone D that are surrounded by residential areas are dominated by students who mostly lived around the river. Zone E is located across the residential areas and surrounded by commercial areas, such as offices, shops and health facilities, so it is dominated by workers. Zone F is located far away from residential area, thus the users are people who pass or transit only in the riverbank. They are normally housewives who accompany their children to play in the riverbank development.

3.1. Accessibility
Accessibility supports the intensity of the users. It can be the access of community to the riverbank, vehicle access and access to the water. Furthermore, it includes visual and physical accessibility. The visual accessibility supports the existence of the riverbank by giving a visual connection from the environment to the riverbank and vice versa. According to Betsy (2004), physical access is available through stairs, ramp, pedestrian, and roads [7].

| Zone A | Zone B | Zone C | Zone D | Zone E | Zone F |
|--------|--------|--------|--------|--------|--------|
|        |        |        |        |        |        |
| 18 cm<sup>a</sup> | 16 cm<sup>a</sup> | 7 cm<sup>a</sup> | 25 cm<sup>b</sup> | X      | 17 cm<sup>a</sup> |
| 25 cm<sup>b</sup> | 45 cm<sup>b</sup> | 30 cm<sup>b</sup> | 35 cm<sup>b</sup> | Ceramic<sup>c</sup> | 59 cm<sup>b</sup> |
| Concrete<sup>c</sup> | Concrete<sup>c</sup> | WPC<sup>c</sup> | Ceramic<sup>c</sup> | Ceramic<sup>c</sup> | Ceramic<sup>c</sup> |
| X      | X      | 1:3<sup>d</sup> | X      | X      | X      |
| 80 cm<sup>e</sup> | 80 cm<sup>e</sup> | 80 cm<sup>e</sup> | 150 cm<sup>e</sup> | 80 cm<sup>f</sup> | 162 cm<sup>e</sup> |
| 120 cm<sup>f</sup> | 50-250 cm<sup>f</sup> | 50-200 cm<sup>f</sup> | 30 cm<sup>f</sup> | 20 cm<sup>f</sup> | 30-200 cm<sup>f</sup> |
| Conblock<sup>g</sup> | Concrete<sup>g</sup> | Conblock<sup>g</sup> | Conblock<sup>g</sup> | Conblock<sup>g</sup> | Ceramic, conblock<sup>g</sup> |
| X      | X      | X      | X      | X      | 120 cm<sup>b</sup> |
| Vehicle access | X | X | X | X | X | X |

*Table 1. Physical access in A-F riverbank development zones*

*Source: observation result*
Access to the water

| Access to the water | √ | X | √ | √ | X | X |
|---------------------|---|---|---|---|---|---|
| a Riser stairs      |   |   |   |   |   |   |
| b Thread stairs     |   |   |   |   |   |   |
| c Material stairs   |   |   |   |   |   |   |
| d Ramp              |   |   |   |   |   |   |
| e Pedestrian width  |   |   |   |   |   |   |
| f Tree's distance   |   |   |   |   |   |   |
| g Pedestrian material |   |   |   |   |   |   |
| h Cycleways width   |   |   |   |   |   |   |

X: the parameter is not found
✓: the parameter is found

‘Table 1’ above shows the physical access in each zone. The vehicle access is only available in Zone C, Zone E and Zone F. Every zone has their adequate access to the riverbank yet only three of six zones that have access to the water. Those are Zone A, Zone C and Zone D. However, Zone A is quite special because this is the only place where community can get direct access to the water. Here, some community members still use the water to wash their clothes and take a bath as a form of annual community’s tradition. Additionally, Zone D is a place for paddling.

3.2. Recreation Area

Riverbank development on Cisadane Riverside opens an opportunity to be a recreation area for the community. The activities performed by the users are relaxing, playing, eating, working and water activity such as paddling.

Based on the results of observation and interview, ‘Figure 3’ above shows that each zone accommodates at least three activities for the users except Zone E that accommodates five activities. This recreation area is not only improving the social aspect for community but also opening job opportunities. The observation result shows that in these six zones of the riverbank development there two categories recreation area: (1) tourism and (2) culinary area.

3.2.1. Tourism

Tourism appears due to the existence of riverbank development in the form of public space that can be used by every community member without exception [8]. From the six zones of the riverbank development in Cisadane Riverside, four public spaces with different functions are available and served as a place for leisure activities. Those places are promenade, plaza, playground and amphitheatre.

- Promenade

According to The Claude Worthington Benedum Foundation (n.d.), promenade is a moving space along the river that gives different point of view throughout the river [9]. In this area, promenade is located in four out of six zones included Zone A, Zone C, Zone D and Zone E. Promenade that provides shade trees attract people, so it forms similar activities in Zone A and Zone C.
• **Plaza**
  Plaza should be provided by shading that can be created from the trees or building. Plaza is only located in Zone C and Zone D with no shades at all except in Zone D that is provided by building shades in front of the plaza.

• **Playground**
  Playground is located in Zone B, Zone E and Zone F. Surface is one of the considerations in playground because it can be dangerous for the children who use it. Moreover, most of the playgrounds in this riverbank is using ceramic. The surface can become slippery, especially during and after raining, except zone B that uses paving block. Although zone B is covered by paving blocks, bumpy paving blocks can also harm the children who play along the playground in zone B.

• **Amphitheater**
  Amphitheater can only be found in Zone E. It is used by the visitors for sitting around and eating. This amphitheatre is covered by non-slippery ceramic, so it is quite safe for people to do some activities.

3.2.2. **Culinary Area**
Tourism and the usage of public space generated by riverbank development has increased the economic opportunity for the community around Cisadane River. Based on the interview, those economic opportunities include selling foods and beverages and also tourism organization. Some people who live around Cisadane River are offered to sell foods and beverages, such as in Zone A and Zone D.

![Figure 4. Culinary areas in Zone A, Zone D, Zone E and Zone F](source: personal documentation)

‘Figure 4’ shows that not all zones have culinary area. Moreover, only Zone A and Zone D are allowed as culinary areas by the riverbank development management. However, street vendors also utilize the spaces in the riverbank for trading, such as in Zone B, Zone E and Zone F. For the traders, riverbank development increases the number of visitors in the area.

In order to keep the cleanliness in every zone, the riverbank development management provides waste bin near the stall. Besides that, the traders are cooperated with the riverbank development management in cleaning program, which is done by the tourism organization. The tourism organization collects all the garbage from the waste bin and around the riverbank environment to keep the riverbank’s environment clean.

3.3. **Environment**
Environment in the riverbank includes natural environment, built environment and its supporting facilities. Vegetation is part of natural environment, which is shown in buffer area. Buffer area is a treated area that makes vegetation as its component so it can solve the environment problems, such as water quality and resist soil erosion [7]. Native vegetations are used because of their ability to adapt to their original environment, flood mitigation and increase the biodiversity of flora and fauna [8]. Built
The environment is in the form of the pedestal surface. Grass can be used as the surface of the riverbank, which can increase the ecology value and environment aesthetic as infiltration area [7].

**Table 2.** Natural environment, built environment and its supporting facilities in every zone

|                | Zone A                  | Zone B                  | Zone C                  | Zone D                  | Zone E                  | Zone F                  | Standard               |
|----------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|
| **Height**     | 250 cm                  | 200-400 cm              | 200-250 cm              | 150-350 cm              | 200 cm                  | 200 cm                  | Min. 210 cm            |
| **Tree pits**  | Concrete                | Conblock                | Conblock                | Conblock                | Conblock                | Conblock                | Concrete/brick         |
| **Distance**   | 150 cm                  | 250 cm                  | 350 cm                  | 30 cm                   | 30 cm                   | 50 cm                   | Min. 75 cm             |
| **River border**| Soil and grass vegetation| Soil, grass, vegetation| Soil, grass, vegetation| Concrete                | Concrete                | Soil, vegetation         | Vegetation             |
| **Material**   | Concrete, conblock      | Conblock                | Conblock, WPC           | Conblock, ceramic, Grey| Conblock, ceramic, Grey| Conblock, ceramic, Grey| Conblock, ceramic, Grey|
| **Colour**     | Grey                    | Grey, red               | Grey, brown             | Grey, brown             | Grey, brown, red        | Grey, pink, cream       | Earth tone             |
| **Height**     | 46 cm                   | 45 cm                   | 36 cm                   | 50 cm                   | 43 cm                   | X                       | 45-50 cm               |
| **Supporting** | X                       | X                       | ✓                       | ✓                       | ✓                       | ✓                       | ✓                      |
| **Height**     | 120-450 cm              | 300 cm                  | 300 cm                  | 450 cm                  | 200-300 cm              | 250-300 cm              | 300-600 cm             |

*aVegetation *bSurface *cBench (supporting facilities) *dLamp (supporting facilities)

‘Table 2’ shows the natural and built elements in each zone. Only four out of six zones meet the standard of river border that should be consisted of vegetation. Every zone is covered by conblock yet they still have another material such as concrete, WPC, ceramic or brick, which affects the environmental aspect that responds to the rainwater. The other parameters, such as distance between trees and trees height, give impact to humans who use the area that will in turn affect the users’ comfort and eventually leads to usability of the riverbank development. The existing condition in each zone can be found in ‘Figure 5’ and ‘Figure 6’.

‘Figure 5’ shows the riverbank development in Zone A, Zone B and Zone C. Those zones are equipped with buffers and many vegetations that are planted in each zone. Buffers in Zone A, Zone B
and Zone C are functioned as water absorption areas. All of them still have pedestal surface yet only Zone A and Zone C have the access to the river. The buffer zone, which is planted by vegetation, keeps each zone from the flood risk. Moreover, cleaning activities carried out by the tourism organization keep the riverbank, especially Zone A which has the direct access to the river, clean and avoid the flood risk.

![Figure 6. Condition in Zone D, Zone E and Zone F](image)

Source: personal drawing from observation result

‘Figure 6’ above shows the condition in Zone D, Zone E and Zone F. Zone D and Zone E have different condition with ‘Figure 5’ which has buffer. They have no buffer and other water absorption area because almost all the surfaces in Zone D and Zone E are covered with ceramic and conblock. That condition brings negative impacts for the environment as it may increase the flood risk. Different from those two zones, Zone F has buffer and it is dominated by vegetation because of its function as city’s forest. Zone F is mostly covered by soil and grass, which are beneficial for the ecology in that zone. Grass can maintain air humidity, prevent erosion and absorb rainwater [10].

Riverbank development gives positive impacts for communities’ economic condition, but it will also give negative impacts for the environment and human’s health if people do not care of the environment properly. A simple case is by throwing the garbage in the waste bin. This is proven by plastic garbage scattered around in every zone, especially Zone B and Zone E. That garbage can cause flood if it continuously accumulates and clogs the sewer line and river. Beside plastic garbage, leaves are strewed in Zone C and Zone F, yet they do not disturb the activities as well as the view in those zones.

3.4. Sustainability Elements in Every Zone
From those six zones, every zone is multifunctional area used as community activity spaces for recreation and working. The function in every zone is different. However, each zone has relaxation area as its main function. The similarity of function in every zone allows the community to enjoy the space in every zone with the same function. If the community is aware of the environmental impacts as one of the sustainability aspects, then Cisadane River in Kota Tangerang can be used continuously. Moreover, the different functions give every zone unique characteristics to be enjoyed by every user with different needs.

Not only community, the riverbank development also affects the environment in increasing the vegetation amount, which then improves the absorption area so that the flood risk will decrease. Besides that, vegetation gives shading for the riverbank and changes the structural roof into vegetation that can produce oxygen and invite habitat for flora and fauna, such as butterfly and birds. The multifunctional area shows that Cisadane Riverside uses blue-green networks that are useful for community as the user and the environment. The blue-green networks are one of the ways that have been done to create connection from the water elements, such as river and canal, with vegetation elements, such as park and open spaces from the city so that it can benefit the community and its
environment [11]. Blue-green networks increase the accessibility, connectivity, economy and recreation because of their multifunctionality [12].

Those six zones open job opportunities for the community members to trade or organize tourism activities. The ability of every zone to open job opportunities constitutes economic aspects to reach the urban sustainability in every zones of the riverbank development in Cisadane Riverside.

Table 3. Riverbank development zones that support sustainability based on their aspects

|   | Environment | Social | Economy | Notes                                      |
|---|-------------|--------|---------|--------------------------------------------|
| A | ✓           | ✓      | ✓       | Buffer, access, multifunctionality, working area |
| B | ✓           | ✓      | X       | Buffer, access, multifunctionality          |
| C | ✓           | ✓      | ✓       | Buffer, access, multifunctionality, working area |
| D | X           | ✓      | ✓       | Access, multifunctionality, working area    |
| E | X           | ✓      | X       | Access, multifunctionality                  |
| F | ✓           | ✓      | ✓       | Buffer, access, multifunctionality, working area |

From the six riverbank development zones that have been observed and analysed based on riverfront development principal in ecological ways, Zone A, Zone C and Zone F are the ones that can support the urban sustainability (see Table 3). Those three zones apply buffer as border area between river and the riverbank although they still use concrete as the border to the other urban’s spaces. The existence of buffer allows riverbank development to conserve the environment and control the rainwater.

The only aspect that can be found in every zone is access. It is one of the social aspects that keeps community connected to use the riverbank and the river itself. The other social aspect that supports the sustainability is multifunctionality of the area. This drives the community to keep using both in the future and in turn retain the existence of the riverbank and make it sustainable.

Economic improvement takes place due to the riverbank development that shows the support for surrounding communities by providing them with working area. Working area is provided in Zone A and Zone B as selling area and Zone C and Zone F as tourism organization. Zone D did not show the the balance between those three aspects so it cannot be said that it supports urban sustainability. The environment aspect is missing because there are lots of impermeable surface and the absence of buffer decreases the absorption area.

4. Conclusion

Based on the study of the riverbank development in Cisadane Riverside, it can be concluded that the riverbank in the riverfront development creates activities in support of sustainability and river sustainability. It gives impacts to community and its environment by providing the community a space for doing activities with the river water, supporting recreation activities and community’s economy. River and riverfront are part of urban elements that affect its existence and sustainability. Therefore, the damage of riverbank, part of the riverfront, as a space to fulfil the community’s needs will affect the existence of community in that city. From the social point of view, it is proven that destroyed environment will not fulfil the community activity needs anymore in term of recreation. Besides, it may also cause economic issues in the form of losing job opportunities for some people in the community.

Environmental, social and economic aspects in the riverfront development are interrelated and affecting one another so that they should be maintained to support the sustainability. If one of the aspects is missing, it will affect the other aspects and impact the overall function of the riverbank. On the other hand, if all the aspects from riverbank in the riverfront development are fulfilled then the
sustainability is feasible. Furthermore, the communities around the riverfront will also continue to exist and so will the urban sustainability.

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