Land Use Change of Cisadane River Buffer Strips, South Tangerang City, Indonesia

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Abstract. A river buffer strip is a vegetated area along river water bodies that protect and conserve river functions and eco-drainage of watershed. Currently, buffer strip quality has degraded by many land use conversion to settlement area. The critical condition of river buffer strip is more vulnerable in urban areas. Urbanization is also a driving factor for emergence of settlements at the banks of river in urban area. This land conversion may disrupt ecological functions of river buffer strips as well as river functions. The disruption of river functions may increase flooding risk that would be harmful to human community as well. Cisadane River is a large river that crosses many cities - one of them is South Tangerang City. This study aims to map and analyse land use changes in Cisadane river buffer strip. Land use change analysis based on satellite image data coverage in 2010 and 2015 using Geographic Information System. Source of land use data from google earth image. The result showed that in 5 years period, land built up has increased up to 1.04%, agricultural land has decreased up to 2.24%, the shrubs has increased up to 13.40%, open field has increased to 2.49%, stands vegetation has decreased to 15.73%, and water bodies has increased to 1.04%. The land use changes of Cisadane River buffer strips show a negative change - there is increasing built up land, open field, and shrubs; but declining stands vegetation. Changes in land use also do not disregarding river buffer designation; therefore those changes can disrupt ecological functions and give negative impact to river and watershed.

1. Introduction
River buffer zone or river borderline is located on the right side and the left side of and along the river. River buffer zone, based on UU No. 26 of 2007 on Spatial Planning, is one of local protected areas included in river-protected area. Naturally, river buffer zone reserved for vegetation for eco-hydrological function protection [1]. The vegetation along river buffer called riparian buffer strips [1,2]. Riparian buffer strips are trees, shrubs, and grasses [3] Riparian buffer strips have riparian ecosystems conservation and eco-drainage control functions on watershed [4]. Riparian buffer strips are an integral part and important component of watersheds worldwide although they only represent a fraction in total land area composition, hence its hydrological and ecological functions should be consider in watershed management [4].

Based on PP No. 38 of 2011 on the River, it is not allowed to build any building on river buffer zone. However, especially in urban area, there are many changes in land-use on river buffer zone, to become settlements, agricultural area, or other uses that are inappropriate [5,6,7,8]. The riverside community’s behavior also decreases river buffer functions. They generally dispose their waste in river buffer and streams [9,10]. The effect of this condition is the disruption of buffer and river functions so that the risk of flooding that can harm humans life also increases. River buffer strips need to be protected because of their hydrological risks such as flooding and erosion [11].

This study aims to map and analyze changes in land use of river buffer strips of Cisadane River
of South Tangerang City. This study is important because Cisadane River is a large river that crosses several cities. It is a main river of Cisadane watershed and based on the Strategic Plan of the Directorate General of Watershed Control and Protected Forest 2015-2019, Ministry of Environment and Forests, Cisadane watershed is one of 15 watersheds classified as priority watershed category [12]. One of the cities crossed by Cisadane River is South Tangerang City - one of Jakarta's Special Capital Region buffer areas that affected by massive development of DKI Jakarta that encourage the urban development and urbanization in South Tangerang [13, 14]. Continued urbanization changes the very nature of eco-hydrological regimes of watersheds and increases their vulnerability to flooding, soil loss, and water pollution [11]. The results of this study can be used as a basis in urban development that considers hydrological risks and in accordance with spatial and regional plans, especially in river buffer.

2. Area of Study and Data
This study conducted in Cisadane River segment in South Tangerang City with starting point A to end point B (Figure 1). The length of segment covers 20.15 km, with 30 m width. This segment is included in the middle stream of Cisadane watershed.

![Figure 1. Location of study area](image)

This study used high-resolution satellite image data obtained through downloading available data using Google Earth application. The image data are available in June 2010 and December 2015. The difference based on the current year used to see land use changes that classified as built-up land, agricultural area, shrubs, open field area, stands vegetation, and water bodies in Cisadane River buffers in South Tangerang City.

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3. Methodology
Land use data and changes derived from interpretation process through qualitative classification or visual analysis by delineating on-screen digitizing using geographic information system software. The delineation process carried out in an area previously marked as river buffer through buffering process with a width of 30 m on river body. Then, ground check conducted after image interpretation activity. The ground check should be perform to verify the image data satellite interpretation with actual land use on river buffer.

Land use change known by calculating percentage of decrease or increase in river buffer use. Increasing open field area, built-up land, agricultural area, shrubs, and vegetation decline show a negative change in conditions of Cisadane River buffer in South Tangerang City.

4. Result and Discussions
Land use change of buffer area of Cisadane River in South Tangerang City over the period of 5 years presented in Table 1.

| No | Notes               | Area (ha) 2010 | Area (ha) 2015 | Changes (ha) | Changes (%) |
|----|---------------------|----------------|----------------|--------------|-------------|
| 1  | Built-up Land       | 2.46           | 3.11           | 0.64         | 1.04        |
| 2  | Agricultural Area   | 7.02           | 5.65           | -1.38        | 2.24        |
| 3  | Shrubs              | 17.36          | 25.57          | 8.22         | 13.40       |
| 4  | Open Field Area     | 0.05           | 1.58           | 1.53         | 2.49        |
| 5  | Stands Vegetation   | 34.01          | 24.37          | -9.64        | 15.73       |
| 6  | Water Bodies        | 0.40           | 1.04           | 0.64         | 1.04        |
|    | **Total**           | **61.31**      | **61.31**      |              |             |

Land use change of Cisadane River buffer area in South Tangerang City as a whole (Table 1) show that there was a negative changes by increasing built-up land area by 0.64 ha (1.04%), increasing shrubs by 8.21 ha (13.4%), increasing open field area by 1.53 ha (2.49%), and decreasing stands vegetation by 9.64 ha (15.73%). These negative changes are closely related to changes in vegetation cover in river buffer that have eco-hydrological functions for river and watershed protection.

Vegetation cover can lower the land surface erodibility and reduce the risk of soil erosion [15]. Furthermore, denser vegetation slows overland water flow, the root systems of trees and shrubs play an important role in decreasing runoff by improving soil characteristics, the interception of raindrops by denser vegetation also decreased the velocity of raindrops and prevented them from directly impacting the soil surface particles, and it improves the soil porosity and organic matter content, thus increasing the infiltration rate and decreasing erosion and runoff [15]. Therefore, the vegetation cover in buffer area is necessary to play the significant role in carrying out its eco-hydrological functions.

Increased vegetation cover lost due to land use change for built-up land, open field area, or decreasing stand vegetation in the river buffer will decrease their eco-hydrological function. The built-up land referred to in this study is not only houses but also includes other buildings such as road and office or companies (Figure 2).
Built-up land will increase as urbanization increases. As a result, impervious land will also increase so that the run-off will also increase [16].

This study also found that the biggest land use change is decreasing stand vegetation (15.73%). Land use change of forest area and agricultural strongly affect eco-hydrological regimes of watersheds and make them vulnerable to floods, soil loss, and eutrophication [11]. It is also has strong influence on soil erosion and sediment transport rates that will negatively affecting water supply, reservoir storage capacity, and freshwater ecology of the river [17].

The largest land use in Cisadane River buffer area is shrubs (25.57 ha). Ecologically, shrubs still give a role for river protection as vegetation cover. However, tree planting would enhance the protection better than shrubs area. Trees have higher functionality in providing wetland and wildlife habitats as well as flood protectors - a function that less provided by shrubs [18]. The combination of trees and shrubs will be better in carrying out eco-hydrological functions in buffer area. Forests provided more canopy cover (greater than 30%), shrubs, and dense grasses reduced soil loss more than woods (10 to 30% cover) and sparse grass [15]. Furthermore, stated that vegetation restoration can improve the effectiveness of land cover and reduce susceptibility to soil erosion.

Land use change that have a positive impact are decline of agricultural area. The change in land use from agricultural to uncultivated lands has been shown to reduce land loss [17]. Agricultural area might disrupt river water conditions, since it reduces river buffer strips functions to protect from scraping and erosion. Land damage will occur as soon as vegetation such as forests, shrubs, or grasses cleared off for crops [2]. The land damage is increasing if type of crops planted is cassava and peanut - the type of plant that harvested by removing tubers from the soil (Figure 3). This harvesting method will damage soil structure, thus soil particles will be easily released. The amount of soil loss was higher in cultivated land compared with natural vegetation due to the loss of vegetative cover and the detachment of soil particles [15].
Cisadane river buffer strips of South Tangerang City divided into three parts: Setu sub-district, Serpong sub-district, and North Serpong sub-district with different characteristics.

4.1. Land-use changes of river buffer strips in Setu Sub-district
Setu sub-district is the southernmost part of Cisadane River in South Tangerang City. Land use changes of river buffer strips in Setu generally have a negative change (Table 2).

The largest land use in this part is for shrubs (9.75 ha) and agricultural area (4.37 ha). The use of river buffer for agricultural area in this part is the most extensive one in comparison to other parts. The agricultural sector in Setu Sub-district is still high. Setu Sub-district has the widest area of paddy field commodity in comparison with other sub-districts in South Tangerang City, i.e. 58 ha in 2014 [19]. The next largest harvest area is corn commodity that covers 42 ha and 31 ha of peanuts [19]. The reason for this is many people in this sub-district still do agricultural activities. Agricultural commodities such as paddy and peanuts are found in this buffer part (Figure 4). The decreasing stand vegetation stands vegetation are relatively low (1.85%), because the stands vegetation area in this part is relatively limited (9.95%).

Table 2. Land-use changes on Cisadane river buffer strips in Setu sub-district of South Tangerang City

| No | Land Use            | 2010  | 2015  | Changes | 2010  | 2015  | Changes |
|----|---------------------|-------|-------|---------|-------|-------|---------|
| 1  | Built-Up Land       | 0.40  | 0.44  | 0.04    | 2.35  | 2.60  | 0.25    |
| 2  | Agricultural Area   | 5.46  | 4.37  | -1.09   | 32.26 | 25.81 | 6.45    |
| 3  | Shrubs              | 8.66  | 9.75  | 1.09    | 51.12 | 57.58 | 6.46    |
| 4  | Open Field Area     | 0.02  | 0.29  | 0.27    | 0.11  | 1.73  | 1.62    |
| 5  | Stands Vegetation   | 2.00  | 1.69  | -0.31   | 11.80 | 9.95  | 1.85    |
| 6  | Water Bodies        | 0.40  | 0.40  | 0.00    | 2.36  | 2.36  | 0.00    |
|    | Total               | 16.94 | 16.94 | 100     | 100   | 100   | 100     |

Figure 4. Agriculture area on river buffer strips (left: rice fields and cassava, right: peanuts)
Source: Researcher documentation (2017)

4.2. Land-use changes of river buffer strips in Serpong Sub-district
Serpong Sub-district is located at middle parts of Cisadane River in South Tangerang City. Land use changes of this part generally also show a negative change. This indicated by increasing built up land, shrubs, open field area and decreasing stands vegetation within 5 years (Table 3).

Serpong Sub-district is a region with a high economic level. This is because of BSD developer that absorbs a lot of labor [20]. BSD developer dominates Serpong Sub-district and housing area in BSD region is included in elite housing in South Tangerang City [14]. Some of housing is located at river buffer, even though the house is still far from river borderline. Yet, some housing fences built up at the river buffer area. However, to note is a compliance of developer for not building anything on river buffer area. It is due to rules and regulations that there should be no building whatsoever in
river buffer area. The land included in river buffer area should be categorized under social and public facilities.

This part has the largest stands vegetation area but also the largest decline (13.58%). The increase of open field area is also relatively large (6.49%). The loss of vegetation will remove vegetation role to protect river in eco-hydrology function. This condition can disrupt the river functions and increase runoff, flooding risk, and soil lost [11,15,16,17].

### Table 3. Land-use changes on Cisadane river buffer strips in Serpong sub-district of South Tangerang City

| No | Land Use         | 2010 | 2015 | Changes | 2010 | 2015 | Changes |
|----|------------------|------|------|---------|------|------|---------|
| 1  | Built up land    | 0.57 | 0.86 | 0.29    | 2.97 | 4.48 | 1.51    |
| 2  | Agricultural area| 0.61 | 0.32 | -0.29   | 3.18 | 1.68 | 1.51    |
| 3  | Shrubs           | 5.90 | 7.05 | 1.15    | 30.65 | 36.63 | 5.98 |
| 4  | Open field area  | 0.01 | 1.26 | 1.25    | 0.07 | 6.56 | 6.49    |
| 5  | Stands Vegetation| 12.15| 9.53 | -2.61   | 63.14 | 49.55 | 13.58 |
| 6  | Water bodies     | 0.00 | 0.21 | 0.21    | 0.00 | 1.10 | 1.10    |
|    | Total            | 19.24| 19.24|         | 100  | 100  |         |

4.3. Land-use changes of river buffer strips in North Serpong Sub-district

North Serpong sub-district is the northernmost part of Cisadane River in South Tangerang City, close to the downstream of Cisadane watershed. Land use change of this part generally also show a negative change (Table 4).

### Table 4. Land use change in Cisadane river buffer strips in North Serpong sub-district South Tangerang City

| No | Land Use         | 2010 | 2015 | Changes | 2010 | 2015 | Changes |
|----|------------------|------|------|---------|------|------|---------|
| 1  | Built up land    | 1.50 | 1.80 | 0.31    | 5.95 | 7.18 | 1.23    |
| 2  | Agricultural Area| 0.94 | 0.95 | 0.01    | 3.76 | 3.78 | 0.03    |
| 3  | Shrubs           | 2.81 | 8.78 | 5.97    | 11.16 | 34.92 | 23.76 |
| 4  | Open Field Area  | 0.02 | 0.02 | 0.00    | 0.08 | 0.09 | 0.01    |
| 5  | Stands vegetation| 19.86| 13.15| -6.71   | 79.05 | 52.32 | 26.72 |
| 6  | Water Bodies     | 0.00 | 0.43 | 0.43    | 0.00 | 1.71 | 1.71    |
|    | Total            | 25.13| 25.13|         | 100  | 100  |         |

Built-up land use on Cisadane River buffer in this part is the largest one in comparison to other parts, i.e. 1.80 ha (7.18%). The built up land in this sub-district also increased by 0.31 ha (1.23%). North Serpong sub-district, based on field observations, is a densely populated area. In this part, there are many settlements built in river buffer area. The more buildings in the river buffer area, the more loss in vegetation cover, hence eliminating its eco-hydrological functions. Based on field observations, behavior of riverside community also add river burden since they dispose waste in river body and river buffers (Figure 5).

North Serpong sub-district development is different from Serpong and Setu sub-districts. This sub-district has more industries, comprises of 3 convection industries, 5 food and beverage industries, 2 paper industries, 2 rubber/plastics industries, as well as 1 chemical industry and 1 industry of metal goods [21]. Industries located near Cisadane River found are paper industry and shoes industry. The large number of industries in this region provides many employment opportunities. This condition also encourages increasing settlements building in river buffer area. Some people encountered during field research were retired workers from that industries.
Overall, the use of stands vegetation area in Cisadane River buffer strips in South Tangerang City has decreased in three parts. In contrast, the use of open field area, built-up land, and shrubs have increased in all three parts. More further to north area, there is higher number of decreasing stands and the wider built up land area. Percentage of shrubs use is still relatively large in 3 sub-districts, i.e. Setu sub-district is 57.58%, Serpong sub-district is 36.63% and North Serpong sub-district is 34.92%. Shrubs are one of potential land uses for trees enrichment planting in river buffers because its vegetation component could still be optimize, so that riparian buffer vegetation functions more optimal.

The three parts have their own characteristics. In Setu sub-district there are still many agricultural practices, in the Serpong sub-district there are many housing around the buffer, and in the North Serpong sub-district there are industries around the buffer and many settlements appear on the buffer area. Based on overall analysis, parts that have the highest rate of changes are the North Serpong sub-district. The high decline in stands vegetation, the increase in built-up land, and waste problem will be a challenge in the future that must be considered.

Based on land use analysis in Cisadane River buffer in South Tangerang City, the use of settlement land or built-up land has found. This result is in accordance with some research in Indonesia [6,7,8]. The existence of similar conditions showed there are several river buffer strips area in Indonesia converted into settlements, even though it categorized under protected areas that are not allowed for buildings. Therefore, the implementation of existing regulations must be carried out to maintain the river buffer strip for the maintenance of their eco-hydrological functions.

5. Conclusion and Recommendation
The results of the study showed that changes in Cisadane River buffer strips of South Tangerang City showed a negative change with decreasing stands vegetation and increasing open field area, built-up land, and shrubs area. Therefore, a strategy is need to stop stands vegetation decline and upgrading built-up land, as well as to increase vegetation cover and composition in open field and shrubs area to maintain eco- hydrology functions of river buffers. This result can be used as a basis in urban development process, and to give more attention on spatial and area planning of city.

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