Community structure of tree at three location points of Ciliwung riparian zone in Depok–South Jakarta

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Abstract. Rapid urban development leads to changes of vegetation community structure in the riparian zone. Research on tree community structure has been done at 3 location points of Ciliwung riparian zone in Depok–South Jakarta with different habitat condition. Habitat at location 1 is known to be natural, habitat at location 2 has undergone land use conversion, and habitat at location 3 has undergone river bank concretization. This study aimed to compare tree community structure in the 3 locations. We used plot method for data sampling. A total of 4 plots at each location with size of 20x20 m were determined purposively. The results showed that the 3 locations showed differences in the tree community structure. Compositions of tree at location 1, 2, and 3 respectively consists of 11 species in 8 families, 14 species in 10 families, and 4 species in 4 families. Overall, all three locations have low to moderate level of tree diversity (H’ 1.26–2.3) and high level of tree evenness (E 0.81–0.90). Based on Importance Value (IVi), location 1, 2, and 3 respectively are dominated by species of *Cecropia peltata* (85.12 %), *Paraserianthes falcataria* (142.40 %), and *Leucaena leucocephala* (105.94 %).

Keywords: Ciliwung, community structure, riparian zone, tree, urban development

1. Introduction

Rapid urban development has led to deforestation of vegetation along Ciliwung riparian zone from Bogor to Jakarta [1]. Loss of those riparian vegetations causes many negative impacts for environment, such as landslide of river bank, lowering of water quality, reduction of fishery productivity, and declining of aquatic species diversity [1, 2].

One of the Ciliwung watershed area that still has relatively more riparian vegetation is in the middle stream of Ciliwung [3]. Riparian ecosystem conservation efforts need to be done so that the remaining riparian vegetation can be avoided from the threat of deforestation. The first thing that can be done is through vegetation analysis to find out basic information about the structure of riparian vegetation community.

The previous data shows that riparian vegetation that dominates Ciliwung middle stream area in Bogor–Depok is bamboo and tree [3]. Ecologically, bamboo and tree is known to play an important role as a buffer vegetation that can prevent erosion of river bank. Along with rapid physical development of the region, the presence of bamboo and tree in that area is now threatened, so that structure of the community is expected to change.
Further research on structure of vegetation community has been done in 3 location points of Ciliwung riparian zone in Depok–South Jakarta, but only focused on tree vegetation. These three locations have different habitat condition of riparian zone. Location 1 is known as natural habitat, location 2 has undergone land use conversion, and location 3 has undergone river bank concretization. The purpose of this research is to compare tree community structure located at those 3 location points of Ciliwung riparian zone in Depok-South Jakarta.

2. Methodology

2.1. Study site
The research location is located at 3 location points of Ciliwung watershed area along Depok to South Jakarta. Location 1 is located at Panus Bridge Depok City (coordinates 106°49'54.7"E and 06°24'02.1"S), location 2 is located at Srengseng Sawah South Jakarta (coordinates 106°50'09.1"E and 06°21'06.4"S), and location 3 is located at TB Simatupang Bridge South Jakarta (coordinates 106°51'15.6"E and 06°18'10.6"S).

2.2. Data collection
The method used to collect the data of vegetation is plot method. Four plot samples were determined purposively at each location 1, 2, and 3. Each sample plot is installed starting from the riverside perpendicularly with the size of 20x20 m on the right and left side of river body. That sample plot are further divided into smaller plots of 2x2 m, 5x5 m, and 10x10 m, respectively. Plot of 2x2 m is for seedling, plot of 5x5 m is for sapling, plot of 10x10 m is for pole, and plot of 20x20 m is for tree.

2.3. Data analysis
Vegetation data were analyzed descriptive-quantitatively based on Importance Value (IVi), species diversity index of Shannon-Wiener, and species evenness index at each location. The data were then compared to look at the differences between the three locations.

3. Results and discussion

3.1. Composition of tree
Ciliwung riparian zone in Depok-South Jakarta has varied tree composition at all three locations (table 1). Tree composition found at location 1 consists of family Anacardiaceae, Arecaceae, Bombacaceae, Fabaceae, Verbenaceae, Meliaceae, and Urticaceae. Tree composition found at location 2 consists of family Altingiaceae, Anacardiaceae, Arecaceae, Burseraceae, Casuarinaceae, Fabaceae, Gnetaceae, Meliaceae, Moraceae, and Pinaceae. Tree composition found at location 3 consists of family Fabaceae, Moraceae, Oxalidaceae, and Urticaceae.

| Location points | Total of species | Total of families | Most common family | Diversity index (H') | Evenness index (E) |
|-----------------|------------------|-------------------|--------------------|---------------------|------------------|
| Location 1      | 11               | 8                 | Moraceae           | 1.96                | 0.81             |
| Location 2      | 14               | 10                | Moraceae           | 2.33                | 0.88             |
| Location 3      | 4                | 4                 | -                  | 1.26                | 0.90             |
Based on table 1, location 1 is known to have fewer tree species and families than location 2, but more than location 3. Composition of tree species at location 1 consists of 8 species of cultivated tree and 3 species of non-cultivated tree that grows naturally. All species of cultivated tree at location 1 are found only on the west side of river flow, whereas species of non-cultivated tree can be found on the west and east side of river flow. Based on observation result, the difference of cultivated and non-cultivated tree composition at location 1 is probably due to differences in topography of riparian zone between the west and east side of river flow. The east side is known to have steep topography with high slope, making it quite difficult to reach. The east side reflects the condition of riparian vegetation that grows naturally. Meanwhile, the west side is known to have a relatively sloping topography which is close to the settlements. This causes the riparian zone on the west side of river to be easily accessible and planted by the people around Ciliwung.

Location 2 is known to have largest number of tree species and families compare to the location 1 and 3. This is due to the community intervention around Ciliwung in managing riparian land. All tree species found at location 2 are cultivated tree that are intentionally planted by surrounding communities. The south side of river flow is part of the rear garden of Gunadarma University, while the north side of river flow is part of mixed garden that is intensively managed by Matpeci community for land rehabilitation and eco-tourism area.

Based on the mentioned above, Ciliwung riparian zone is known to be more dominated by cultivated tree species than non cultivated tree species. According to previous data, Ciliwung riparian zone in the middle stream has much larger percentage of cultivated plant species than non-cultivated plant species, 74 % and 26 %, respectively. The existence of intensive land management intervention by the community around Ciliwung causes the percentage of cultivated plant species growing higher [3]. The number of cultivated trees in Ciliwung riparian zone should be evaluated whether it is in accordance to the riparian ecological function or not. Planting cultivated trees can give positive impact if carried out for the purpose of riparian ecosystem conservation, and adapted to the objectives and functions of riparian ecosystem to be achieved. Riparian zones should be planted with native plant species, as they have the best adaptability to local climates without reducing plant diversity within a community. Non-native plant species are not recommended for planting in riparian zones, since these non-native plant species could potentially become invasive within riparian vegetation community. In the long run, the presence of non-native plant species in riparian zones can also replace native plant species, as well as damage riparian habitats for some native animals [4, 5]. The examples of native tree species that can be planted in riparian land in Indonesia are *Ficus racemosa*, *Ficus virens*, *Ficus hispida*, *Microcos tomentosa*, etc. [6].

The data on table 1 also shows that Moraceae becomes the family with highest number of species in location 1 and 2. Not only in Ciliwung, family of Moraceae is also one of the families which are commonly found in riparian zones in several river of Indonesia such as Nggeng river in East Kalimantan and Citirem river in Sukabumi, West Java [7, 8]. Species belonging to this family in location 1 and 2 are *Artocarpus altilis*, *Artocarpus heterophyllus*, *Ficus benjamina*, *Ficus racemosa*, and *Ficus septica*. Genus of Artocarpus is often planted to be used for its fruit, while genus of Ficus is commonly found growing naturally along Ciliwung riparian zone. Several species from genus of Ficus are known to act as keystone species that maintain the survival of other organisms and balance the riparian ecosystem. Some birds and mammals use Ficus fruit as a feed source [9, 10]. Ficus trees can also be the right choice for conserving springs and riparian land rehabilitation because they have a very strong root system with many branches, and dense canopy cover [11].

### 3.2. Diversity and evenness index of tree

Tree community structure at 3 location points of Ciliwung riparian zone in Depok–South Jakarta has a wide variety of species diversity index (H') and evenness index (E) (table 1). Tree species diversity index in table 1 shows that the highest value is at location 2 and the lowest point is at location 3. Location 2 has medium diversity level, meanwhile location 1 and 3 have low diversity level [12]. High value of tree species diversity index at location 2 is caused by intensive riparian land management conducted by
surrounding community, so that the number of species and individual trees are more commonly found. Low value of tree species diversity index at location 3 is likely due to geographical factors and river bank concretization. Area of location 3 is known to be bordered by downstream part of Ciliwung watershed. The density and cover of tree canopy at downstream will be likely lower and more open so that the diversity of tree species will decrease further [2, 13]. Beside that, river bank concretization program by the Provincial Government of DKI Jakarta is suspected to be the cause of low diversity index of tree due to tree removals around the riverside. Location 3 is also known to be more dominated by shrubs and herb species such as *Manihot utilissima*, *Carica papaya* and *Musa paradisiaca*. Herb species like *M. paradisiaca* is actually not recommended to be existed in riparian land close to the river water because it can reduce the strength of the soil structure, thus it will be unable to withstand the landslides [3].

Tree species evenness index at all three locations shows an index value of >0.6, so that all three locations are known to have high degree of species evenness. This suggests that the distribution of individual trees number falls into equal category within each species. No species dominates most tree community in riparian zones at each location [14].

### 3.3. Importance value of tree

Based on Importance Value (IVi), tree community structures in Ciliwung riparian zone of Depok-South Jakarta are dominated by different plant species at each location point. Location 1 is dominated by *Artocarpus altulis* at seedling level, *Mangifera indica* at sapling level, and *Cecropia peltata* at pole and tree level. Location 2 is dominated by *Ficus racemosa* at sapling level, *Swietenia macrophylla* at pole level, and *Paraserianthes falcataria* at tree level. Location 3 is dominated by *Leucaena leucocephala* at sapling and tree level, and *Avreroa carambola* at pole level.

Species of *C. peltata* are species at pole and tree level with highest IVi in location 1. That high important value index are respectively due to high value of RD, RF, and RC compared to other species. High RD value indicates that *C. peltata* are found in relatively large numbers of individual in each sample plot, high RF value indicates that *C. peltata* has the highest dispersion rate compared to other species, high RC value indicates that *C. peltata* also has high degree of competitiveness with other species [15, 16]. Species of *C. peltata* became the 5th most dominant species along the middle stream of Ciliwung riparian zone [3]. This species is known to originate from South America and were first cultivated in Bogor Botanical Garden in 1868. People around Ciliwung recognize that species as "Kopo Tree".

Species of *C. peltata* is also known as fast growing plant species, especially in disturbed areas. Currently, Ciliwung riparian zone can be classified as disturbed area due to extensive deforestation of riparian vegetation because of rapid development of the region. Based on the Global Invasive Species Database, *C. peltata* is also included in the list of 100 most invasive plant species in the world. Invasive plant species are able to release allelopathic compounds that can suppress growth of other species, thus becoming dominant within community [17]. The invasion of *C. peltata* in karst Cibodas Mountain Bogor is known to decrease the diversity of seedling and sapling of tree, as well as lower plants [18]. So far, *C. peltata* has spread 35–40 km away from Bogor [19]. High spread rate of *C. peltata* is closely related to its ability to produce millions of seed per year as far as 3 km radius [20]. Based on the foregoing, *C. peltata* has the potential to dominate entire Ciliwung riparian zone in the future. However, people around Ciliwung currently have not realized and considered this species as ecosystem threat.

Species of *P. falcataria* is species at tree level with highest IVi in location 2. It is caused by significantly high RD and RC value. This indicates that *P. falcataria* tree has dominant role in plant communities at location 2 because of its large numbers of individual and high level of competitiveness. All species at level of sapling, pole, and tree at location 2 are known to have relatively low RF value because their distribution is concentrated only on certain sample plots [17, 18]. Species of *P. falcataria* is one of the native species suitable for planting in riparian land in Indonesia. Species of *P. falcataria* became the 3rd most dominant species along the middle stream of Ciliwung riparian zone. Such species are commonly found in gardens with similar commodities grown in regular stands [3].
Species of *L. leucocephala* is species at tree level with highest IVi in location 2. An IVi of *L. leucocephala* tree is slightly higher than *C. peltata* pole and tree because of its higher RC and RD value, but *L. leucocephala* tree is known to have a lower RF value compared to *C. peltata* tree. This indicates that the spread rate of *C. peltata* as non-cultivated wild plant specie is relatively superior compared to cultivated plants that are deliberately planted [17, 18].

4. Conclusion
Those 3 locations of Ciliwung riparian zone in Depok–South Jakarta region have different community structure due to different habitat condition with three species dominated, *Cecropia peltata*, *Paraserianthes falcatoria*, and *Leucaena leucocephala*. Human activities and physical development, such as land use conversion and river bank concretization play an important role in driving the changes of tree community structure along Ciliwung watershed.

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### Appendix

Importance value of tree at three Location points

| Location point | Life form | Name of species          | RD|^a | RC|^b | RF|^c | IV|d |
|----------------|-----------|--------------------------|-----|-----|-----|----|----|
| Seedling       | Sapling   | Artocarpus altilis       | 100 % | 100 % | 100 % | 300 % |
|                |           | Mangifera indica         | 25 %  | 55.68 % | 33.33 % | 114.01 % |
|                | Pole      | Cercopita peltata        | 42.85 % | 48.75 % | 40 % | 131.60 % |
|                | Tree      | Cocos nucifera           | 34.28 % | 27.77 % | 23.07 % | 85.12 % |
| Location 1     |           | Ficus racemosa           | 8.69 %  | 37.76 % | 15.38 % | 61.83 % |
|                |           | Swietenia macrophylla    | 26.08 % | 12.16 % | 15.38 % | 53.62 % |
|                |           | Ficus benjamina          | 4.35 %  | 18.45 % | 7.69 % | 30.49 % |
|                |           | Cocos nucifera           | 8.69 %  | 1.08 % | 7.69 % | 17.46 % |
|                |           | Tectona grandis          | 4.35 %  | 1.05 % | 7.69 % | 13.09 % |
|                |           | Ceiba pentandra          | 4.35 %  | 0.76 % | 7.69 % | 12.80 % |
|                |           | Leucaena leucocephala    | 4.35 %  | 0.57 % | 7.69 % | 12.61 % |
|                |           | Artocarpus altilis       | 4.35 %  | 0.36 % | 7.69 % | 12.40 % |
| Sapling        | Pole      | Swietenia macrophylla    | 12.50 % | 3.00 % | 16.67 % | 32.17 % |
|                | Tree      | Canarium cf. indicum     | 16.13 % | 7.72 % | 9.09 % | 32.94 % |
|                |           | Cocos nucifera           | 6.45 %  | 0.94 % | 9.09 % | 16.48 % |
|                |           | Gnetum gemonon           | 6.45 %  | 0.83 % | 9.09 % | 16.37 % |
|                |           | Liquidambar excelsa      | 6.45 %  | 0.67 % | 9.09 % | 16.21 % |
| Location 2     | Tree      | Artocarpus heterophyllus | 3.22 %  | 0.44 % | 9.09 % | 12.75 % |
|                |           | Casuarina equisetifolia  | 3.22 %  | 0.42 % | 9.09 % | 12.73 % |
|                |           | Lansium parasiticum      | 3.22 %  | 0.24 % | 9.09 % | 12.55 % |
|                |           | Ficus septica            | 3.22 %  | 0.23 % | 9.09 % | 12.54 % |
|                |           | Adenanthera pavonina     | 3.22 %  | 0.16 % | 9.09 % | 12.47 % |
|                |           | Swietenia macrophylla    | 3.22 %  | 0.16 % | 9.09 % | 12.47 % |
| Sapling        | Pole      | Averrhoa carambola       | 57.14 % | 65.72 % | 50 % | 172.86 % |
|                | Tree      | Cercopita peltata        | 42.85 % | 34.27 % | 50 % | 127.12 % |
|                |           | Leucaena leucocephala    | 42.85 % | 43.09 % | 20 % | 105.94 % |
|                |           | Cercopita peltata        | 34.27 % | 33.18 % | 30 % | 101.75 % |
|                |           | Averrhoa carambola       | 14.28 % | 20.17 % | 20 % | 54.45 % |
|                |           | Ficus racemosa           | 14.28 % | 3.55 % | 20 % | 37.83 % |

^aRD = Relative Density  
^bRF = Relative Frequency  
^cRC = Relative Coverage  
^dIV = Importance Value