Characteristics of pekarangan in organic settlement and planned settlement along Ciliwung River riparian, Bogor Municipality, Indonesia

J Jesica¹, R L Kaswanto² and H S Arifin²
¹ Graduate Student of Landscape Architecture, Department of Landscape Architecture, Faculty of Agriculture, IPB University, Jl. Meranti Kampus IPB Darmaga, Bogor 16680, Jawa Barat, Indonesia.
² Lecturer of Department of Landscape Architecture, Faculty of Agriculture, IPB University Jl. Meranti Kampus IPB Darmaga, Bogor 16680, Jawa Barat, Indonesia.
E-mail: jenniejesica@gmail.com

Abstract. Riparian is part of the river that contributes to ecosystem preservation. There are green spaces in riparian that have many functions. One of the green spaces in riparian is pekarangan. The purpose of this paper is to show the result of analysis characteristics of pekarangan in the organic settlements and planned settlements along the Ciliwung River riparian. The study area consists of three riparian zones in two types of settlements, organic settlements and planned settlements, i.e. the upper part (Kelurahan Katulampa); the middle part (Kelurahan Babakan Pasar and Kelurahan Sempur); and the lower part (Kelurahan Kedunghalang). Characteristics of pekarangan were analysed through the approach of size and zoning of pekarangan; vertical and horizontal diversity of plants; plant biodiversity; and types of pekarangan utilization. The results showed that the orientation of organic settlements tends to turn away from the river, while planned settlements face the river. The organic settlements and planned settlements, both have small pekarangan (<120 m²). The pekarangan productivity average of the Shannon-Wiener index in organic settlements was 3.76, while planned settlements were 4.11. The result of the study of all sites are typology of pekarangan in organic settlement and planned settlement.

Keywords: plant biodiversity, settlement orientation, typology of pekarangan

1. Introduction
The increasing of the Bogor Municipality population has been impacted by Ciliwung riparian ecosystem structure, dynamics, and function. The existence of settlements around the river can negatively affect the landscape physical condition, river water quality, and riparian aesthetic quality. Riparian areas are the ecological links between terrestrial and aquatic components of the landscape. Well-functioning riparian landscapes can filter surface and sub-surface water flow, prevent riverbank erosion, filter air pollution, and provide habitat for various species and active corridors for species to move through increasingly fragmented urban landscapes [1].

The green space infrastructure provides natural drainage, water interception, infiltration, storage, pollutant removal, surface flow and rainwater runoff reduction, and water quality [2]. Pekarangan as

3 To whom any correspondence should be addressed (jenniejesica@gmail.com)
part of the green space and also as part of a settlement area that has the potential to preserve the river ecosystem. *Pekarangan* is a small-scale agroforestry landscape in Indonesia and also known as home garden, homestead plot, and open space surrounding a house [3]. *Pekarangan* can serve the productive purpose of minimizing the negative effects of pollution along the Ciliwung River riparian, Bogor Municipality. Leaves, branches, and roots contribute to soil productivity and stability. Empowerment of *pekarangan* based on local wisdom, local culture, and local ecological knowledge is productive for fulfilling subsistence food needs [4]. This study was conducted on two types of settlements, i.e. organic settlements and planned settlements. The purpose of this paper is to show the result of the analysis of *pekarangan* characteristics in the organic settlements and planned settlements along the Ciliwung River riparian.

2. Methods

2.1. Time and location
Research was conducted for six months from December 2018 until May 2019. The research was held in organic settlements, i.e. Kelurahan Katulampa, Kelurahan Babakan Pasar, and Kelurahan Kedunghalang, as the upper, the middle, and the lower part of Ciliwung riparian. In the same case, research also was conducted in planned settlements, i.e. Kelurahan Katulampa, Kelurahan Sempur, and Kelurahan Kedunghalang as the upper, the middle, and the lower part of Ciliwung riparian in Bogor Municipality, respectively (figure 1).

Figure 1. Research area of Ciliwung riparian in Bogor Municipality.

2.2. Data types and collection methods
Data needed for this study are location and accessibility of settlements, size, and zoning of the yard [5], type and number of plants, livestock, and fish, and classification of strata and plant functions [5], and diversity of vegetation [6]. Each segment i.e. upper, middle and lower in organic settlements and planned settlements are represented by 10 houses that have a yard ≤ 200 m from the river [7]. The data
were collected through field observations. Those are sixty pekarangan \((n = 60)\). The recruitment process used the reference chain sampling technique \([8]\), where respondents are asked to recommend their neighbours who have pekarangan. This method has similarities with the snowball sampling technique where samples are processed through a rolling process from one sample to another \([9]\).

2.3. Data analysis
Each pekarangan sample was analyzed for its size, spatial, zoning, and diversity of commodities. Pekarangan sizes are small scale \(< 120 \text{ m}^2\), medium scale \(< 400 \text{ m}^2\), large scale \(< 1000 \text{ m}^2\), and very large scale \(> 1000 \text{ m}^2\) \([5]\). The zoning classification is front side, right side, left side, and back side \([5]\). Plant structure was analyzed based on plant stratification, i.e. strata I \(< 1 \text{ m}\), strata II \(< 2 \text{ m}\), strata III \(< 5 \text{ m}\), strata IV \(< 10 \text{ m}\), and strata V \(> 10 \text{ m}\) \([5]\). Furthermore, eight plant functions were analyzed, i.e. ornamental plants, fruit plants, vegetable plants, herbs plants, starch plants, medicine plants, industry and other plants (producing fuelwood, feed, handicraft materials, conservatives, etc) \([5]\). Plant biodiversity was analyzed based on the Shannon-Wiener Diversity Index \((H')\). The diversity index \((H')\) is classified into diversity of high species \((H' > 3)\), moderate species diversity \((1 < H' < 3)\) or low diversity of species \((H' < 1)\) \([6]\).

3. Results and discussions
3.1. General condition
The geographical conditions of the four kelurahan are generally similar because they are in the same area, Bogor Municipality. The average temperature every month is 26.0°C, solar radiation is 58.5%, rainfall is 3,937.2 mm/year, and humidity is 82% \([9]\). The type of soil is latosol \([10]\). By using remote sensing, the ecological structures of all sites were found. Kelurahan Katulampa was dominated by natural structures 366.17 ha \((78.58\%)\), Kelurahan Babakan Pasar was dominated by artificial structures 26.36 ha \((77.52\%)\), Kelurahan Sempur was dominated by artificial structures of 17.10 ha \((56.65\%)\), and Kelurahan Kedunghalang was dominated by artificial structures of 139.44 ha \((74.57\%)\).

An overview of the orientation and location of the distribution of houses is shown as a landscape mosaic (figure 2). This typology has the same variable, i.e. the location that along the river riparian, the type of soil (litosol), and the climate. Each typology is based on community background factors and the level of community distribution in each settlement. The planned settlement pattern generally has an orientation to access roads and close to rivers. While the orientation of organic settlement tended to turn away from the river. Unfortunately, not all houses have views of the river due to high building density and random settlement patterns.

![Figure 2. Landscape mosaics (a) organic settlements and (b) planned settlements in Ciliwung River riparian, Bogor Municipality.](image-url)
3.2. Size and zone of pekarangan

Pekarangan size of organic settlements and planned settlements in the riparian are mostly small, < 120 m² (figure 3). Riparian settlements tend to be small because of limited land. Besides, land-use change has occurred due to the land ownership change. The availability of open spaces (green spaces and rivers) in settlements is another reason people assume that pekarangan is not urgent. Organic settlements have a higher diversity of zoning than planned settlements (figure 4). In addition, pekarangan zoning was influenced by the availability of land, the needs, and the background of the pekarangan owner.

![Figure 3. Pekarangan size in the settlements along Ciliwung River riparian, Bogor Municipality.](image3)

![Figure 4. Pekarangan zone in the settlements along Ciliwung River riparian, Bogor Municipality.](image4)

3.3 Vertical diversity (strata) and horizontal diversity (function) of plants

The result of vertical diversity is shown most biodiversity was dominated by strata I plants (<1 m). Strata I plant such as adam eva (Rhoeo discolor), orchids (Paphiopedilum glaucophyllum), shallots (Allium fistulosum), chilli pepper (Capsicum annuum), yellow walking iris (Neomarica longifolia), nest fern (Asplenium nidus), and lemon grass (Cymbopogon citratus). The majority of strata I, II, and III plants characterize agricultural cultivation on limited land as well as on land (table 1). The horizontal structure of the two types of settlements was predominantly ornamental plants (table 1). Respondents highly preferred aesthetic characteristics such as flowers and leaves. Their plants preferred were wave of love (Anthurium plowmanii), bougainvillea (Bougainvillea spectabilis), cananga (Cananga odorata), variegated croton (Codiaeum variegatum), and lipstick palm (Cyrtostachys renda).

3.4 Plant diversity and pekarangan utilization diversity

The species diversity index in 60 pekarangan samples is relatively high with H' values ranging from 3.63 - 4.34 (table 1). High species diversity has high community stability in an ecosystem. Plant diversity in pekarangan can significantly contribute to providing landscape services. Landscape services are utilized to preserve the surrounding environment and at the same time also become an asset for their owners in improving household welfare [11]. The existence of a yard with various types of commodities will contribute optimally to river riparian areas. Not only for gardening, but pekarangan was also used to house cattle sheds, fish ponds, and household attributes. It was influenced by the agro-climate conditions of river riparian areas, water and land availability, and the habits and knowledge of the local community. The diversity of vegetation types showed that settlements on the Ciliwung River riparian in Bogor Municipality were still well preserved.
Table 1. Frequency of plant species based on strata and functions, and Shannon Wiener ($H'$) species diversity index on the land use of riparian settlements in Ciliwung River, Bogor Municipality.

| Location          | Species frequency (strata) | Species frequency (function) | The diversity index ($H'$) | Category |
|-------------------|----------------------------|-----------------------------|---------------------------|----------|
|                   | I  | II | III | IV | V  | A  | B  | C  | D  | E  | F  | G  | H  |         |
| Organic settlement|    |    |     |    |    |    |    |    |    |    |    |    |    |         |
| Upper part        | 25 | 11 | 4   | 5  | 2  | 32 | 6  | 2  | 6  | 1  | 6  | 0  | 1  | 3.60 | High   |
| Middle part       | 43 | 16 | 7   | 2  | 4  | 45 | 12 | 6  | 7  | 1  | 7  | 0  | 2  | 4.06 | High   |
| Lower part        | 32 | 14 | 4   | 3  | 3  | 37 | 12 | 4  | 4  | 0  | 2  | 1  | 3  | 3.63 | High   |
| Average           | 33 | 14 | 5   | 3  | 3  | 38 | 10 | 4  | 6  | 1  | 5  | 0  | 3  | 3.76 | High   |
| Planned settlement|    |    |     |    |    |    |    |    |    |    |    |    |    |         |
| Upper part        | 25 | 24 | 3   | 5  | 4  | 45 | 7  | 3  | 8  | 0  | 6  | 0  | 2  | 3.87 | High   |
| Middle part       | 48 | 12 | 11  | 6  | 2  | 51 | 11 | 7  | 7  | 1  | 9  | 0  | 2  | 4.12 | High   |
| Lower part        | 42 | 24 | 13  | 9  | 5  | 70 | 11 | 5  | 8  | 0  | 9  | 0  | 2  | 4.34 | High   |
| Average           | 38 | 20 | 9   | 7  | 4  | 55 | 10 | 5  | 8  | 0  | 3  | 8  | 0  | 4.11 | High   |

Note: I < 1 m, 1 m ≤ II < 2 m, 2 m ≤ III < 5 m, 5 m ≤ IV < 10 m, V >10 m; A = ornamental plants, B = fruit plants, C = vegetable plants, D = herbs plants, E = starch plants, F = medicine plants, G = industry, H = other plants (producing fuelwood, feed, handicraft materials, conservatives, etc.); low species diversity ($H' < 1$), moderate species diversity ($1 < H' < 3$), dan high species diversity ($H' > 3$).

3.5 Typology of pekarangan in Ciliwung River riparian

The results of pekarangan characteristics analysis in each segment of organic settlements and planned settlements are an illustration of the typical pekarangan characteristics in the Ciliwung River riparian. Each segment of settlements has a typology based on the similarity of pekarangan characteristics (figure 5). The field observations found similarities in organic settlements and planned settlements along the Ciliwung River riparian. Those are small pekarangan area < 120 m², plant dominance of strata I (< 1 m). In addition, those size was completed the critical minimum size (100 m²) to guarantee the ecological production process [5].

![Figure 5. Pekarangan typology in each segment of settlements along the Ciliwung River riparian in Bogor Municipality.](image-url)
The three segments of organic settlements have similar physical forms, i.e. semi-open space with boundaries in the form of plants. The pekarangan pattern tends to follow the shape of the building according to the availability of land. Only a few houses have ponds and livestock cages, the rest was dominated by clotheslines. Whereas in planned settlements, the three segments have the same physical form, which is closed with a barrier such as a fence and a wall. Pekarangan has a symmetrical pattern. It tends to be on the front and side of the house. There were various functions of the yard such as the place of vegetation, playground, ornamental ponds, bird cages, vehicle parking, and religious attributes. The pattern and structure of the yard, both plant and non-plant elements were influenced by community knowledge and culture [12].

4. Conclusion
The organic settlements tend to turn their backs on rivers with semi-open pekarangan. The substance of pekarangan are plants, ponds and livestock production, and clothesline. Whereas, the planned settlements tend to face the river. It has a clear division of areas namely private and public areas. The substance of pekarangan were dominated by plants and ornamental ponds. The organic settlements and planned settlements, both have limited land to be used as pekarangan. On the other hand, pekarangan production has high land productivity along the Ciliwung River, Bogor Municipality.

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