Chapter 15
Management of Landscape Services for Improving Community Welfare in West Java, Indonesia

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Abstract A sustainable management of landscape services is needed to resolve ecological problems in rural and urban landscapes, particularly in developing countries, such as Indonesia. A specific management for particular area such as homegarden has to be developed in order to improve utilization of landscape services based on community activities. Four classic landscape services, i.e. biodiversity conservation, carbon stock and sequestration, water resources management, and landscape beautification are approached inside intensively managed homegarden. The landscape ecology approach was conducted through micro-, meso-, and macro-scales to figure out the potential ecology-economy-social benefit for urban-rural landscape inside homegarden as a small-scale agroforestry landscape or usually called as "*pekarangan*". A well planned and managed agroforestry landscape practices may suppress social, economical and ecological condition in rural marginal society and would improve the community welfare. Therefore, by managing *pekarangan* systems for landscape services, marginal communities would have the possibility to advance their asset of landscape services through plant biodiversity (H'), carbon stock (C), water resources utilization, and scenic beauty inside *pekarangan*. The aims of this research are to develop basic landscape service of plant biodiversity, carbon stock, water management and landscape beautification and to arrange recommendation for revitalizing *pekarangan*. The results show that *pekarangan* has diverse plant biodiversity (0.77–3.57) and diverse carbon stock (0.13–136.20 Mg/ha). *Pekarangan* also has the ability to utilize water effectively and at the same time contribute to provide amenity from its beautification for human well-being. Those landscape services provided by *pekarangan* could directly and indirectly improves the community welfare.

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1 Introduction

Revitalization of *pekarangan* towards a low carbon landscape (LCL) is a concept that answers to landscape management issues from a multidisciplinary. *Pekarangan* at the rural landscape provides various types of services that eventually improve community welfare. Arrangement of the *pekarangan* as a process of social and cultural landscape should be considered as sustainable ecological functions. Arrangement of the *pekarangan* can be investigated on a macro-scale, meso-scale and micro-scale. Macro-scale focused on two watersheds, meso-scale on the upstream, middle stream and downstream of the watershed and micro-scale on the *pekarangan* itself.

Pekarangan is one very representative for agroforestry landscape model. Agroforestry landscape is frequently defined as a combination of agriculture and forestry that are managed to create a balance between intensification of agriculture and forestry conservation. Agroforestry landscape also often developed in a complex land management, eventually able to optimize the sustainability advantages both ecological and social aspects arising from biological interactions when organisms therein contained grow effectively. *Pekarangan* can be interpreted as micro-scale agroforestry landscape, because in *pekarangan* annual and seasonal crops can be found, including livestock that are cultivated effectively. *Pekarangan* can provide various types of landscape services that are beneficial. In this article, four classic landscape services were observed, i.e. plant biodiversity, carbon stock, landscape beautification and water resources management.

Pekarangan can be assumed as a home garden, yard or open space that surrounds the house. *Pekarangan* also be defined as a complex agroforestry system which is rich with a blend of diverse species of annual and perennial plants with multi-storey vertical structure and often combined with livestock (Christanty 1990; Soemarwoto 1987). *Pekarangan* is a collection of plants, including trees, shrubs, bushes and vines, that exist on homegarden (Landauer and Brazil 1990). Various types of multipurpose products that can be produced from *pekarangan* with the needs of labour and other input costs are relatively low (Christanty 1990; Hochegger 1998; Soemarwoto and Conway 1992). Furthermore, *pekarangan* as also mentioned contributed significantly in the cycle of carbon stock and at the same time also improved the welfare of rural communities (Arifin and Nakagoshi 2011).

The benefits of *pekarangan* as mentioned above were not positively correlated with the utilization at present time. In the current situation, most of *pekarangan* are not managed properly, and even there is *pekarangan* which do not provide landscape services naturally (biodiversity and carbon stocks). Therefore, this article emphasizes how the links between biodiversity and carbon stocks on the landscape *pekarangan* can be managed in a sustainable manner.

This study has two objectives related to landscape services provided by *pekarangan* as one of agroforestry practice. These objectives are to develop classical landscape services from *pekarangan* by calculating the biodiversity index (H'), analyzing the carbon stock (*C*), measuring its beautification, observing the water management and to arrange recommendation of ideal management for sustainable *pekarangan*. Managing those landscape services both directly and indirectly is proving to improve community welfare.

2 Methods

2.1 Study Site

The study was conducted in four watersheds in West Java, namely Ci Liwung, Cisadane, Cimandiri and Cibuni Watershed (Fig. 1). These sites selection are based on the consideration of the following: (1) the same area of the upper watersheds so it can assume the same elevation, (2) the same orientation, i.e. towards the north and south which is used as a comparative analysis, and (3) the high effect of urbanization, because those four watershed areas are located at the greatest level of population growth and development in Indonesia.

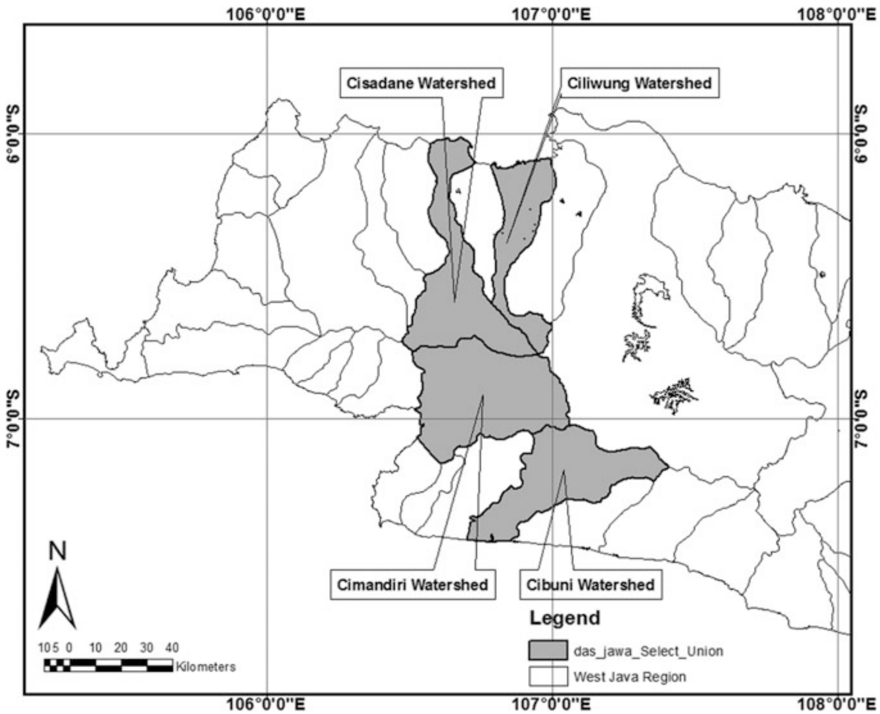


Fig. 1 Site study in two watersheds on West Java, Cisadane and Ci Liwung watersheds

Table 1 The general information of four watersheds of study areas

Name of watershed	Administrative location (district)	Total area (ha)	Perimeter (km)	Stream flow	Main river length (km)	Climate condition[a]
Cisadane (CS)	Bogor, Tangerang, Depok	153,485.47	273.50	Northern	112.7	A & B
Ci Liwung (CL)	Bogor, Jakarta, Bekasi, Depok	89,036.33	221.84	Northern	82.9	A & B
Cimandiri (CM)	Sukabumi, Cianjur	196,947.51	207.05	Southern	55.8	B
Cibuni (CB)	Sukabumi, Cianjur, Bandung	147,052.32	232.02	Southern	34.3	B

[a]Climate classifications are based on Schmidt and Ferguson (1951)

Cisadane watershed covers several districts and cities in West Java Province, DKI Jakarta, as well as Tangerang District and Tangerang City, Banten Province. Three subdistricts that were sampled were Ciampea Subdistrict on upstream, Ciseeng Subdistrict on middle and Karawaci Subdistrict on downstream. Ci Liwung watershed includes West Java Province and DKI Jakarta, the study sample was in Cisarua Subdistrict on upstream, Cibinong Subdistrict on middle and Tebet Subdistrict on downstream. In general, Ciliwung and Cisadane watersheds have humid climate with rainfall of 2000 mm/year (BMKG West Java in 2016), while Cimandiri dan Cibuni have B type climate condition (Table 1).

2.2 Sample Frame

In this study, the approach of landscape ecology was used to analyze the entire process of landscape agroforestry in *pekarangan* to assess the availability of landscape services relating to (1) plants biodiversity conservation, (2) carbon stock value, (3) landscape beautification and (4) water resources management on *pekarangan* (Fig. 2). The research process uses direct measurement methods and interview. The method was performed by landscape ecology perspective through a micro-scale of landscape agroforestry in *pekarangan*. The calculation of *pekarangan* sample starts with four watersheds, then in each watershed, there are three sub-watersheds, namely upstream, middle stream and downstream. In each sub-watershed, we selected two villages, and then in every village, we choose a hamlet. At each hamlet, we measured four *pekarangan* of G1, G2, G3 and G4. At the end, a total of 192 *pekarangan* samples have been measured directly and interviewed to figure out the potential diversity of landscape services inside (Table 2).

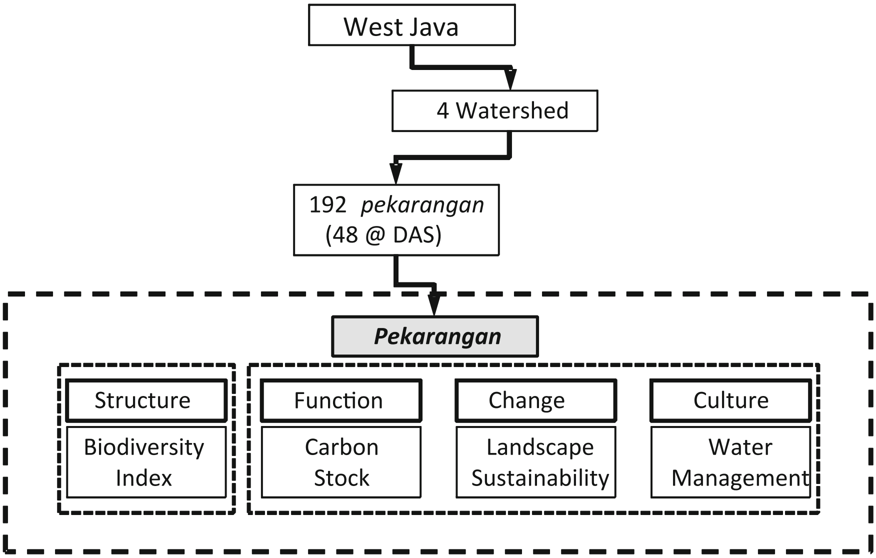


Fig. 2 Landscape ecology approach to analyze four aspects, (1) structure, (2) function, (3) change, and (4) culture on micro-scale agroforestry landscape (*pekarangan)*

Table 2 *Pekarangan* sample selection based on size and *other agricultural land* (OAL) ownership

Group	*Pekarangan* size (m^2)	Other agricultural land (OAL) ownership
G1	<120	Without OAL
G2	<120	With OAL < 1,000 m^2
G3	120–400	Without OAL
G4	120–400	With OAL < 1,000 m^2

2.3 Analysis of Plants Biodiversity Index

Vegetation analysis was conducted to calculate biodiversity index on plants that are found in *pekarangan*. Vegetation analysis procedure is as follows: (1) *pekarangan* selection as sample frame, (2) record and identify plant species, and (3) calculate important value index and Shannon–Wiener Index. Shannon–Wiener Index is a formula to calculate diversity, namely a combination number of species and number of individuals of each species in *pekarangan*, with formula as follows:

$$H' = -\left\{\sum \rho i \ln \rho i\right\};\ \text{with}\ \rho i = n_i/N$$

where:

H' = Shannon–Wiener Index
ρi = Relative abundance
n_i = Number of species (i)
N = Total number of individuals
Shannon–Wiener Index divided into three classes, i.e.
$H' < 1$ = Low diversity
$1 < H' < 3$ = Moderate diversity
$H' > 3$ = High diversity.

2.4 Carbon Stock Analysis

Carbon stock measurement analysis was approached by plant biomass analysis. Un-destructive method is used for biomass calculation using allometric equations based on the plant species found in *pekarangan*. Allometric is a mathematical function that shows the relationship between particular parts of the living creatures. The allometric equation which is used for estimating certain paramertes by using other parameters are more easily measured, in this study is prediction of tree biomass through measuring the diameter of the tree trunk (diameter breast height - DBH) (Hairiah and Rahayu 2007). Allometric formula for biomass estimation (Hairiah and Rahayu 2007) is as follows:

$$Y = a \cdot \mathrm{DBH}^b$$

where:

Y = Plant Biomass
DBH = *Diameter Breast Height* (1.35 m)
a = Conversion coefficient
b = Allometric coefficient.

Allometric formulas used in this study are tree allometric equations developed by Chave et al. (2005), while the bush is generalized using the equation by Ali et al. (2015). Estimation of carbon stock in herbaceous plants was done using the results of research by Roshetko et al. (2002, 2007) who has conducted sampling through harvesting (destructive sampling) in *pekarangan* area on Lampung with an average of 0.3 Mg/ha. Then estimate the carbon content of above ground in *pekarangan* using a formula according to Brown (1997), namely:

$$C = Y \times 0.5$$

where:

C = Carbon stock above ground (kg)
Y = Biomass value (kg)
0.5 = 50% carbon stock on biomass

2.5 Water Resources Management Analysis

Observation of water resources management in *pekarangan* was conducted through interview and questionnaire. We asked the flow of water utilization in each household, the utilization from water sources to the consumption and disposal activity. We mark every water pool and follow the distribution of water from each household member. We designed the *pekarangan* system inside and outside. The inside systems are house, pond, home yard (vegetation), waste (dump), animals (livestock) and for composting. While at the outside, we simulate the water that comes from spring, flows to river, to market and to the OAL.

2.6 Landscape Beautification Analysis

Measurement of landscape beautification was conducted by collecting the front side of each *pekarangan*. In total, 192 pictures of front yard *pekarangan* were displayed. The scenic beauty estimation (SBE) analysis was used to evaluate the quality of landscape of each *pekarangan*. The process of this analysis began with taking pictures of front side *pekarangan*. The views that had been taken were then presented to the respondents to get valuated. Every slide was played for ten seconds. The valuation score ranges from 1 to 10. Score one is the landscape with the worst aesthetic quality and ten is for landscape with the best aesthetic quality. Those scores were then used to get the SBE score, index estimation quantity of landscape beautification (Daniel and Boster 1976; Febriana and Kaswanto 2015), with this formula:

$$\mathrm{SBE}_x = \left(Z_{yx} - Z_{yo}\right) \times 100$$

where:

SBE_x = value estimation score of *x*th landscape beauty
z_{yx} = average value of *n*th landscape
z_{yo} = *z* average value of a landscape as a standard.

3 Results and Discussion

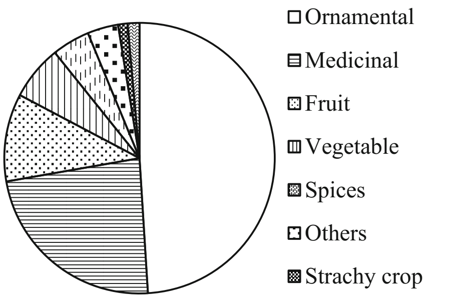
3.1 Plants Biodiversity Index in Pekarangan

There are 265 species of plants from 80 families that have been observed with eight functions classification, i.e. ornamental plants, industrial plants, starch crops, medicinal plants, herbs, vegetables, fruits and more. This is higher than a previous study conducted in four watersheds in West Java, namely 214 species (Kaswanto and Nakagoshi 2014). This is also higher when compared to some *pekarangan* researches in other tropical regions, courtyard Santa Rosa in the Peruvian Amazon with 168 species (Padoch and de Jong 1991) and in homegarden of northern Thailand with 230 species (Moreno-Black et al. 1996), as well as 253 species of western Kenya (Backes 2001). However, this result is smaller than other areas in West Java, namely Cianjur watershed of 440 species (Arifin et al. 2014), Zaire 272 species (Mpoyi et al. 1994) and Nicaragua 324 species (Méndez et al. 2001). Moreover, the highest number in West Java were reported by Karyono (1990), it reached 602 species. And our study nearly 40% of plants to number of Karyono (1990).

Horizontal structure on *pekarangan* with high biodiversity index related to the number and species of various ornamental plants. Plants in *pekarangan* are dominated by ornamental plants reached 50.03%. This shows that there are preference owners to utilize *pekarangan* as a purely aesthetic interest. As to meet the need for starch (carbohydrate), vegetables, herbs and industrial purposes (i.e. fuelwoods and housing board) is still relatively low (Fig. 3). Based on the functions of the plant, in *pekarangan* there are mangoes, *Pachystachys lutea* (lollipops) as hedgerow, as well as ornamental plants *Phalaenopsis* sp., and *Anthurium* sp.

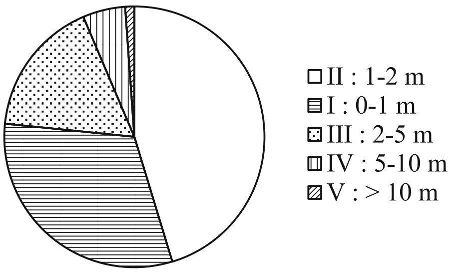
The vertical structure on *pekarangan* showed that most biodiversity is dominated by plants on Stratum II between 1 and 2 m (45.3%). However, plant with more than 2 meters high (Stratum III, IV and V) reached more than 20%, which means that the capacity of *pekarangan* space allows the plant to grow vertical optimally (Fig. 3). For example, *Crinum moorei* (daffodil) in stratum I, *Codiaeum* sp. (croton) in stratum II and *Mangifera indica* (mango) in stratum III. The ecological conditions of horizontal and vertical diversities showed that *pekarangan* has greatly contributed in maintaining sustainable environment (Kaswanto and Nakagoshi 2011). Hylander and Nemomissa (2009) also concluded that the species composition of *pekarangan* sometimes resembles plantation areas.

Plants biodiversity index indicated by the number of species and individual plants is found in 96 *pekarangan* samples. Most of *pekarangan* structures found almost have a same condition of forestry landscape, where the vertical and horizontal diversities are relatively high with a value of H' on a scale of moderate diversity (Fig. 4). The H' value ranges from 0.77 to 3.57, but the value of $H' > 1.00$ reaches 98.95% of total *pekarangan* samples. G1 and G3 are the pictures of *pekarangan* without ownership of OAL, while G2 and G4 *pekarangan* with ownership of OAL. The mean biodiversity index in *pekarangan* without OAL (G1 and G3) is higher than *pekarangan* with OAL (G2 and G4). This shows that the absence of the OAL will make homeowners take advantage of *pekarangan* intensively, thus making the biodiversity in *pekarangan* without OAL higher. Most of *pekarangan* without OAL have food crops and medicinal plants that can be used to fulfil the food needs of family members or increase income derived from *pekarangan* production. Karyono (1990) states *pekarangan* without a paddy field can be used as a carbohydrate-producing land with planting starchy crops such as cassava and sweet potatoes. Further, it is mentioned that some studies suggest the production of *pekarangan* also contributes to generate calories, protein, vitamins A and



Function	Presentase (%)
Ornamental	50.03
Medicinal	21.06
Fruit	12.42
Vegetables	7.01
Spices	5.18
Others	2.03
Strachy Crop	1.26
Industrial plant	1.01

Plant function as horizontal structure



Plant stratification	Presentase (%)
II : 1-2 m	48.21
I : 0-1 m	32.21
III : 2-5 m	12.62
IV : 5-10 m	5.7
V : > 10 m	1.26

Plants stratification as vertical structure

Fig. 3 Plant composition in *pekarangan* classified in eight use categories and five strata. Plants in *pekarangan* are dominated by ornamental plants (50.03%) and plant on second strata (1–2 m) up to 48.21%

C (Arifin et al. 2014; Christanty 1986; Christanty et al. 1986; Kaswanto and Nakagoshi 2014; Mulyoutami et al. 2009; Niñez 1987; Soemarwoto and Conway 1992). The income is derived from selling fruits and other plants from *pekarangan*.

Pekarangan with high biodiversity value tends to be maintained. Homeowners in addition to using land intensively yard also have habits or preferences (hobbies) associated with plants or gardening. Front *pekarangan* is often planted with ornamental plants, hedges and cherry trees as a shade, vegetables, herbs and spices at sides of *pekarangan*. This provides a positive impact on the management of *pekarangan*. Christanty et al. (1986) suggest ornamental plants usually placed in the front yard as well as economic value plants such as fruit trees so that the owner can see these plants, while medicinal plants, starchy crops and others are usually planted in back yard or front yard.

The diversity of plants is influenced by people's attention on *pekarangan*. Equipping *pekarangan* for families who lack land or cultivation area can help these families to get food supplies and fuel from the surrounding area. And finally,

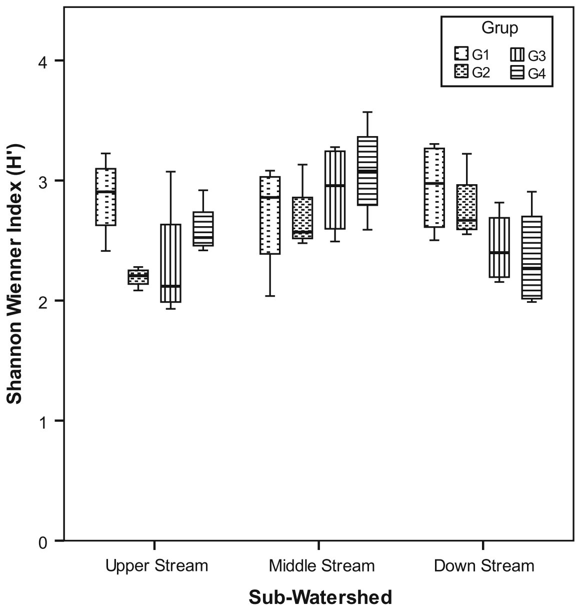


Fig. 4 Shannon–Wiener Index value on up-middle-downstream level and G1, G2, G3 and G4 groups

pekarangan always maintain diversity and at the same time preserve the surrounding forest (Mitchell and Hanstad 2004). This situation makes diversity of plant can continue to increase, indirectly. A high diversity can sustain carbon fluctuations in the environment (Henry et al. 2009), thus *pekarangan* can be one of the guard stabilities of the amount of CO_2 in the atmosphere.

3.2 Carbon Stock in Pekarangan

Carbon stock in *pekarangan* ranges from 0.13 to 90.80 Mg/ha in a small *pekarangan* (G1 and G2), while for medium-sized *pekarangan* (G3 and G4), it was higher ranging from 0.18 to 136.20 Mg/ha (Fig. 5). In total, the average carbon stock in *pekarangan* reached 22.26 Mg/ha. Results of the calculations also show that the carbon stock in *pekarangan* can reach up to 20% of the total carbon stock from carbon stock in natural forests. This means that the density and growth of plants in *pekarangan* have the ability to resemble (mimic) natural forest conditions. In the context of carbon stock, there is a real correlation between groups; however, there is no correlation between *pekarangan* with OAL and *pekarangan* without OAL. The average of carbon stock on *pekarangan* on middle stream of Cisadane watershed tends to be higher (26.11 Mg/ha), as well as the value of diversity index. Overall, *pekarangan* which have carbon stock >10:00 Mg/ha reaches 45.83% of the total samples. On average, in the upper stream is equal to 18.70 Mg/ha, and in the downstream equal to 21.96 Mg/ha.

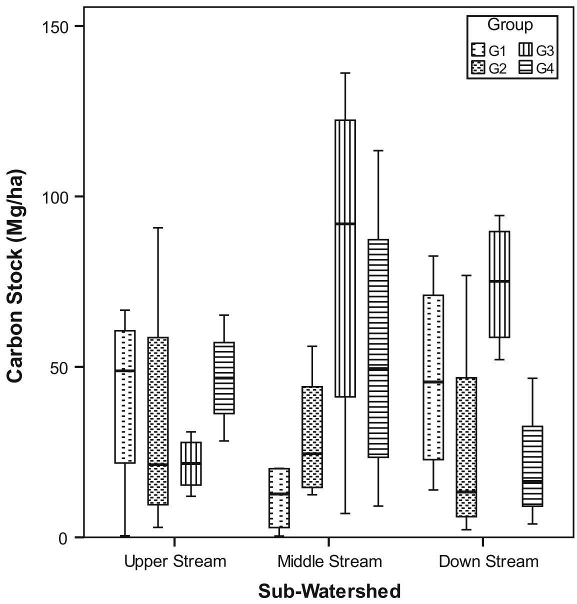


Fig. 5 Number of carbon stock on plants (Mg/ha) in *pekarangan* based on sub-watershed and group classification. Shows that small *pekarangan* also have capability to capture numerous carbon

The existence of large trees is causing carbon stock on middle stream of Cisadane watershed to be higher. One of *pekarangan* with a high value of carbon stock has several large trees with (DBH) more than 10–41 cm. Carbon stock above ground level mainly contained in plants, especially in permanent crops (Henry et al. 2009). Carbon stock is influenced by structure and composition of vegetation such as type, size, height and density of trees (Bajigo et al. 2015).

One of G3 *pekarangan* in middle stream of Cisadane watershed saves C up to 108.52 Mg/ha. Big trees of mango, *rambutan* and guava planted in this area accounted for nearly 95.32% 103.44 Mg/ha. Overall, carbon can be stored in above-ground parts of plants, litter, herbs, soil and roots. Above-ground biomass potential saves 32.9% of the total, while below ground can be reached 56.7% (Roshetko et al. 2002). Agroforestry practices will set the quantity of carbon that can be stored; it is associated with the species composition and ecological and environmental variations (Kumar 2011). Another thing is the speed of tree growth and the number of trees per unit of land (Henry et al. 2009).

In general, cultivation of tree on *pekarangan* will certainly store carbon much higher. It became one of the reasons the carbon stored in *pekarangan* without OAL higher than *pekarangan* with OAL. However, ownership of OAL significantly affects quantity of carbon stock in *pekarangan*, because *pekarangan* without OAL prefer to have ornamental plants that are profitable but have a low carbon content. On the other hand, it can be said that the small and medium *pekarangan* (<400 m^2) also have potential stored high carbon.

Wood of slower-growing species usually has higher density; therefore, the slow-growing species may accumulate more carbon in the long term

(Baker et al. 2004). Some examples of trees with high density which is more than 800 kg /m^3 are timber for furniture or other industries such as teak (*Tectona grandis*), *merbau* (*Intsia bijuga*) or *meranti* (*Shorea javanica*). Local trees are often planted in *pekarangan* and have medium density, namely cinnamon (*Cinnamomum burmanii*). People use this plant as a medicine and also herb. In general, community more often cultivated fruit trees like mango, *rambutan*, *durian* and jackfruit. Of course, densities of fruit trees are not high as timber. Even so homeowners can plant these two trees as needed, as fruits for consumption or timber for additional income. In addition there is also some kind of exotic plants, especially ornamental plants. Exotic plants will grow faster and also multiply by themselves, and will certainly contribute to carbon sequestration. However, the presence of exotic plants related carbon stock in the agroforestry landscape is still debated. Local plants are more adaptable than exotic plants (Nair et al. 2009), besides exotic plants will be more harmful especially if located near the conservation area (Bajigo et al. 2015; Kaswanto and Nakagoshi 2014).

3.3 Correlation Between Plants Biodiversity Index and Carbon Stock

Correlation analysis is conducted to see the linkages between biodiversity index and carbon stock in *pekarangan*. Management of landscape services such as biodiversity and carbon stock in *pekarangan* must be sustained for a long period, so that the study of relationship between these two things is important. The hypothesis is *pekarangan* with a lot of vegetation will be able to store much carbon.

As a result of linear regression, Shannon–Wiener Index and carbon stock are positively related. The relationship between Shannon–Wiener Index of trees with its carbon stock has a greater value of $R^2 = 0.234$. A variation of carbon stock does not affect plant biodiversity. These results are in line with the research of Mandal et al. (2013) and Karna et al. (2012). A comparative study in northern region of West Java showed that there is a possibility of positive correlation between Shannon–Winner Index and carbon stock inside *pekarangan* (Filqisthi and Kaswanto 2017).

The composition of tree species and agroforestry affects the quality and quantity of biomass on the ground and also carbon stored below ground (Nair et al. 2009). Water availability, quality and quantity of litter, root composition and distribution of carbon in the soil profile will influence both the quality and the quantity of the biomass returned to the soil. Recent research (Dayamba et al. 2016) found a positive relationship between species richness and underground carbon biomass in the West African region.

3.4 The Potential of Landscape Beautification Inside Pekarangan

The perspective of beauty from each *pekarangan* can be defined as social value, which means the highest value comes from the idea of productivity and the naturalness. The more beauty is implying to more natural. The landscape variables used for the analyses of the "society" value of the rural landscapes were defined on the scales for the "local" (human-natural) and for the "landscape" (not human-natural) perceptives (Franco et al. 2003).

The landscape beautification mainly came from the naturalness and the land use compatibility (Kaswanto 2015). Therefore, to increase the scenic beauty of each *pekarangan*, the natural arrangement of hardscapes and softscapes is a must. In addition, the beautification is also related to the experience of comfort, brightness and safety from a landscape (Febriana and Kaswanto 2015). It means to improve the landscape services from *pekarangan* can be reached by interfere the comfortability of microclimate inside *pekarangan* through planting functional plants such as oxygen provided plants, phytoremediation plants and high absorbed carbon dioxide plants. At the same time, the penetration of sunlight should reach the ground level (lawn area) to improve the brightness. Thus, increasing the maintenance of *pekarangan* to give the safety impression through well managed plants condition, routine pruning, standard thinning and well treated of old/broken plants (such as cavity treatment).

3.5 Water Resource Management in Pekarangan

As a lotic system, those four streams are particularly conditioned in a flow rate, turbidity and effects of temperature on the biota of rapids and pools. With a high flow rate over rocks or logs, the surface of a stream is broken and considerable water turbulence occurs and there is an increasing sedimentation process (Kaswanto et al. 2008). According to Seyhan's categories of watershed (1990), the characteristics of those four watersheds could be influenced by area, shape, slope, vegetation, land use, fishpond and lake number, drainage and pH permeability. In addition, those four watersheds can be dominantly categorized into perennial stream type with the presence of a defined channel. It means a defined channel was entrenched into the landscape or had an active water path that is noticeably scoured, sorted or settled materials. Those conditions proofed that rural landscapes have ability to absorb and clean the water contamination through natural process. However, the use of fertilizer and chemical pesticide should be monitored because some indicators of inorganic matters showed likely tendencies to polluted water (Kaswanto et al. 2012). Furthermore, the community is practicing local wisdom through landscape agroforestry management in restoring the value of water quality. The abilities to maintain the local wisdom knowledge to maintain the environmental quality are more likely the best options for achieving sustainable management in rural landscapes (Kaswanto et al. 2012).

Water management in each stream gradually changes the water cycling system, particularly in *pekarangan* system. Upper stream is almost free from house waste disposal. It is contrary to downstream that pollutes water streams with dump and waste pond water. But the most sustainable cycling system is located in middle stream where it is supported by a sustainable agroforestry system and has subsistence cycle in home activities and production. This situation has still in same typical condition which has been researched since almost ten years ago (Kaswanto et al. 2008). Figure 6 shows the investigation of the latest condition for water management inside and outside *pekarangan* system. A research in West Java shows that there are positive correlations between land use change and water quality (Karima and Kaswanto 2017).

Most households are connected to the water based on gravity utilization. Their concerns focused on water availability, demand, quality and management conflict on the watershed level (Kammerbauer et al. 2001). Anthropogenic activities can act on pristine wetland and change water quantity and water quality (Alvarez-Cobelas et al. 2001), and hydrological and ecological processes (Zalewski 2014). The different kinds of management conflicts can be observed as water fluxes in the creek were reduced during the dry season period (Kaswanto et al. 2008). In addition, the communities competed for irrigation water for their farming, as clear rules for the assignment of irrigation water were not established effectively. One of the water improvement practices is using water quality priority scenario that increases the agroforestry system production which is sustainable (Coiner et al. 2001) such as ecohydrology (Zalewski 2000). Degradation of freshwater ecosystems and those of water resources have two facets: pollution and the disruption of water and nutrient cycles, and pollution can be substantially eliminated by biotechnology. The optimization of ecotone (transition ecosystem) structure (Harashina et al. 2003) in whole watershed usually fights a lack of space for ecohydrologically relevant structure, and a lack of funding, although ecotones and other structural biotic elements provide basis for sustainable landscape management (Janauer 2000) and for ecological resilience (Ungaro et al. 2017).

3.6 Landscape Management of Pekarangan as Landscape Services Provider

In the context of productivity, G1 and G2 are significantly different from G3 and G4, which means a small *pekarangan* is more productive than a medium-sized *pekarangan*. This is because the management of small *pekarangan* is more intensive than a medium *pekarangan*. Small *pekarangan* (G1 and G2) are tending to develop an open space by growing more crops and raising more livestock/fish. This tendency is also because they have no other cultivated land they could manage, so that they are more focused on their own *pekarangan*. *Pekarangan* without OAL groups tend to have a higher income than *pekarangan* with OAL, because

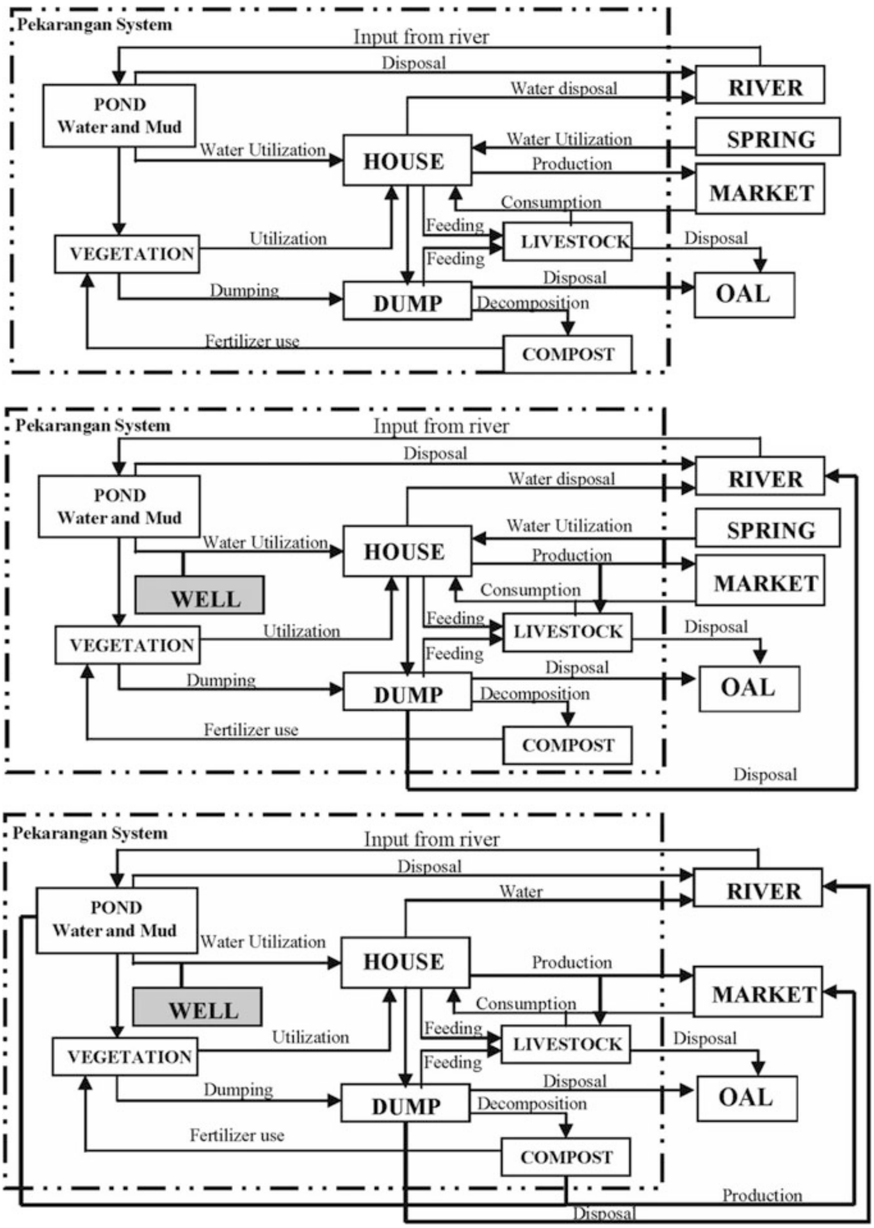


Fig. 6 Water management in the *pekarangan* system differentiates from upper stream (top), middle stream (middle) and downstream (bottom). The bold arrow and shading box indicate the differences. Modification from Kaswanto (2008)

pekarangan without OAL will always try to develop and increase *pekarangan* productivity, this is in line with the explanations at the beginning of this article.

Mitchell et al. (2004) also mention that *pekarangan* contribute significantly in many ways and significantly improve the financial status of the family. Furthermore, *pekarangan* not only play a role in ecology, but also social and cultural functions (Arifin et al. 2001). Small *pekarangan* should be considered as a model for the sustainable micro-scale agroforestry systems, integrated ecological and economic benefits that will improve community welfare for a better future, as proposed by Schultink (2000). *Pekarangan* can also contribute to improve household welfare, and it is in line with several previous studies (Albrecht and Kandji 2003; Harashina et al. 2003; Kabir and Webb 2008; Mulyoutami et al. 2009). In the end, *pekarangan* should be recommended as one strategy to aspire malnutrition and deficiency of micronutrients, especially for people in marginal areas. Some studies have also found that *pekarangan* significantly increase household consumption (Abdoellah et al. 2006; Marsh 1998; Mitchell and Hanstad 2004; Niñez 1985; Soemarwoto 1987; Wiersum 2006).

3.7 Management of Landscape Services for Improving Community Welfare

Managing landscape services, from classical types such as biodiversity, carbon stock, landscape beautification and water resources, would give a positive contribution for community welfare, particularly for those who have *pekarangan*. A community-based development to increase the community welfare could be as tourism activities and attractions (Qian et al. 2017), in particularly as agrotourism (Garrido et al. 2017; Kaswanto 2015; Lestrelin et al. 2017). Improved access to markets and social provision of education and health care have mostly improved the welfare of previously isolated groups (Cramb et al. 2009), particularly for *pekarangan* land use system.

4 Conclusion

Most of *pekarangan* structures have vertical and horizontal diversity relatively high with a value of H' ranged from 0.77 to 3.57, but the value of $H' > 1.00$ reaches 98.95% of the total samples of *pekarangan*. The average of H' in *pekarangan* without OAL (G1 and G3) is higher than *pekarangan* with OAL (G2 and G4). It shows that the absence of OAL will make homeowners take advantage of *pekarangan* more intensively, thus creating higher biodiversity index in *pekarangan* without OAL.

Similarly with carbon stock, especially if homeowners had decided to plant trees that have high density. OAL ownership affects the amount of carbon stock in *pekarangan*, because *pekarangan* without OAL prefer to have ornamental plants that are profitable but have a low carbon content. On the other hand, *pekarangan*

<400 m^2 also has potential for storing high carbon. Thus, it can be concluded that *pekarangan* will function both as a biodiversity conservation and as a carbon stock.

There are several recommendations which need to be concerned in *pekarangan* management. Those are (1) *pekarangan* should be maintained with multistrata composition and various type of plants, which create high biodiversity index, (2) *pekarangan* with high biodiversity index is necessarily to increase the carbon stock, which means that the existence of the tree becomes important because of its effectiveness in storing carbon and (3) *pekarangan* should be considered as a community capital not only as a tangible asset but also as an intangible asset (social value). On the other hand, related to the concept of low carbon landscape, there are three concepts that need to be implemented, namely optimizing the *pekarangan*, cultivating productive plant and planting local species to increase the value of landscape services.

Beautification should be considered for giving comfort, brightness and safety, while water utilization in three zones indicates optimal improvement of human activity and agricultural production. According to material balance cycling system, the middle stream of watershed has more sustainable water management pattern than the others.

As a conclusion, *pekarangan* as micro-scale agroforestry landscape can contribute significantly in providing landscape services. Landscape services are used to preserve the surrounding environment and at the same time could be as a community asset to improving household welfare. *Pekarangan* preservation from plant biodiversity and carbon stock aspects can provide added value for quality of the rural landscape. Therefore, the revitalization of *pekarangan* by improving landscape services as a rural communities asset needs to be empowered. Community should consider appropriate *pekarangan* agroforestry practices rather than relying only on cultivation of agricultural land. Community can also expect to revitalize the utilization of diverse local species in order to increase ecological, economic and social values. Furthermore, the well managed *pekarangan* system can be a way to achieve sustainable development goals (SDGs), particularly for developing countries.

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