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# Tree Diversity in Home Gardens in the Bogor Regency, West Java

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## ABSTRACT

We used the point-centered quarter method for trees and quadrats for saplings in home gardens of 42 hamlets within 40 districts in the Bogor Regency, West Java, to investigate the floristic composition and structure of home garden tree communities. We found a diverse range of fruit trees. A total of 64 fruit tree species were identified accounting for 93.2% of all tree species. *Artocarpus heterophyllus* and *Nephelium lappaceum* were the two species with the highest importance value, frequency, and degree of association. The *Artocarpus heterophyllus–Nephelium lappaceum* association or in the local names *Nangka–Rambutan* association is justified based on these species' characteristics. The distributional patterns of tree species support categorizing them into six groups: very common, common, rather common, rather rare, rare, and very rare. *Annona squamosa*, *Phyllanthus acidus*, *Syzygium polyanthum*, *Glochidion borneense*, *Mangifera foetida*, and *Diospyros philippensis* were the fruit tree species that made up the extremely rare group. *Nephelium lappaceum*, *Artocarpus heterophyllus*, and *Lansium domesticum*, had the highest importance value (40%) at the tree level, whereas *Punica granatum*, *Annona muricata*, and *Averrhoa bilimbi* at the sapling stage. Species diversity indices for trees and saplings in the sampled home gardens fell into the H' = 1 to 3 categories, while similarity indices among the home gardens species composition were quite low (IS 64%). The fruit tree species had a low ability to regenerate.

Keywords: Bogor, diversity, fruit trees, home gardens

## INTRODUCTION

A home garden is a piece of land having boundaries and makes livelihood needs available to its owner in the form of fruit plants, vegetables, and medicinal plants that could become a source of income (Soemarwoto, 1987; de Foresta and Michon, 1992; Kumar and Nair, 2004). It has also economic, biophysical, and socio-cultural relationships with its owner (Abdoellah, 1990).

A home garden has a stratified structure with species composed of trees including fruit trees (Karyono, 1985). High species diversity is one of the characteristics of home gardens, (Soemarwoto, 1987 citing Terra, 1949; Karyono, 2000) and species diversity maintains ecosystem stability (Soemarwoto et al., 1976; Soemarwoto, 1987; de Foresta and Michon, 1992). It is also a source of germplasms of many plant resources, making them the alternative source of a variety of foods (Abdoellah and Isnawan, 1980).

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In the Bogor Regency, West Java, large varieties of fruit trees are planted in home gardens. In the village of Jabon Mekar, Parung Subdistrict, Bogor Regency, for instance, Prasetyo (2006) recorded 57 fruit plant species, belonging to 23 families. He further noted that the Bogor Regency was the area of distribution of high genetic diversity of fruit tree species, including, *Mangifera indica* (Mangga), *Nephelium lappaceum* (Rambutan), *Durio zibethinus* (Duren), *Carica papaya* (Papaya), and *Musa paradisiaca* (Pisang).

The rapid population increase in the Bogor Regency has led to land conversion into settlements and other land uses, resulting in decreased plant species diversity (Benton, 2007). Because of the above facts, we feel that research should be conducted to secure data on the current diversity of fruit tree and non-fruit tree species in the Bogor Regency to provide and contribute data to support biodiversity utilization and conservation programs in Indonesia.

## METHODS

The study was carried out from May to August 2012 in the Bogor Regency, West Java, at 6º18′–6º47’10 South and 106º23’45–107º13’30 East. Topographically the Bogor Regency is composed of 29.28% lowlands with altitudes of 50–100 m asl (meter above sea level), 42.62% undulating lands (100–500 m asl), 19.34% hills (500–1.000 m asl), and 8.35% mountains (1.000–2.500 m asl).

Most of the areas in the Bogor Regency have a very wet climate with the Schmidt and Ferguson (1951) rainfall type A and small areas with rainfall type B. The mean annual rainfall ranges from 2,500 mm to 5,000 mm and the mean annual temperature of 26°C (Lembaga Meteorologi dan Geofisika, 1969). The mean monthly rainfall ranges from 100 mm to 500 mm with the relatively dry period from May to October, as exemplified by the rainfall patterns in the districts of Ciawi, Cisarua, Dramaga, Jasinga, and Parung (Figure 1).

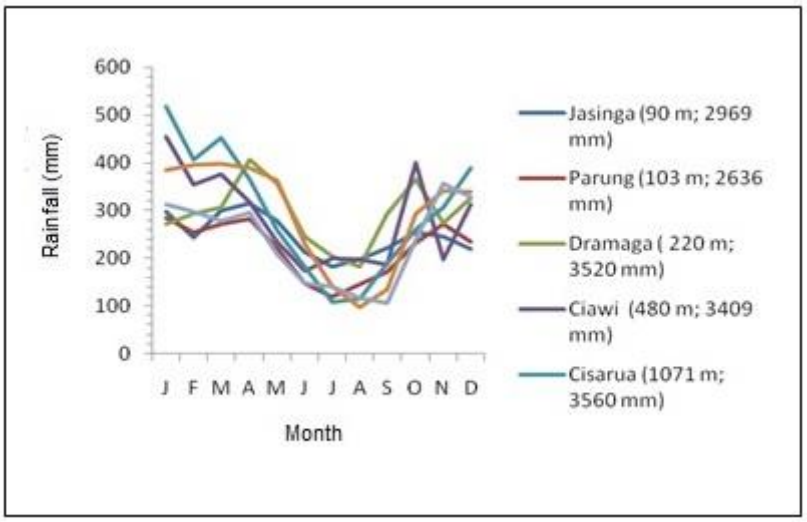


Figure 1. Patterns of the mean monthly rainfalls for January–December, complemented with data on altitudes and mean annual rainfall in six districts within the study sites (Source: Lembaga Meteorologi dan Geofisika, 1969)

We applied the same method used by Susanto *et al*. (2021), who wrote an article on carbon potential, which constituted a part of the present study on home gardens in the Bogor Regency. We adopted a purposive random sampling in all (40) Subdistricts (*kecamatan*) within the Bogor Regency (Figure 2). We randomly selected one village a (*desa*) in each

district, and in each village, a hamlet (*kampung*) was selected. In Tajurhalang Subdistrict, however, we selected two villages and two hamlets to satisfy the sampling requirements, stipulating that the number of samples should be 10% of 410 hamlets in 40 villages in the Bogor Regency, in line with the sampling prerequisites of 10% of the total area of the study (Mueller-Dombois and Ellenberg, 1974; 2016).

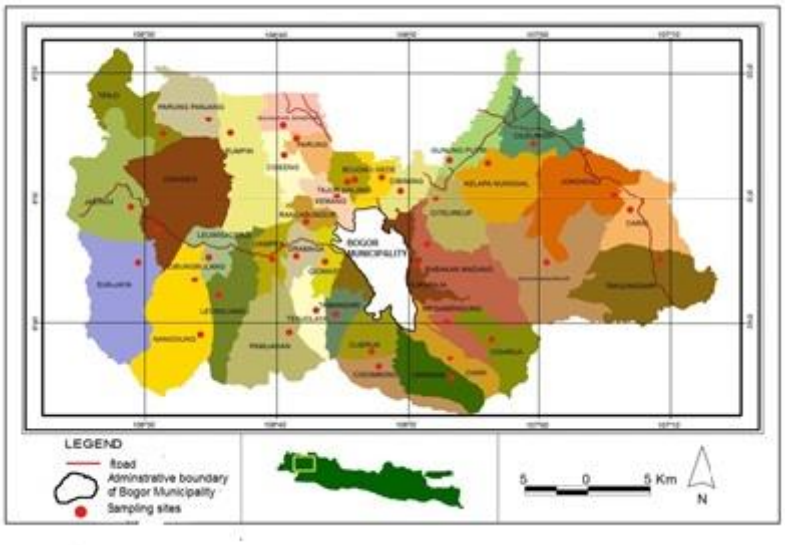


Figure 2. Sampling sites at 41 hamlets in 40 villages within 40 districts in the Bogor Regency (Source: Dinas Pertanian dan Kehutanan Kabupaten Bogor, 2006)

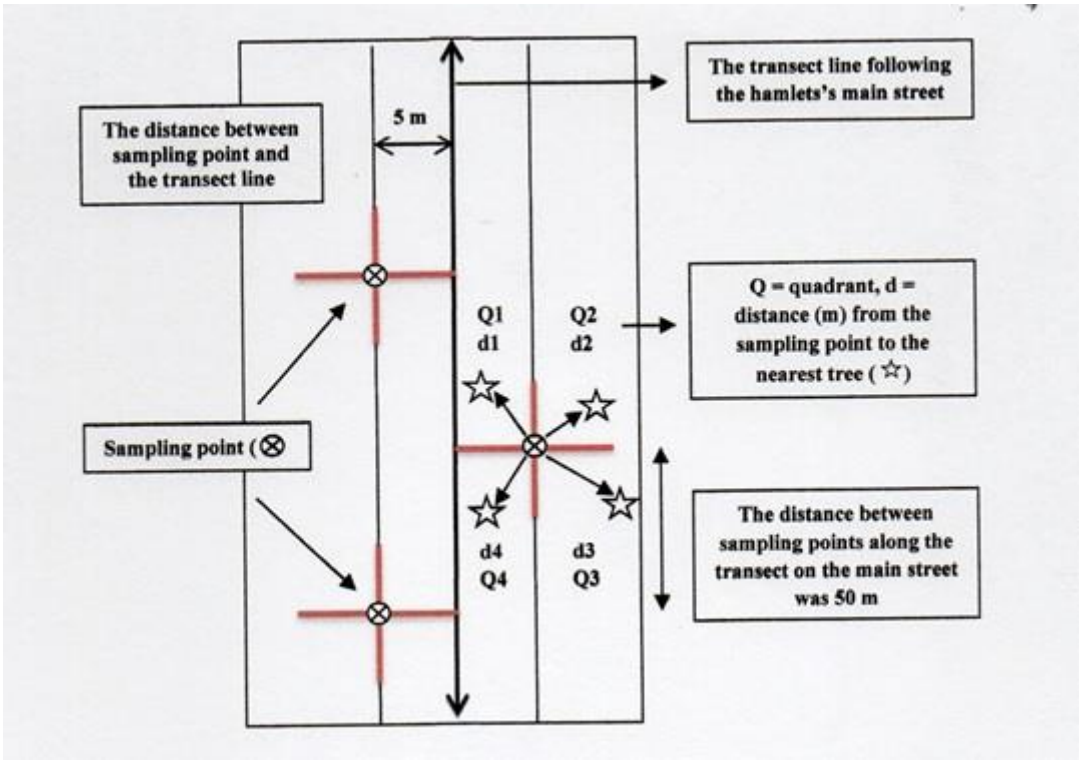


Figure 3. Design of sampling using the point-centered quarter method with 10 sampling points laid out at 50 m intervals along a transect in a sampled hamlet

We used the point-centered quarter method (Cox, 1967; Mueller-Dombois and Ellenberg, 1974, 2016) to sample trees. In each selected hamlet the sampling was carried out

in a transect line following the hamlet's main street. In each hamlet, we placed 10 sampling points alternately at a distance of 5 m to the left and 5 m to the right side of the transect line, with the distance between sampling points of 50 m (Figure 3), thus creating the length of the transect line of 500 m. At each sampling point, we established 4 quadrants (Q1–Q4) by making a line parallel to the transect line and another line crossed and perpendicular to the first line. In each quadrant, we measured the distance from the sampling point to the nearest tree with a diameter at breast height (DBH) ≥ 10 cm and the four distances were designated as d1, d2, d3, and d4. To sample tree saplings, with DBH of 2.0–9.9 cm, we constructed a quadrat of 5 m x 5 m at the Q2 sampling point. The total number of sampling points in 41 hamlets was 410. Data collected included the tree identity, distance of individual trees to the sampling points, number of trees, Diameter at Breast Height (DBH), and the heights of trees.

Data analysis included the calculation of Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), dominance (Do), Relative Dominance (RDo), and Importance Value (IV) (Cox, 1967; Mueller-Dombois and Ellenberg, 1974, 2016, Rahmah *et al.* 2013). The standard method (Mueller-Dombois and Ellenberg. 1974, 2016; Rahmah *et al.*, 2016; Purwaningsih *et al.*, 2017) was applied to calculate density frequency and dominance. Density was defined as the number of individuals per unit area. In the present study, we use the Point-Centered Quarter Method and the number of all trees per hectare (D) was calculated by:

$$D = \frac{\text{area in hectare}}{\text{md}}$$

where the *area in hectare* is 10,000 $m^2$ and *md* is the *mean distance* (meter) of all distances of trees and the sampling points. The density in the plot was the sum of the trees of all species and was presented as the number of trees per hectare. The Relative Density (RD) for each species was then computed as follows:

$$RD = \frac{\text{number of individuals of a species}}{\text{total number of individuals of all species}} \; x\; 100\ \%$$

Frequency is the number of times a species occurs in a given number of sampling points in the samples and is expressed as a percentage of the total number of sampling points. No counting of individuals was carried out, it was just recording the species' presence. The Relative Frequency (RF) for each species was calculated as follows:

$$RF = \frac{\text{the frequency of a species}}{\text{the sum of the frequency of all species}} \; x\; 100\ \%$$

Dominance for trees is usually defined as stem cover, which is the same as basal area. The basal area (BA) is obtained with the formula:

$$BA = (½\ dm\ )^2 \text{ x } \pi$$

where *dm* stands for *diameter*. The Relative Dominance (RDo) was obtained with the following formula:

$$RDo = \frac{\text{the dominance of a species}}{\text{the dominance of all species}} \; x\; 100\ \%$$

The sum of density, frequency, and dominance could be used to indicate the importance of a species in the sample and this could be done only if they were expressed in terms of relative values. The Importance Value (IV) was then calculated with the following formula (Curtis and Cottam, 1967; Mueller-Dombois and Ellenberg, 1974, 2016):

$$IV = RD + RF + RDo$$

and the IV of a species reached a maximum of 300 in the sample when only one tree species was present.

Diversity Index was calculated using Shannon Wiener with the following formula:

$$H' = -\sum \left(\frac{ni}{N}\right) \log \left(\frac{ni}{N}\right)$$

where *ni* = number of individuals of the *i-th* species and *N* was the number of individuals of all species. The diversity value criteria were H' < 1 = low; H' = 1–3 = medium; H' > 3 = high (Greig-Smith, 1983).

Community similarities were analyzed using Sorensen Similarity (IS) and are presented in a dendrogram constructed using *Multivariate Statistical Package* (MVSP).

## RESULTS AND DISCUSSION

### Species Diversity in the Home Gardens

The study on floristic composition and structure of tree communities in the home gardens located in 41 hamlets in 40 villages and 40 districts within the Bogor Regency recorded 74 species belonging to 31 families including 64 tree species from 28 families (Appendix 1). We recorded 69 fruit species and 5 non-fruit species. The scientific names of the fruit trees furnished with the authority are listed in Appendix 1. The species are represented by 1,640 trees with a total BA (Basal Area) of 110.402 $m^2$ and 462 saplings with a total BA of 1991.10 $m^2$ (Table 1). Of 74 tree species, A total of 29 species of woody trees were timber-producing species used for building construction and tools, spices, materials for medicine, fragrance, and beverages.

Table 1. Characteristics of the tree communities in the home gardens studied in the Bogor Regency

| Community characteristics | Fruit trees | Non-fruit trees | Total |
|---|---|---|---|
| Number of species (trees and saplings) | 69 (93.2%) | 5 (6.8%) | 74 |
| Number of individuals | | | |
| Trees | 1,616 (98.5%) | 24 (1.5%) | 1,640 |
| Saplings | 446 (96.5%) | 16 (3.5%) | 462 |
| Mean density (stems/ha) | | | |
| Trees | 578 | 9 | 587 |
| Saplings | 435 | 16 | 451 |
| Basal Area ($m^2$) | | | |
| Trees | 109,068 (98.8%) | 1,334 (1.2%) | 110,402 |
| Saplings | 1,955 (98.2%) | 36.10 (1.8%) | 1991.10 |
| Mean Basal Area/individual ($m^2$) | | | |

| | | | |
|---|---|---|---|
| Trees | 67.49 | 55.58 | 123.07 |
| Saplings | 4.38 | 2.25 | 6.63 |

We recorded three non woody fruit tree species, i.e., *Areca catehu* (Pinang), *Carica papaya* (Pepaya), and *Musa paradisiaca* (Pisang). The non-fruit woody tree species encountered were *Cassia siamea* (Johar), *Glochidion borneense* (Mareme), *Maesopsis eminii* (Kayu Afrika), *Paraserianthes falcataria* (Sengon), *Samanea saman* (Trembesi), and *Tectona grandis* (Jati).

The importance and roles of species in a community were expressed by their Importance Value (IV). Species with high IVs indicated their influence on the function and stability of an ecosystem (Odum, 1971). Table 2 shows 10 species with the highest IVs, which might be implied as those having a strong influence on the home garden tree communities.

Table 2. Ten fruit tree species with the highest Importance Value (IV)

| No. | Species | Family | IV (%) |
|---|---|---|---|
| 1 | *Nephelium lappaceum* | Sapindaceae | 64.6 |
| 2 | *Artocarpus heterophyllus* | Moraceae | 41.5 |
| 3 | *Lansium domesticum* | Meliaceae | 41.4 |
| 4 | *Mangifera indica* | Anacardiaceae | 35.9 |
| 5 | *Durio zibethinus* | Bombacaceae | 30.2 |
| 6 | *Myristica fragrans* | Myristicaceae | 23.1 |
| 7 | *Garcinia mangostana* | Clusiaceae | 20.0 |
| 8 | *Persea americana* | Lauraceae | 19.0 |
| 9 | *Sandoricum koetjape* | Meliaceae | 17.8 |
| 10 | *Spondias dulcis* | Anacardiaceae | 17.2 |

Two species with the highest IV were *Nephelium lappaceum* (64.6%) and *Artocarpus heterophyllus* (41.5%), which were the dominant fruit tree species throughout the Bogor Regency. It was observed in the field that the home gardens did not require species maintenance, such as fertilizing and pruning, yet they are fruiting throughout the year. Karyono (1985) reported that *Artocarpus heterophyllus* (Nangka) was an important species as a food source in home gardens.

Two families that *Fabaceae* and *Myrtaceae* contained the highest number of species, eight species each (Table 3). Species belonging to *Fabaceae* included *Archidendron pauciflorum* (Jengkol), *Leucaena leucocephala* (Petai cina), *Parkia speciosa* (Petai), and *Tamaridus indica* (Asam), while those of *Myrtaceae* were *Psidium guajava* (Jambu batu), *Syzygium aqueum* (Jambu air), *Syzygium cumini* (Jamblang), and *Syzygium malaccense* (Jambu bol).

Table 3. Ten families with the high number of species and Importance Value

| No | Family | Number of Species | No | Family | IV (%) |
|---|---|---|---|---|---|
| 1 | Fabaceae | 8 | 1 | Meliaceae | 92.2 |
| 2 | Myrtaceae | 8 | 2 | Sapindaceae | 90.2 |
| 3 | Anacardiaceae | 7 | 3 | Anacardiaceae | 85.2 |
| 4 | Moraceae | 4 | 4 | Fabaceae | 76.9 |
| 5 | Euphorbiaceae | 4 | 5 | Myrtaceae | 72.2 |
| 6 | Meliaceae | 4 | 6 | Moraceae | 64.2 |

| | | | | | |
|---|---|---|---|---|---|
| 7 | Sapindaceae | 4 | 7 | Bombacaceae | 41.6 |
| 8 | Sapotaceae | 4 | 8 | Sapotaceae | 38.5 |
| 9 | Annonaceae | 3 | 9 | Euphorbiaceae | 37.0 |
| 10 | Rutaceae | 3 | 10 | Myristicaceae | 23.0 |

Table 3 shows that species included in *Meliaceae* had a total IV of 92.2%. They were *Lansium domesticum* (Duku), *Lansium domesticum* var. *aqueum* (Kokosan), *Sandoricum koetjape* (Kecapi), and *Swietenia mahagoni* (Mahoni). High IVs were contributed by *Lansium domesticum*, and *Sandoricum koetjape* having diameters of 20-34.5 cm and *Swietenia mahagoni* with diameters greater than 35 cm.

The distribution of fruit trees and non-fruit trees in the villages was not homogeneous. Six categories of distribution may then be identified as shown in Table 4 and Figure 4.

Table 4. Category of distribution of fruit trees and non-fruit trees based on the frequency percentage ( F = % )

| No | Category | Species |
|---|---|---|
| 1 | Very Common (F = 75-100%) | *Artocarpus heterophyllus*, *Durio zibethinus*, *Syzyzgium aqueum*, *Mangifera indica*, and *Nephelium lappaceum* |
| 2 | Common (F = 50.1-75%) | *Annona muricata*, *Averrhoa carambola*, *Lansium domesticum*, *Psidium guajava*, and *Sandoricum koetjape* |
| 3 | Rather Common (F = 25.1-50%) | *Archidendron pauciflorum*, *Artocarpus altilis*, *Garcinia mangostana*, *Leucaena leucocephala*, *Mangifera odorata*, and *Manilkara zapota* |
| 4 | Rather Rare (F = 10.1-25%) | *Artocarpus champeden*, *Averrhoa bilimbi*, *Baccaurea racemosa*, *Syzyzgium polycephalum*, *Dimocarpus longan*, *Gnetum gnemon*, *Mangifera caesia*, *Muntingia calabura*, *Parkia speciosa*, *Persea americana*, and *Syzygium malaccens* |
| 5 | Rare (F = 5.1-10%) | *Anacardium occidentale*, *Antidesma bunius*, *Bouea macrophylla*, *Ceiba pentandra*, *Chrysophyllum cainito*, *Citrus hystrix*, *Citrus maxima*, *Lansium domesticum* var. *aqueum*, *Maesopsis eminii*, *Manilkara kauki*, *Morinda citrifolia*, *Musa paradisiaca*, *Pangium edule*, *Paraserianthes falcataria*, *Pometia pinnata*, *Pouteria campechiana*, *Punica granatum*, *Spondias dulcis*, *Syzygium aromaticum*, *Syzygium cumini*, *Swietenia mahagoni*, *Tamarindus indica*, and *Theobroma cacao* |
| 6 | Very Rare (F = < 5%) | *Annona squamosa*, *Cassia siamea*, *Cerbera manghas*, *Diospyros philippensis*, *Filicium decipiens*, *Glochidion borneense*, *Mangifera foetida*, *Michelia champaca*, *Phyllanthus acidus*, *Samanea saman*, *Syzygium polyanthum*, *Tectona grandis*, and *Terminalia catappa* |

Two species with the highest distribution and IV were *Artocarpus heterophyllus* (F = 100%; IV = 41.5%) and *Nephelium lappaceum* (F = 97.6%; IV = 64.6%), see Table 2 and Table 5. The two species had the strongest association in distribution with the Jaccard Similarity Index of 97.6 %. The most common species (F = 75.1-100 %) can be designated as character species (Mueller-Dombois and Ellenberg, 1974; 2016) for the home garden tree

community in the Bogor Regency. Based on this character species the home garden community can be designated as the *Artocarpus heterophyllus–Nephelium lappaceum* association and using the local name we can call it the *Nangka-Rambutan* association. In Indonesian, we designated as *Asosiasi Nagka-Rambutan*.

The fruit tree species of the Rare Category (5) and Very Rare (6) in Table 4 were not common in the home gardens. Several fruit-tree species of these groups were recorded as rare species according to the criteria of the IUCN Red List of Threatened Species (IUCN, 2022). They were *Mangifera foetida* (Mangga limus), *Mangifera caesia* (Kemang), *Gnetum gnemon* (Melinjo), and *Punica granatum* (Delima) which were listed in the *Least Concern* (LC) category or species with low risk. Three species, *Mangifera indica* (Mangga), *Mangifera odorata* (Mangga kuweni), and *Myristica fragrans* (Pala) were included in the *Data Deficient* (DD) category.

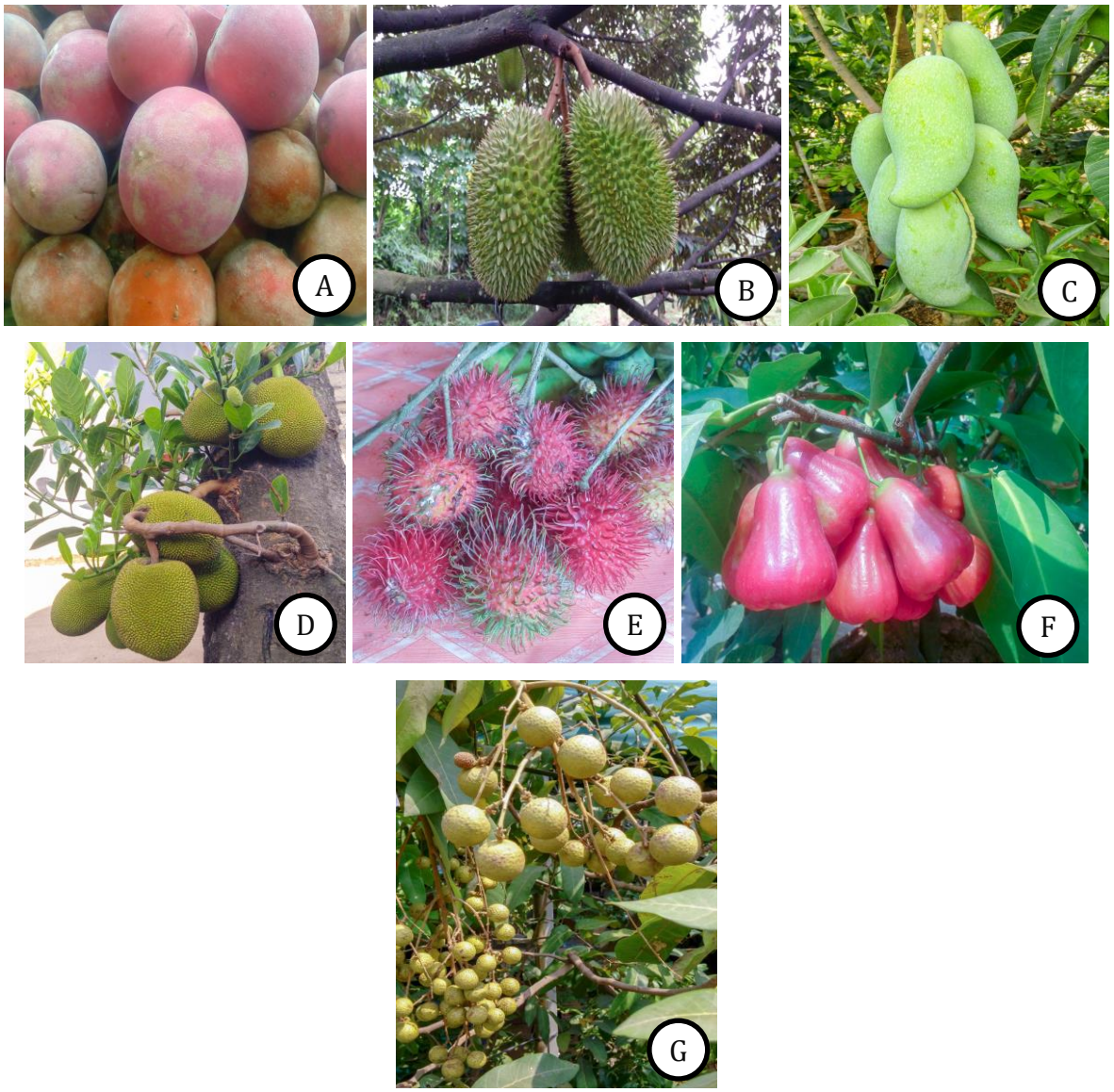


Figure 4. Some fruit-tree species found in the study area. A. *Diospyros philippensis* (Desr.) Gurke, B. *Durio zibethinus* Murray, C. *Mangifera indica* L., D. *Artocarpus heterophyllus* Lam., E. *Nephelium lappaceum* L., F. *Syzygium aqueum* (Burm.f.) Alston, G. *Dimocarpus longan* Lour.

Of all species, *Swietenia mahagoni* (Mahoni) was listed as an *endangered* (EN) species that seemed to be threatened species in its natural habitat in Mexico. In Indonesia, however, it has been recorded as an exotic species commonly cultivated as shade trees along roads and in forest plantations.

Woody fruit trees that have been rarely found in the fruit markets but were present in the studied home gardens were *Antidesma bunius* (Buni), *Bouea macrophylla* (Gandaria), *Diospyros philippensis* (Bisbul), *Mangifera caesia* (Kemang), *Lansium domesticum* var. *aqueum* (Kokosan), and *Syzygium polycephalum* (Gowok).

Table 5 shows that *Nephelium lappaceum* (Rambutan), *Artocarpus heterophyllus* (Nangka), *Mangifera indica* (Mangga), and *Durio zibethinus* (Duren) had the highest frequency > 90% and following Table 4, they can be categorized as very common species indicating that they had the highest adaptability to the variability of the environment. The saplings of *Psidium guajava* (Jambu batu), *Artocarpus heterophyllus* (Nangka), and *Annona muricata* (Sirsak) had the frequency of 61%, 56.1%, 51.2%, respectively (Table 5).

Table 5. Ten tree and sapling species with the highest frequency (F)

| No | Tree species | F (%) | No | Sapling species | F (%) |
|---|---|---|---|---|---|
| 1 | *Artocarpus heterophyllus* | 100 | 1 | *Psidium guajava* | 61.0 |
| 2 | *Nephelium lappaceum* | 97.5 | 2 | *Artocarpus heterophyllus* | 56.1 |
| 3 | *Mangifera indica* | 95.1 | 3 | *Annona muricata* | 51.2 |
| 4 | *Durio zibethinus* | 90.2 | 4 | *Nephelium lappaceum* | 48.8 |
| 5 | *Syzygium aqueum* | 75.6 | 5 | *Manilkara zapota* | 36.6 |
| 6 | *Averrhoa carambola* | 63.4 | 6 | *Mangifera indica* | 34.1 |
| 7 | *Lansium domesticum* | 63.4 | 7 | *Syzygium aqueum* | 31.7 |
| 8 | *Sandoricum koetjape* | 58.5 | 8 | *Averrhoa bilimbi* | 29.3 |
| 9 | *Psidium guajava* | 56.1 | 9 | *Lansium domesticum* | 21.9 |
| 10 | *Annona muricata* | 53.7 | 10 | *Sandoricum koetjape* | 21.9 |

Table 6 presents the total basal area of *Nephelium lappaceum* (Rambutan), *Artocarpus heterophyllus* (Nangka), *Durio zibethinus* (Duren), *Mangifera indica* (Mangga), and *Lansium domesticum* (Duku) that reached > 10.000 $m^2$ or equivalent to one hectare. Most of them had a mean diameter range of 20-34.9 cm to 35 cm and many of them up to > 35 cm (Figure 5).

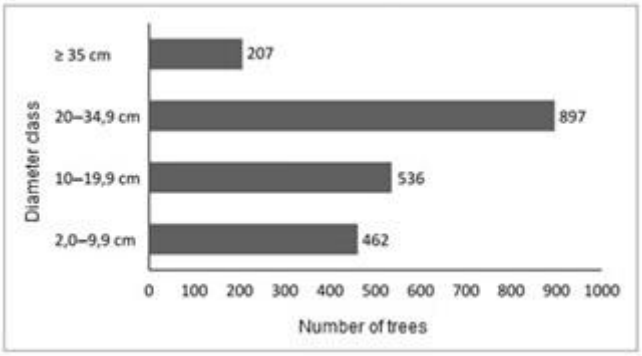


Figure 5. Number of trees according to diameter classes of fruit tree communities in home gardens in the Bogor Regency

Table 6. Ten fruit tree species that have the highest Basal Area (BA)

| No | Species | Family | Basal Area ($m^2$) |
|---|---|---|---|
| 1 | *Nephelium lappaceum* | Sapindaceae | 29,252.6 |
| 2 | *Artocarpus heterophyllus* | Moraceae | 15,563.5 |
| 3 | *Durio zibethinus* | Bombacaceae | 13,659.8 |
| 4 | *Mangifera indica* | Anacardiaceae | 11,758.6 |
| 5 | *Lansium domesticum* | Meliaceae | 10,080.4 |
| 6 | *Sandoricum koetjape* | Meliaceae | 3,327.4 |
| 7 | *Garcinia mangostana* | Clusiaceae | 2,003.9 |
| 8 | *Mangifera odorata* | Anacardiaceae | 1,846.1 |
| 9 | *Archidendron pauciflorum* | Fabaceae | 1,767.6 |
| 10 | *Syzygium aqueum* | Myrtaceae | 1,728.2 |

Figure 6 shows the number of species according to the diameter classes. The (20-34.9 cm) diameter class registered the highest number (64 species), followed by the (10-19.9 cm) diameter class (58 species), (2.0-9.9 cm) diameter class (49 species), and the (≥ 35 cm) diameter class (39 species).

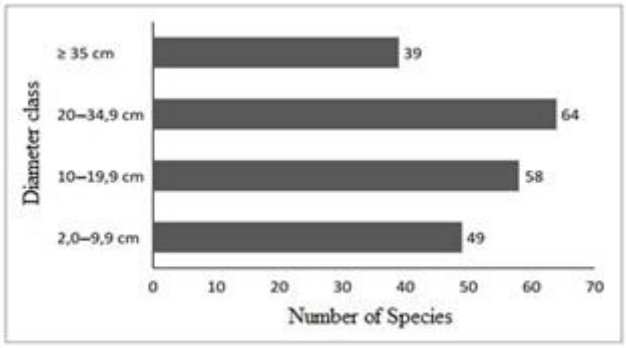


Figure 6. Number of species according to diameter classes of fruit tree communities in home gardens in the Bogor Regency

A comparison of Shannon Wiener (H') indices in the hamlets is shown in Figure 7. Applying the classification of Greig-Smith (1983), species diversity in the sampling sites was categorized as medium with H' = 1-3. In the hamlets with high registered H' = 1.19-1.25 the mean number of species was 23 and in the hamlets with H' = 1.0-1.09 was 15-18 species. The total number of species recorded in our study was 64, which was slightly higher than in the Parung Subdistrict, Bogor Regency (Prasetyo, 2006), but much smaller than that reported by Abdoellah and Isnawan (1980) in the Bantarkalong village in West Jawa, where 228 species were recorded. In the home gardens in the forest environment in East Kalimantan, Soedjito (1988) registered 91 species in the Long Sei Barang village and 128 in Long Segar village, North Kalimantan. Karyono (1985) noted that home gardens with little interference from their owners contained a high number of species, where he recorded 50 species in the land of 400 $m^2$.

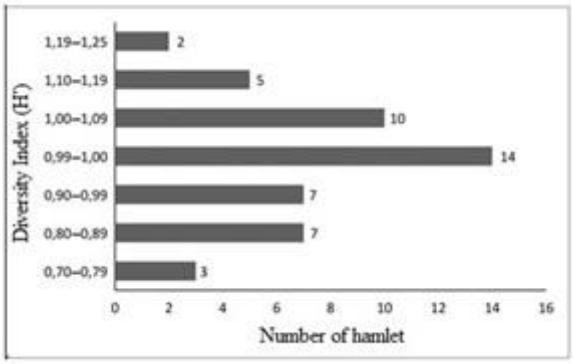


Figure 7. Species diversity is indicated by the Shannon-Wiener Diversity Index (H') in 41 hamlets in the Bogor Regency

Figure 8 shows the dendrogram of Sorensen's IS (Index of Similarity) revealing that most hamlets had similarities > 0.4 and two hamlets (Sirnagalih and Tugu Utara) had IS < 0.4. It should be noted that two hamlets (Bojong Nangka and Megamendung) had IS = 1, implying that they had identical species compositions. For other hamlets (Kalong, Kiarapandak, Parakan Muncang, and Tapos), had IS = 0.88. Parakan Muncang contained 10 species, i.e., *Artocarpus heterophyllus* (Nangka), *Averrhoa carambola* (Belimbing), *Durio zibethinus* (Duren), *Mangifera indica* (Mangga), and *Nephelium lappaceum* (Rambutan). All species occurring in Tapos could be found in Parakan Muncang, except *Syzygium aqueum* (Jambu air), and *Garcinia mangostana* (Manggis). A similar situation occurred also in Kalong (12 species) and Kiarapandak (13 species). All species in Kalong could be found also in Kiarapandak, including *Artocarpus altilis* (Sukun), *Artocarpus heterophyllus* (Nangka), *Annona muricata* (Sirsak), *Averrhoa carambola* (Belimbing), *Durio zibethinus* (Duren), *Nephelium lappaceum* (Rambutan), and *Psidium guajava* (Jambu batu).

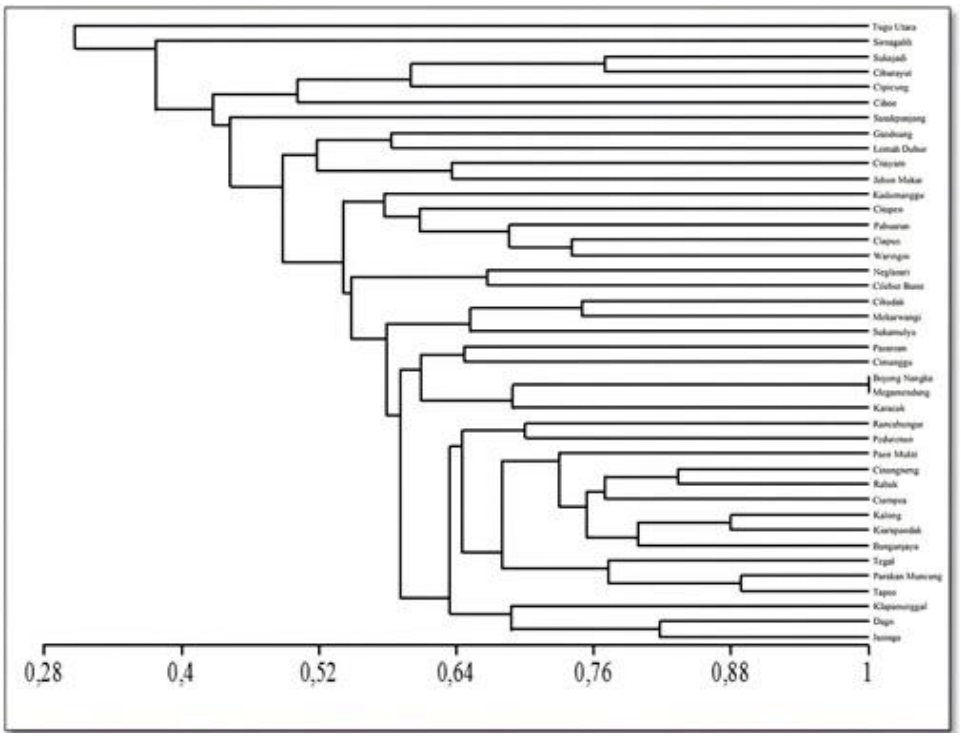


Figure 8. Dendrogram of Sorensen's Similarity Indexes of 41 hamlets in 40 villages in Bogor Regency

## Species Regeneration in the Home Gardens

Observation revealed that the regeneration of fruit trees in the home gardens did not proceed well. Regeneration plays important role in maintaining the sustainability and survival of species in the community now and in the future. If a home garden changes, the structure, and composition will consequently change, starting with the regeneration of saplings and trees.

Most of the owners of home gardens in the hamlet investigated did not care about the regeneration of their fruit trees, for instance through the planting of seeds, cuttings, grafting, and other means of propagation. In the Jabon Mekar hamlet, some home garden owners prefer to plant trendy trees, such as soursop (*Annona muricata*) since it has also medicinal value, or planting species whose fruits are easily marketable, including *Syzygium aqueum* and *Psidium guajava*.

Table 7. Ten species of saplings with the highest Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo), and Importance Value (IV)

| No | Family | Species | RF (%) | RD (%) | RDo (%) | IV (%) |
|---|---|---|---|---|---|---|
| 1 | Lythraceae | *Punica granatum* | 21.5 | 19.9 | 20.5 | 61.9 |
| 2 | Annonaceae | *Annona muricata* | 20.0 | 19.0 | 19.6 | 58.6 |
| 3 | Oxalidaceae | *Averrhoa bilimbi* | 17.1 | 16.1 | 25.1 | 58.3 |
| 4 | Moraceae | *Artocarpus heterophyllus* | 19.3 | 20.4 | 15.7 | 55.4 |
| 5 | Annonaceae | *Annona squamosa* | 17.5 | 17.5 | 19.4 | 54.4 |
| 6 | Rubiaceae | *Coffea* spp. | 14.2 | 12.5 | 26.0 | 52.8 |
| 7 | Sapotaceae | *Manilkara zapota* | 14.8 | 14.4 | 19.3 | 48.5 |
| 8 | Sapindaceae | *Nephelium lappaceum* | 18.6 | 20.1 | 9.3 | 48.0 |
| 9 | Myrtaceae | *Syzygium aqueum* | 14.4 | 13.5 | 19.3 | 47.1 |
| 10 | Caricaceae | *Carica papaya* | 14.4 | 14.9 | 16.2 | 45.6 |

Table 7 shows the sapling species of *Punica granatum* (Delima), *Annona muricata* (Sirsak), and *Averrhoa bilimbi* (Belimbing wuluh), with the highest IVs of 61.9%, 58.6%, and 58.2%, respectively. They were usually planted in the home gardens because they possessed high economic value. For the same reasons, other species with the highest IVs, including *Artocarpus heterophyllus* (Nangka), *Carica papaya* (Papaya), *Nephelium lappaceum* (Rambutan), and *Syzygium aqueum* (Jambu air), were planted and well maintained. Uji (2004) stressed that Rambutan was a fruit species in the home gardens because it gave an added economic value to its owners.

## CONCLUSION

The home gardens in the Bogor Regency, West Java, contained a high diversity of fruit tree and non-fruit tree species, with variable population structures. The dominant fruit tree species were Nangka, Rambutan, and Duku. Some rare tree species were found in the home gardens. Regeneration of planted trees was poor, yet it plays an important role in maintaining the species diversity and the home gardens as plant communities in the future.

The home gardens can be used and maintained as conservation sites and should be linked with the regeneration of various useful species, including rare fruit trees, food plants, medicinal plants, and species with cultural values. They are also suitable for the conservation

of genetic variabilities of useful plants, such as Duren, Manggis, and Duku, which so far have been neglected. Home gardens can be used also as one of the supporting components of forest conservation. It is, therefore, very important to maintain the survival of tree species in the home gardens and even to step up the quantity, quality, and diversity of the species contained therein. Such undertaking can be easily implemented in the home gardens and concurrently it is indispensable in raising the awareness and involving the participation of local communities in biodiversity conservation through integrative management of the home gardens.

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Appendix 1. List of tree species with DBH ≥ 10 cm at 41 hamlets in 40 villages within the Bogor Regency, West Java, Indonesia, containing data and information on the number of individuals of species in the sample plots (N), density (D=Trees/ha), absolute frequency (F=%), relative density (RD=%), relative frequency (RF=%), relative dominance (RDo=%), and importance value (IV=%), uses of parts of plants (UPP), and the status in the IUCN (*International Union for Conservation of Nature*) Red List (RL).

| NO | FAMILY and SPECIES | LOCAL NAME | N | D | F | RD | RF | RDo | IV | UPP and RL |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Anacardiaceae** | | | | | | | | | |
| 1 | *Anacardium occidentale* L. | Jambu mete | 1 | 0.3 | 2.4 | 2.1 | 3.6 | 2.5 | 8.0 | Fruit, stem |
| 2 | *Bouea macrophylla* Griff. | Gandaria | 6 | 2.1 | 7.3 | 4.8 | 8.0 | 5.0 | 15.6 | Fruit, stem |
| 3 | *Mangifera caesia* Jack | Kemang | 12 | 4.3 | 21.9 | 55 | 3.8 | 3.3 | 12.6 | Fruit, stem, LC |
| 4 | *Mangifera foetida* Lour. | Mangga limus | 1 | 0.3 | 2.4 | 3.7 | 4.5 | 3.8 | 12.0 | Fruit, stem, LC |
| 5 | *Mangifera indica* L. | Mangga | 194 | 69.4 | 95.1 | 12.0 | 11.5 | 12.4 | 35.9 | Fruit, stem, DD |
| 6 | *Mangifera odorata* Griff. | Mangga kuweni | 33 | 11.8 | 43.9 | 3.9 | 4.7 | 4.5 | 13.1 | Fruit, stem, DD |
| 7 | *Spondias dulcis* Parkinson | Kedondong | 5 | 1.8 | 7.3 | 8.1 | 4.9 | 4.2 | 17.2 | Fruit, stem, leaf |
| | **Annonaceae** | | | | | | | | | |
| 8 | *Annona muricata* L. | Sirsak | 39 | 13.9 | 53.7 | 1.6 | 4.8 | 4.4 | 10.9 | Fruit, stem, leaf |
| 9 | *Annona squamosa* L. | Srikaya | 2 | 0.7 | 4.9 | 0.6 | 4.0 | 2.5 | 7.1 | Fruit, stem |
| | **Apocynaceae** | | | | | | | | | |
| 10 | *Cerbera manghas* L. | Bintaro | 1 | 0.3 | 2.4 | 0.9 | 2.9 | 2.5 | 6.3 | Fruit, stem |
| | **Bombacaceae** | | | | | | | | | |
| 11 | *Durio zibethinus* Murray | Duren | 129 | 46.2 | 90.2 | 12.8 | 8.8 | 8.7 | 30.2 | Fruit, stem |
| 12 | *Ceiba pentandra* (L.) Gaertn. | Randu | 2 | 0.7 | 4.9 | 5.8 | 3.0 | 2.5 | 11.4 | Fruit, stem |
| | **Combretaceae** | | | | | | | | | |
| 13 | *Terminalia catappa* L. | Ketapang | 1 | 0.3 | 2.4 | 0.4 | 2.9 | 2.5 | 5.8 | Fruit, stem |
| | **Clusiaceae** | | | | | | | | | |
| 14 | *Garcinia mangostana* L. | Manggis | 35 | 12.5 | 29.3 | 6.3 | 6.7 | 6.9 | 20.0 | Fruit, stem |
| | **Ebenaceae** | | | | | | | | | |
| 15 | *Diospyros philippensis* (Desr.) | Bisbul | 1 | 0.3 | 2.4 | 1.5 | 2.9 | 2.5 | 7.0 | Fruit, stem |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gurke. | | | | | | | | | |
| | **Elaeocarpaceae** | | | | | | | | | |
| 16 | *Muntingia calabura* L. | Kersen | 14 | 5.0 | 24.4 | 1.4 | 3.8 | 3.5 | 8.7 | Fruit, stem |
| | **Euphorbiaceae** | | | | | | | | | |
| 17 | *Antidesma bunius* (L.) Spreng. | Buni | 6 | 2.1 | 9.8 | 3.9 | 4.3 | 4.5 | 12.7 | Fruit, stem |
| 18 | *Baccaurea racemosa* (Reinw.ex Blume) Müll. Arg. | Menteng | 7 | 2.5 | 12.2 | 3.1 | 4.0 | 3.5 | 10.5 | Fruit, stem |
| 19 | *Glochidion borneense* (Müll. Arg.) Boerl. | Mareme | 1 | 0.3 | 2.4 | 1.3 | 3.0 | 2.5 | 6.8 | Fruit |
| 20 | *Phyllantus acidus* (L.) Skeels. | Ceremai | 1 | 0.3 | 2.4 | 1.6 | 3.0 | 2.5 | 7.0 | Fruit, stem |
| | **Fabaceae** | | | | | | | | | |
| 21 | *Cassia siamea* Lmk. | Johar | 1 | 0.3 | 2.4 | 1.5 | 2.7 | 2.5 | 6.7 | Stem |
| 22 | *Leucaena leucocephala* (Lam.) de Wit | Petai cina | 13 | 4.7 | 26.8 | 1.8 | 3.1 | 3.0 | 7.8 | Fruit, stem |
| 23 | *Parkia speciosa* Hassk. | Petai | 6 | 2.1 | 14.6 | 4.8 | 3.4 | 2.5 | 10.7 | Fruit, stem |
| 24 | *Samanea saman* (Jacq.) Merr. | Trembesi | 1 | 0.3 | 2.4 | 1.3 | 2.7 | 4.0 | 8.0 | Stem |
| 25 | *Tamarindus indica* L. | Asam | 3 | 1.1 | 7.3 | 1.2 | 2.8 | 2.5 | 6.5 | Fruit, stem |
| 26 | *Archidendron pauciflorum* (Benth.) I.C. Nielsen | Jengkol | 16 | 5.7 | 26.8 | 5.5 | 4.1 | 3.6 | 13.2 | Fruit, stem |
| 27 | *Paraserianthes falcataria* (L.) I.C. Nielsen | Sengon | 4 | 1.4 | 4.9 | 5.3 | 11.1 | 7.5 | 24.0 | Stem |
| | **Flacourtiaceae** | | | | | | | | | |
| 28 | *Pangium edule* Reinw. | Picung | 4 | 1.4 | 4.9 | 7.0 | 4.3 | 5.0 | 16.3 | Fruit, stem |
| | **Gnetaceae** | | | | | | | | | |
| 29 | *Gnetum gnemon* L. | Melinjo | 10 | 3.6 | 19.5 | 1.8 | 3.5 | 3.1 | 8.4 | Fruit, stem, leaf, LC |
| | **Lauraceae** | | | | | | | | | |
| 30 | *Persea americana* Mill. | Alpukat | 23 | 8.6 | 24.4 | 7.2 | 5.8 | 6.0 | 19.0 | Fruit, stem, leaf |
| | **Lythraceae** | | | | | | | | | |
| 31 | *Punica granatum* L. | Delima | 3 | 1.1 | 7.3 | 0.6 | 2.9 | 2.5 | 6.0 | Fruit, stem, LC |
| | **Magnoliaceae** | | | | | | | | | |
| 32 | *Michelia champaca* L. | Kayu kembang | 1 | 0.3 | 2.4 | 1.0 | 2.9 | 2.5 | 6.4 | Stem |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Malvaceae** | | | | | | | | | |
| 33 | *Theobroma cacao* L. | Cokelat | 4 | 1.4 | 4.9 | 2.2 | 5.1 | 5.0 | 12.3 | Fruit, stem |
| | **Meliaceae** | | | | | | | | | |
| 34 | *Lansium domesticum* Corrêa | Duku | 144 | 51.5 | 63.4 | 14.2 | 13.2 | 14.4 | 41.4 | Fruit, stem |
| 35 | *Lansium domesticum* var. *aqueum* Jack | Kokosan | 4 | 1.4 | 7.3 | 2.5 | 2.8 | 3.3 | 8.6 | Fruit, stem |
| 36 | *Sandoricum koetjape* (Burm.f.) Merr. | Kecapi | 58 | 20.6 | 58.5 | 5.5 | 6.3 | 6.0 | 17.8 | Fruit, stem |
| 37 | *Swietenia mahagoni* (L.) Jacq. | Mahoni | 5 | 1.8 | 4.9 | 12.1 | 6.0 | 6.3 | 24.4 | Stem |
| | **Moraceae** | | | | | | | | | |
| 38 | *Artocarpus champeden* (Lour.) Spreng | Chempedak | 11 | 3.9 | 12.2 | 4.9 | 4.9 | 5.0 | 14.7 | Fruit, stem |
| 39 | *Artocarpus altilis* (Parkinson) Fosberg | Sukun | 15 | 5.4 | 31.7 | 1.6 | 3.5 | 2.9 | 8.0 | Fruit, stem, leaf |
| 40 | *Artocarpus heterophyllus* Lam. | Nangka | 225 | 80.5 | 100.0 | 13.7 | 14.1 | 13.7 | 41.5 | Fruit, stem |
| | **Myristicaceae** | | | | | | | | | |
| 41 | *Myristica fragrans* Houtt. | Pala | 28 | 10.0 | 19.5 | 5.3 | 9.1 | 8.8 | 23.1 | Fruit, stem |
| | **Myrtaceae** | | | | | | | | | |
| 42 | *Syzygium aqueum* (Burm.f.) Alston | Jambu air | 50 | 17.9 | 75.6 | 2.2 | 4.6 | 4.0 | 10.9 | Fruit, stem |
| 43 | *Syzygium polycephalum* (Miq.) Merr. & L.M.Perry | Gowok | 9 | 3.2 | 14.6 | 3.6 | 4.2 | 3.8 | 11.5 | Fruit, stem |
| 44 | *Psidium guajava* L. | Jambu batu | 37 | 13.2 | 56.1 | 1.7 | 4.9 | 4.3 | 10.9 | Fruit, stem |
| 45 | *Syzygium aromaticum* (L.) Merr. & L.M.Perry | Cengkih | 7 | 2.5 | 9.8 | 1.0 | 6.1 | 5.0 | 12.2 | Fruit, stem |
| 46 | *Syzygium cumini* (L.) Skeels | Jamblang | 2 | 0.7 | 4.9 | 1.5 | 2.8 | 2.5 | 6.7 | Fruit, stem |
| 47 | *Syzygium malaccense* (L.) Merr. & L.M.Perry | Jambu bol | 7 | 2.5 | 12.2 | 2.2 | 3.9 | 3.5 | 9.5 | Fruit, stem |
| 48 | *Syzygium polyanthum* (Wight) Walp. | Salam | 1 | 0.3 | 2.4 | 5.1 | 2.9 | 2.5 | 10.5 | Fruit, stem |
| | **Oxalidaceae** | | | | | | | | | |
| 49 | *Averrhoa bilimbi* L. | Belimbing wuluh | 6 | 2.1 | 14.6 | 0.9 | 3.0 | 2.5 | 6.4 | Fruit, stem |
| 50 | *Averrhoa carambola* L. | Belimbing | 45 | 16.1 | 63.4 | 2.2 | 4.8 | 4.6 | 11.6 | Fruit, stem |
| | **Rhamnaceae** | | | | | | | | | |
| 51 | *Maesopsis eminii* | Kayu afrika | 3 | 1.1 | 4.9 | 5.5 | 3.0 | 3.8 | 12.2 | Stem |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Engl. | | | | | | | | | |
| | **Rubiaceae** | | | | | | | | | |
| 52 | *Morinda citrifolia* L. | Mengkudu | 3 | 1.1 | 7.3 | 1.1 | 2.8 | 2.5 | 6.4 | Fruit, stem |
| | **Rutaceae** | | | | | | | | | |
| 53 | *Citrus hystrix* DC. | Jeruk purut | 3 | 1.1 | 7.3 | 0.1 | 2.9 | 2.5 | 5.6 | Fruit, stem, leaf |
| 54 | *Citrus maxima* (Burm.f.) Merr. | Jeruk bali | 5 | 1.8 | 9.6 | 0.8 | 3.5 | 3.1 | 7.4 | Fruit, stem |
| | **Sapindaceae** | | | | | | | | | |
| 55 | *Dimocarpus longan* Lour. | Lengkeng | 8 | 2.9 | 14.6 | 0.6 | 3.7 | 3.3 | 7.6 | Fruit, stem |
| 56 | *Filicium decipiens* (Wight & Arn.) Thw. | Kirai payung | 1 | 0.3 | 2.4 | 6.3 | 2.7 | 2.5 | 11.5 | Fruit, stem |
| 57 | *Nephelium lappaceum* L. | Rambutan | 319 | 114.2 | 97.5 | 26.5 | 17.8 | 20.4 | 64.6 | Fruit, stem, LC |
| 58 | *Pometia pinnata* J.R. & G.Forst. | Matoa | 2 | 0.7 | 4.9 | 1.1 | 2.8 | 2.5 | 6.5 | Fruit, stem |
| | **Sapotaceae** | | | | | | | | | |
| 59 | *Chrysophyllum cainito* L. | Sawo duren | 4 | 1.4 | 9.8 | 3.4 | 2.9 | 2.5 | 8.6 | Fruit, stem |
| 60 | *Manilkara kauki* (L.) Dubard | Sawo kecik | 2 | 0.7 | 4.9 | 8.8 | 3.3 | 2.5 | 14.6 | Fruit, stem |
| 61 | *Manilkara zapota* (L.) P.Royen | Sawo manila | 21 | 7.5 | 36.6 | 1.2 | 3.9 | 3.5 | 8.6 | Fruit, stem |
| 62 | *Pouteria campechiana* (Kunth) Baehni | Sawo mentega | 4 | 1.4 | 9.8 | 1.2 | 3.0 | 2.5 | 6.7 | Fruit, stem |
| | **Verbenaceae** | | | | | | | | | |
| 63 | *Tectona grandis* L.f. | Jati | 1 | 0.3 | 2.4 | 1.6 | 3.1 | 2.5 | 7.2 | Stem |
| | **Musaceae** | | | | | | | | | |
| 64 | *Musa paradisiaca* L. | Pisang | 4 | 1.4 | 4.9 | 3.1 | 4.4 | 5.0 | 12.5 | Fruit, stem, leaf |

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