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Land-use strategies of household-based agroforestry in Pendua Village, North Lombok

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Land-use strategies of household-based agroforestry in Pendua Village, North Lombok

I P A T Maya, E Wahyuningsih, and E Hidayati

Forestry Study Program, Faculty of Agriculture, University of Mataram, Mataram, Indonesia

E-mail: endah_wahyu@unram.ac.id

Abstract. Competing needs for land resources are increasing as the world's population grows. Indonesia ranks as the fourth most populous country in the world. The population of Lombok Island has increased more than double in ten years, from around 1.5 million people in 2010 to 3.8 million people in 2020. Home garden improvement has been regarded as one of the important strategies to enhance household food security. Home gardens are also part of local food systems in Lombok. Local people of Pendua Village, North Lombok, are using their home garden for apiculture to meet their needs. This research aims to understand the horizontal land-use allocation of home gardens practicing apiculture in Pendua Village, North Lombok. The horizontal land-use allocation was analyzed using Spatially Explicit Individual-based Forest Simulator (SExI-FS) in 26 home gardens. The result shows that most home gardens allocate an average of 20% of their area for bee's forage plants, 5% for bee hives, 30% for building, and 40% are the potential open area for plants and bee hives enrichment. The highest important value index (IVI) for the tree is Mangifera indica (163.08%), for pole is Theobroma cacao (62.54%), for sapling and seedling is Dimocarpus longan (27.66% and 37.92%, respectively), and Capsicum frutescens (36,44%) for understory.

1. Introduction

According to the State of the World's Land and Water Resources for Food and Agriculture 2021, the land, soil, and water resources are under unparalleled pressure due to population growth, economic growth, and climate change risks [1]. With more than 278 million people, Indonesia ranks the fourth most populous country in the world after China, India, and the USA. An increase in population puts pressure on natural resources important to generate more food, energy, water, and other needs. One of the islands undergoing major development is Lombok Island in West Nusa Tenggara Province. The population has increased more than double in ten years, from around 1.5 million people in 2010 to 3.8 million people in 2020. The Island (4,739 km²) is not immune to the global challenge of sustainable food and nutritional security. In fact, West Nusa Tenggara Province is among the top ten provinces with the highestnumber of stunting cases [2]. The poorest district in the Province is North Lombok District.

The State of Food Security and Nutrition in the World 2021 reported unprecedented setbacks in hungereradication efforts. With the increasing pressure, food and nutritional security are becoming a major global challenge requiring innovative ways to increase food production and diversify food sources while at the same time improving income-generation activities for communities [3]. One of the feasible approaches to improve household food security, particularly for resource-poor and marginalized communities in developing countries, is optimizing the use of home gardens [3–5].

Home garden can be described as a well-defined, multi-storied, and multi-use area near the family dwelling that serves as a small-scale supplementary food production system maintained by the household members and one that encompasses a diverse array of plant and animal species [6]. "Home gardens are a time-tested local strategy that is widely adopted and practiced in various circumstancesby local communities with limited resources and institutional support [4].

North Lombok District is known to provide the best stingless honey (*Trigona*, sp) with a production capacity reaching 5 tonnes per year, sold to various places in Indonesia and even exported to several countries in South East Asia [7]. Pendua Village is one of the villages in North Lombok District where the local people develop household-based agroforestry combined with apiculture (beekeeping) of *Trigona*, sp in their home garden [8]. Home gardens are characterized as [9]: 1) situated adjacent to the residence; 2) contain a high diversity of plants; 3) production is supplemental rather than a main source of family consumption and income; 4) occupy a small area; and 5) a production system that the poor can easily enter at some level.

There are twenty-six householders in Pendua Village currently practicing apiculture in their home gardens. According to Wahyuningsih et al. [8], due to a lack of knowledge of bees' forage plants requirement, the householders planted mostly fruit trees, resulting in insufficient forage for the bees. Given the small area of home gardens, a study on how the local householders in Pendua Village allocate their home gardens to practice household-based agroforestry combined with apiculture is important. Therefore, this study aims to understand the horizontal land-use allocation in the householders' home gardens. The results will contribute to improving the understanding of how the householders manage the limited land in their home garden to diversify food sources while at the same time improving income-generation activities for communities through apiculture.

2. Method

This study was carried out in Pendua Village, Kayangan Subregency, North Lombok Regency, West Nusa Tenggara Province from February to April 2022. The village's total area is 513 hectares. Total sampling area was 1.04 hectares taken from twenty-six (26) home gardens practicing apiculture in the study site (Figure 1).

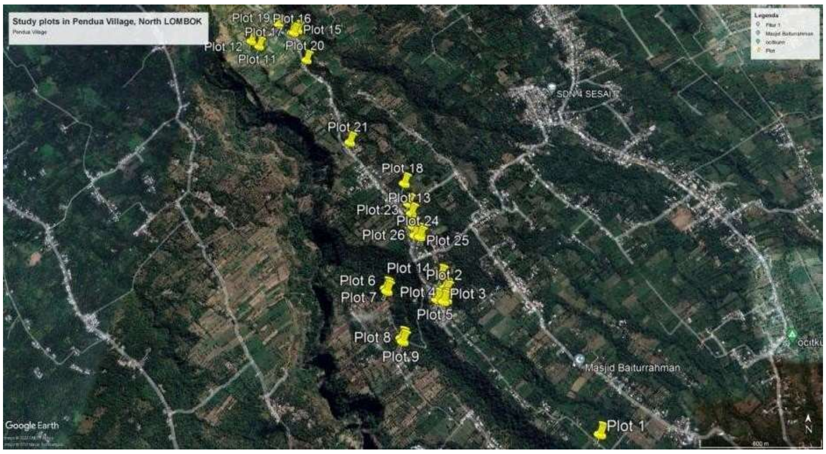


Figure 1. Study Plots in Pendua Village.

In each home garden, data on home garden area (in square meter), floristic composition and abundance, tree diameter, tree crown density, tree height, location of plants, location of house or other building, location of bee hives and types of bee's forage (i.e., nectar, pollen, and resin) were collected. The horizontal land-use allocation was analyzed using *Spatially Explicit Individual-based Forest Simulator* (SExI-FS) where location of plants, tree crown, tree height, location of house or building, and locationof bee's hives were plotted. SExI-FS software was developed by World Agroforestry Center (ICRAF)and *Institut de Recheche pour de Développement* (IRD). SExI-FS is a software program designed to project stand vertically and horizontally [10]. The land-use allocation in each home garden was divided into five categories, namely, (i) house/animal husbandry/fish pond, (ii) bee hives, (iii) tree/pole/sapling, and (iv) seedling/understory.

Using the formula from [11], Important Value Index (IVI) was calculated for each species in each growth stage (i.e., Tree, Pole, Sapling and Seedling) and understory. IVI was used in this study to assess the composition of dominant bee forage plants in the home garden [12].

3. Results and discussions

3.1. Diversity, abundance, and types of bees' forage plants

Table 1 shows the abundance, diversity, types of forage, number of bee hives, distance form bee hivesto plants, and the home garden area. Home garden area of the study plot is ranged between 107.38 m^2(Plot 25) to 1,026 m^2 (Plot 15). The highest diversity of plants for bees' forage is twenty-six (26) speciesfound at study plot 22 (323.79m^2) while the lowest is four (4) species at study plot 5 (297m^2). As for the abundance, the highest is found at study plot 24 (187m^2) with 402 individuals, and the lowest is study plot 5 with four (4) individuals.

The least number of bee hives is two hives (Plot 23) because the householder has just started in 2021. The greatest number of bee hives is sixty-seven hives in Plot 2 where the owner started practicing stingless bee apiculture in 2013. The majority of bees' forage types are nectar and pollen. Only very small portion is from resin. The number of species providing nectar is on a par with species providing pollen (Table 1). Pollen is an important source of protein while nectar provides carbohydrate for the bees [13]. However, from our interviews, we found that the majority of the householders do not know this differentiation in bees' forage types and needs. They mostly planted fruit trees with the main consideration to harvest the fruits [8].

Distances from bee hives to plants in all the study plots fall within the recommended distance for stingless bee (*Trigona*, sp). Stingless bee's flying radius is 40-400 meters, hence the forages should be planted within that distance [14]. Priawandiputra [14] further suggested that the closer the distance between the bee colony and the sources of food, the stronger and faster the colony grows. The home garden owners in the study site hang the bee hives on a wall or arrange them in a shelf. They don't move the bee hives because their home garden is not too big and lies within the stingless bee' foragingradius.

Table 1. Composition and types of bees' forage plants.

Plot No.	Bees' forage plants total abundance	Bees' forage plants total diversity	Bees' forage types			Number of bee hives	Distance from bee hives to plants (m)	Home garden area (m^2)
			Nectar	Pollen	Resin			
1	77	12	10	11	1	26	2-17	299
2	19	10	8	10	1	67	1-12	286
3	33	11	6	10	0	12	1-20	379.25
4	18	6	4	6	1	6	1-18	234
5	4	4	3	4	1	12	9-12	297
6	21	8	5	7	1	13	2-15	354.32
7	13	8	7	7	1	52	6-20	912

8	7	7	5	5	1	6	1-20	561
9	27	14	10	11	3	16	2-25	792
10	26	11	9	11	4	6	5-22	426
11	71	11	10	10	2	6	2-28	684
12	48	8	7	8	1	27	2-11	288
13	28	9	7	8	2	33	2-24	442
14	25	5	5	4	1	26	2-20	231
15	188	8	7	8	2	55	1-35	1026
16	18	8	6	8	0	12	1-25	299.2
17	32	9	5	9	3	17	3-20	289
18	8	4	3	3	1	52	1-18	208
19	185	16	12	13	4	9	1-14	380
20	26	7	5	6	2	7	6-25	323
21	46	12	10	10	1	8	1-20	280
22	123	26	14	24	2	13	2-20	323.79
23	14	6	6	6	2	2	4-19	502.68
24	402	23	9	23	3	57	1-16	187
25	33	14	5	12	2	12	2-10	107.38
26	17	6	4	6	2	12	3-20	272.44

3.2. Horizontal projection of land-use allocation

Land-use allocation for each study plot was developed using SExI-FS software. The land-use allocations are divided into four main categories (houses/other buildings, bee hives, bees' forage plants,and open area). On average, most of the home gardens allocate average 20% of their area for bee's forage plants, 5% for bee hives, 30% for building, and 40% are potential open area for plants and bee hives enrichment.

In this article, we will discuss land-use allocation for the smallest plot in terms of area (Plot 25) versusthe biggest plot (Plot 55), plot with highest plant diversity (Plot 22) versus lowest diversity (Plot 5), plot with most abundant forage plants (Plot 24) versus least abundant (Plot 5), and plot incorporating other income generation activity (i.e., fishpond) in plot 11.

3.2.1. Smallest plot vs biggest plot. Figure 2 shows land-use allocation in the biggest plot (Plot 25) and the smallest (plot 15). In Plot 25 there is not much space left due to its small area (107.38 m^2). Almost 50% of the area is used for house.The diversity of forage plants is higher in Plot 25. But the abundance is higher in Plot 15. The numberof trees, however, is the same where each plot has 7 tree individuals. The strategy for smaller home garden is to have higher diversity in flowering herbaceous plant to minimize competition for light fromtree species. Higher diversity also allows flowers to be available complimentary with trees to provide nutrients to bees at non-overlapping times of the year [15]. Bigger home garden allows householder toengage in other food provision activities such as animal husbandry (Plot 15) and fishpond (Plot 11).

Plot 25: Smallest plot (107.38 m^2) bee hives = 12; bees' forage plant abundance = 33 individuals forage plant diversity = 14 species	**Plot 15:** Biggest plot (1,026 m^2) bee hives = 55; bees' forage plant abundance = 188 individuals forage plant diversity = 8

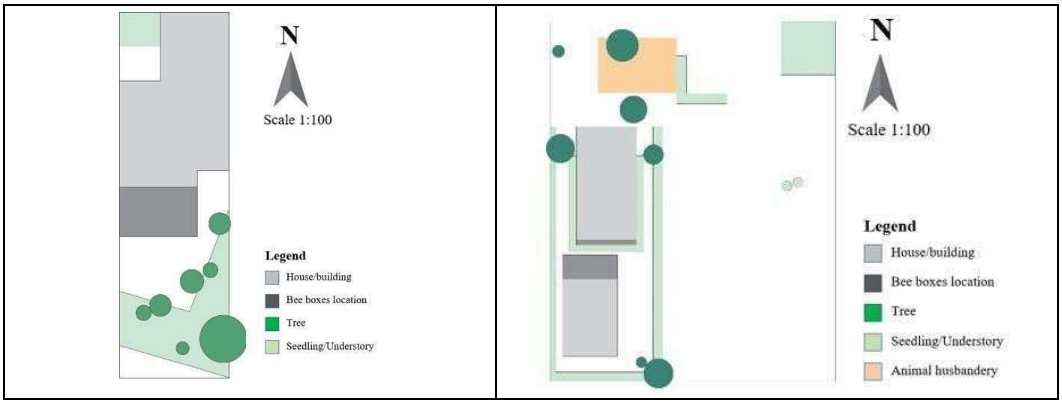


Figure 2. Land-use allocation in the smallest plot vs biggest plot

3.2.2. Highest diversity of forage plants vs lowest

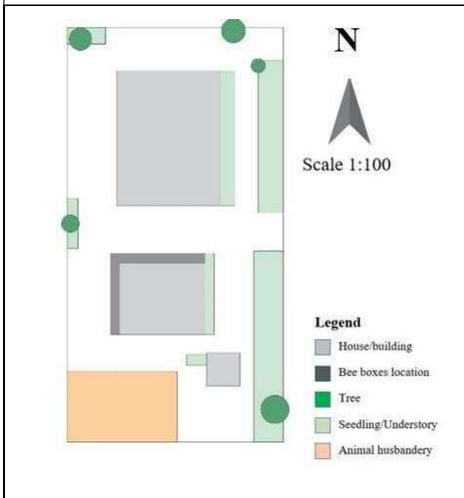
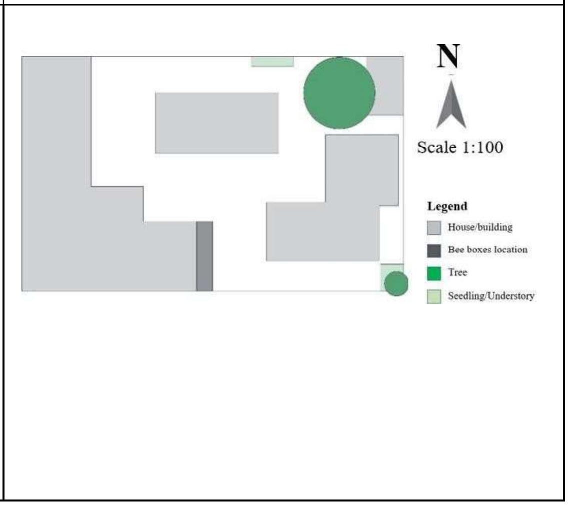
Plot 22 (323.79m^2) Highest diversity (26 species) Abundance = 123 individuals	**Plot 5** (297m^2**)** Lowest diversity of bees' forage plants (4 species)
	

Figure 3. Land-Use Allocation in the Highest Diversity of Forage Plants vsLowest.

Figure 3 shows land allocation in Plot 22 which has the highest diversity of forage plants (26 species)and Plot 5 with the lowest diversity (4 species). In Plot 22, the diversity comes from the melliferous herbaceous plants. Plot 5 needs to be enriched with understory that are tolerant with low light becausethe open space is surrounded by buildings.

3.2.3. Most abundant forage plants vs least. Figure 4 shows land-use allocation in Plot 24 with 402 forage plant individuals and Plot 5 with only 4individuals. Plot 24 is smaller than plot 5, yet it can harbour a lot more forage plant abundance. The strategy is to plant a lot of herbaceous plants combined with few annual trees yielding high economic value fruits. The annual trees in Plot 24 are Mango (*Mangifera indica*), Longan (*Dimocarpus longan*),Orange (*Citrus sinensis*), Guava (*Psidium guajava*), Amazon bean (*Bunchosia argentea*), and jackfruit(*Artocarpus heterophyllus*). The plant diversity is also high with 23 species. High diversity and high abundance are needed in this plot because the number of beehives is also high (57 hives).

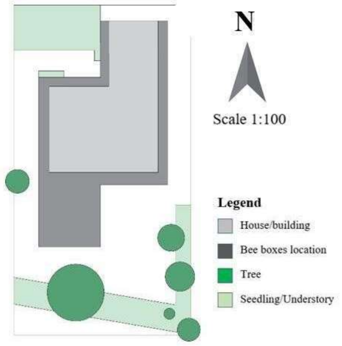
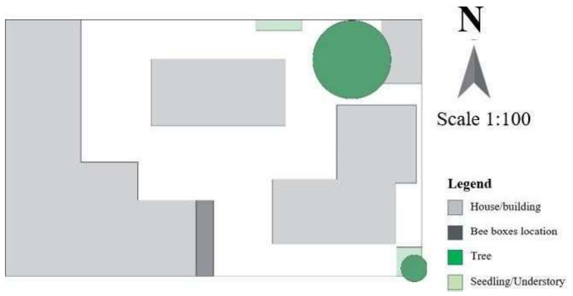
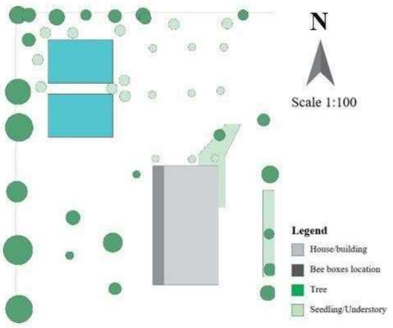
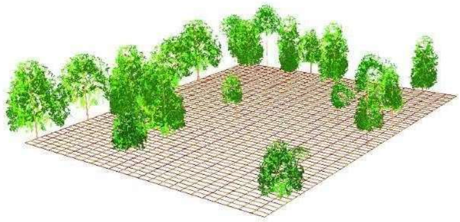
Plot 24 Most abundant forage plants (402 individuals), 23 species 187m^2	**Plot 5** Least abundant forage plants (4 individuals), 4 species 297m^2
	

Figure 4. Land-Use Allocation in Most Abundant Forage Plants vs Least.

3.2.4. Plot incorporating other income activity. Some of the respondents in this study were able to incorporate other income generation activities such as animal husbandry and fishpond. Figure 5 shows an example of land-use allocation in Plot 11 (684m^2) where the householder installed fishpond (blue rectangular) on their home garden. This plot is the fourth largest plot in this study. To allow more land for fishpond, the strategy is to plant the trees as hedgerows while the understory species are spread across the home garden. A study by [15] suggested that hedgerows which avoid gaps, have high species diversity, and abundant understory of plants improve the ecological benefits for pollinators and other functionally important taxa.

Plot 11	
Horizontal projection of home garden	
Vertical projection of trees/poles/sapling	

Species component at tree level

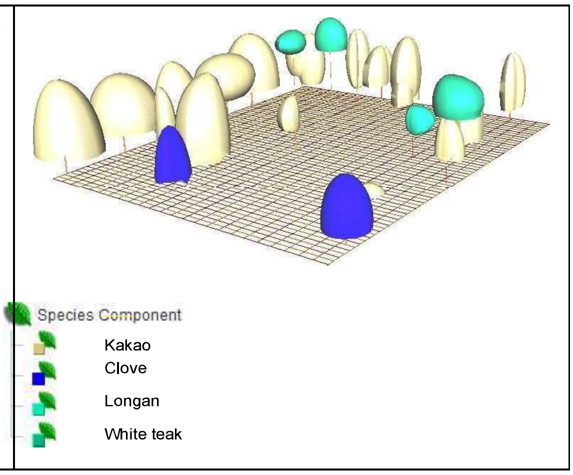


Figure 5. Land-Use Allocation Incorporating Fishpond.

3.3. Composition and Important Value Index (IVI) of Bees' Forage

There were eight species found at the tree level (Figure 6). The most dominant species at the tree level is mango (*Mangifera indica*) with IVI 163% followed by avocado (IVI 33.55%) and rambutan (IVI 31.63%).

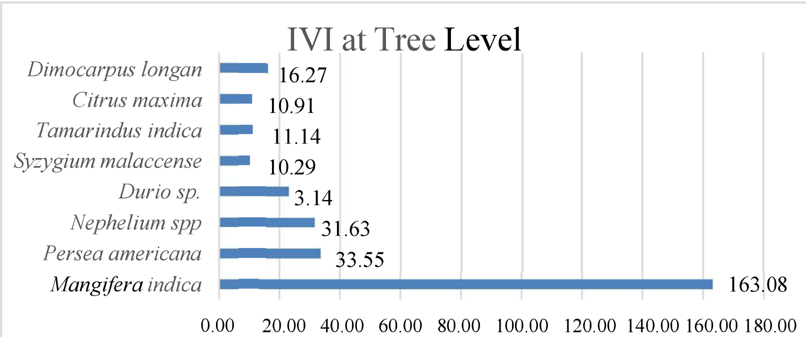


Figure 6. IVI at tree level.

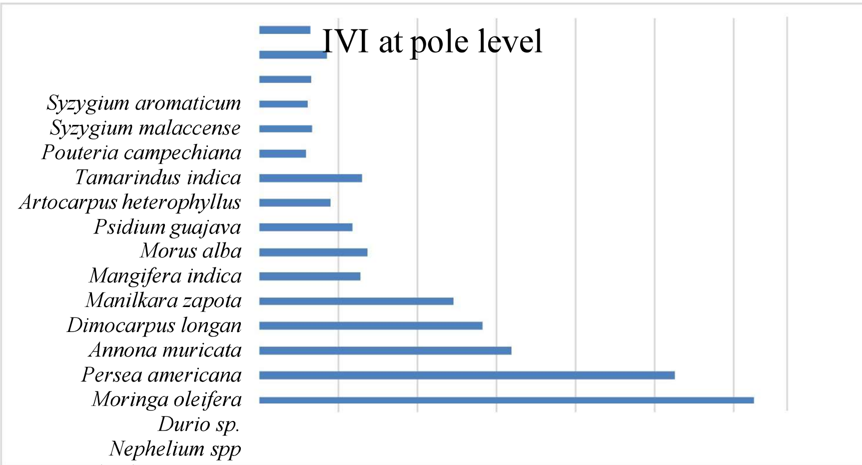


Figure 7. IVI at Pole Level.

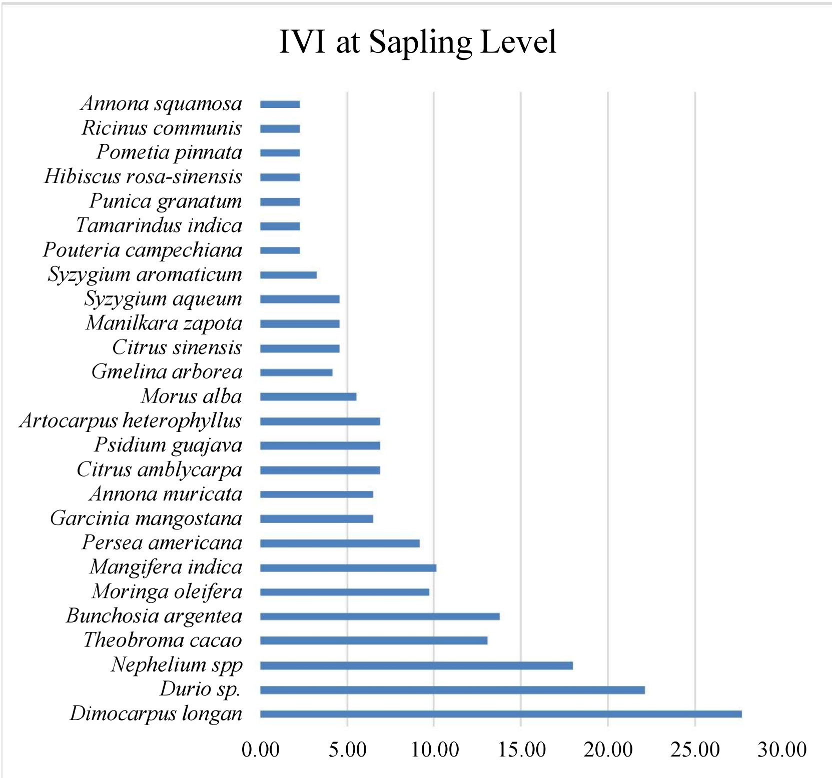


Figure 8. IVI at sapling level.

Manggo is one of multi-purpose tree species (MPTS) [16]. In this study, mango provides fruits for home garden owner and produce flowers as sources of food for bees. The fruits are usually sold and hence providing income for the home garden owner. Marpaung in [16] stated that mango can adapt to various conditions such as wet, dry, hot, cold places, lowland, and highland. While this species gives income through its fruits, the flowering season is very short which is around November and December [14]. Therefore, home gardens with mango as its dominant species need to be enriched with a more diverse set of plants to accommodate all year provision of bees' forage.

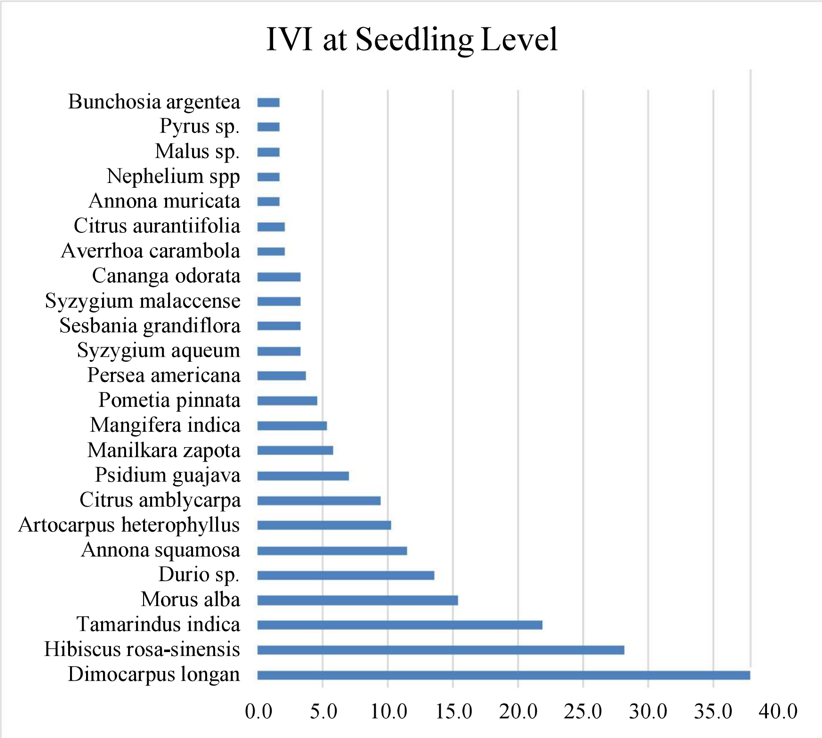


Figure 9. IVI at the Seedling Level.

Table 2. Understory Species with 10 Highest IVI.

No.	Understory Species	IVI (%)
1	*Capsicum frutescens L.*	36.44
2	*Iris pseudacorus*	22.66
3	*Vitis vinifera*	12.82
4	*Eichhornia crassipes*	9.11
5	*Carica papaya*	8.45
6	*Vigna unguiculata ssp. sesquipedalis*	7.80
7	*Impatiens balsamina*	6.52
8	*Rosa sp.*	6.30
9	*Tagetes erecta L.*	5.05
10	*Musa sp.*	4.52

At the pole level, sixteen species were found (Figure 7). Cocoa (*Theobroma cacao*) has the highest IVIat pole level (IVI 62.54%) followed by Rambutan (*Nephelium*, spp) and Durian (*Durio*, sp). At the saplinglevel, twenty-six species were identified (Figure 8). Longan (*Dimocarpus longan*) has the highest IVI at the sapling level (27.66%) followed by Rambutan and Durian. These plants were purposively planted by the householders to harvest its fruits in the future for their consumption as wellas for income generation. Twenty-four species were identified at the seedling level (Figure 9). Forty- nine species were identified at the understory level with Chilli (*Capsicum frutescens)* has the highest IVI (36.44%).Ten highest IVIs at the understory level are presented in Table 2**.** Understory species play important role in diversifying sources of food and increasing visitation from bees [17]. Most of the understory species are melliferous herbaceous plants.

4. Conclusions and recommendations

The result shows that most of the home gardens allocate on average 20% of their area for bee's forageplants, 5% for bee hives, 30% for building, and 40% are potential open area for plants and bee hives enrichment. Highest important value index (IVI) for tree is mango (*Mangifera indica)*, for pole is cacao(*Theobroma cacao)*, for sapling and seedling is longan (*Dimocarpus longan)* and chili (*Capsicum frutescens)* at the understory level. All of these species with highest IVI are favoured by householdersas they have high economic value and easy to be sold. Combining trees and flowering herbaceous is the general strategy to fulfil bees' dietary needs. Householders need to enrich flowering herbaceous plants to accommodate a year-long provision of forage for the bees.

References

[1] FAO 2021 The State of the World's Land and Water Resources for Food and Agriculture—Systems at Breaking Point *Synth. Rep.*
[2] Mufarida B 2022 Angka Stunting di 10 Provinsi Tinggi, Wapres: Perlu Mendapat Perhatian *Sindonews.Com*
[3] Dissanayake D H G and Maredia K M 2020 *Home Gardens for Improved Food Security and Livelihoods* (Routledge, Taylor & Francis Group)
[4] Galhena D Freed, and KM Maredia.(2013). Home gardens: A promising approach to enhance household food security and wellbeing
[5] Musotsi A A, Sigot A J and Onyango M O A 2008 The role of home gardening in household food security in Butere division of western Kenya *African J. Food, Agric. Nutr. Dev.* **8** 375–90
[6] Eyzaguirre P B and Linares O F 2004 *Home gardens and agrobiodiversity*
[7] Liputan6 2020 Desa Berinovasi Kembangkan Madu Trigona di Lombok *Https://Www.Liputan6.Com/Lifestyle/Read/4379285/Desa-Berinovasi-Kembangkan-Madu-Trigona-Di-Lombok*
[8] Wahyuningsih E, Lestari A T, Syaputra M, Wulandari F T, Anwar H, Januardi J, Maya I P A T, Anggraini D, Aditia G B D R and Muin A 2021 Pengayaan Tanaman Pakan Lebah dengan Pola Agroforestry Home Garden untuk Mendukung Kelestarian Sumber Pakan Lebah Madu Trigona *J. Pendidik. dan Pengabdi. Masy.* **4**
[9] Mitchell R and Hanstad T 2004 *Small homegarden plots and sustainable livelihoods for the poor* vol 11 (Roma: FAO LSP WP)
[10] Harja D and Gregoire Vincént 2008 *SExI-FS User Guide and Software Version 2.1.0* (World Agroforestry Centre (ICRAF) and Institut de Recherche pour le Développement (IRD))
[11] Curtis J T and McIntosh R P 1951 An upland forest continuum in the prairie-forest border region of Wisconsin *Ecology* **32** 476–96
[12] Asigbaase T 2019 diversity and its ecological importance value in organic and conventional cocoa agroforests in Ghana *PLoS One* **14**
[13] Nugroho R B and Soesilohadi R C H 2014 Identifikasi macam sumber pakan lebah Trigona sp (Hymenoptera: Apidae) di Kabupaten Gunungkidul *Biomedika* **7** 42–5
[14] Priawandiputra W 2020 *Panduan Budidaya Labah Tanpa Sengat (Stingless Bees) di Desa Perbatasan Hutan* (Bogor: ZSL Indonesia)
[15] Garratt M P D, Senapathi D, Coston D J, Mortimer S R and Potts S G 2017 The benefits of hedgerows for pollinators and natural enemies depends on hedge quality and landscape context *Agric. Ecosyst. Environ.* **247** 363–70
[16] Sobirin S, Banuwa I S, Febryano I G, Wulandari C, Darmawan A and Iswandaru D 2022 Potensi Tegakan di KPHL Batu Serampok, Provinsi Lampung *J. Hutan Trop.* **10** 87–99
[17] Withaningsih S, Andari C D, Parikesit P and Fitriani N 2018 The effect of understory plants on pollinators visitation in coffee plantations: Case study of coffee plantations in West Bandung District, West Java, Indonesia *Biodiversitas J. Biol. Divers.* **19** 554–62