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Home Gardens of the Local Community of Pancasila Village in Tambora Geopark, Sumbawa Island: Biodiversity Conservation and Ecotourism Sites Development

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ABSTRACT

Home gardens in villages near conservation areas play an important role, both in ecological and socio-economical aspects. The aim of this research was to identify plant species diversity in home gardens in Pancasila Village, Tambora Geopark in the Sumbawa Islands. Floristic surveys were conducted at 25 home gardens in the local community. In-depth interviews with informants were conducted to generate information related to species value and home garden management. Results of the study show that 87plant species (46 families) were grown in home gardens. These plants consisted of 49.56% Phanerophytes, 8.90% Chamaephytes, 25.28% Hemicryptophytes and 6.70% Cryptophytes. According to phytogeograpical origins, 24.41% of the species were exclusively Asian-Tropical species. These plants had numerous purposes, including staple food, spices and vegetables, fruit trees, shading trees and ornamental plants. Among all species in home gardens, some plants had high frequency percentages, including *Nephelium lappaceum* (52%), *Bougainvillea spectabilis* (40%), *Mangifera indica* (36%), *Musa paradisiaca* (36%) and *Coffea* sp. (32%). Most of the species were identified as exotic plant species and, therefore, attention to such species groups is needed to protect the environment and biodiversity of Tambora Geopark. Home gardens in Pancasila are ideal sites for biodiversity conservation. It is also crucial environmental component in rural tourism development.

Keywords: *Homegarden, Tambora Geopark, highland conservation, exotic plant species, ecotourism*

INTRODUCTION

Homegardens provide numerous environmental benefits, ranging from sites for biodiversity conservation, reducing global warming and soil conservation. Socio-economically, home gardens are potential sites to provide numerous foods and, therefore, important in local food security programs. Home gardens also contain numerous plants which are related to spiritual and local beliefs. Numerous species in home gardens have medical aspects and, therefore, such plants are important resources for local community health [1, 2, 3]. In many recreation areas, home gardens are important instruments in tourism accommodations. Tourist accommodations (i.e. homestay, lodge) often show large collections of plants in a home garden environment [4, 5, 6].

Home gardens are sites where people introduce and plant numerous plant species. Many of them come from other phytogeographical areas and, therefore, are exotic to the local sites. Scholars point out that exotic plant species are potential agents for environmental disturbance, especially exotic plant species with an invasive character. Surveys on species diversity in home gardens provide significant information for the management of biodiversity in areas with high-value biodiversity content [7, 8].

The growth of nature-based tourism in many areas in Indonesia has been influenced by the establishment of eco-lodges and homestays in rural areas, especially in periphery areas of protected forests. Numerous tourist

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accommodations often set up near the forest with an abundance of ornamental plants as garden components. The arrival of numerous exotic plant species through the tourism industry is important in exotic plant species invasion in protected forests [9], but there are less attention and study on such threats to the native ecosystem in many areas in Indonesia.

The local community settlement in Pancasila Village in Dompu-Sumbawa is located at the periphery zone of Tambora National Park. Pancasila Village is the last community settlement before entering the tracking routes to explore Mt. Tambora. The community in Pancasila is the target for an ecotourism development program, with objectives including the increased local economic benefit from the tourism industry in Tambora Geopark. Tourism development can be numerous, including human resources development, tourism program development, environmental conservation and community-based tourism accommodation development [10]. Community-based ecotourism accommodations, through the development of homestays with rich plant life, are important to attract tourists. Plants are also believed to be able to increase tourist satisfaction and perception of the ecolodge [6]. There are, however, environmental risks caused by abundant exotic plants in ecolodges, especially plants cultivated in home garden ecosystems. The survey of home gardens in Pancasila Village is important to provides basic data for environments, biodiversity conservation and community development in the Tambora Geopark system, Sumbawa Islands. In the perspectives of environmental management and biodiversity conservation, this is also important for some purposes, including developing an early monitoring system for invasive plant species threats. The objectives of the research are to identify the plant species diversity in home garden as a basic of biodiversity conservation and tourism development in rural area in Pancasila Village.

MATERIALS AND METHOD

Study area

A field study was conducted in Pancasila Village on the western slopes of Mt. Tambora (2861 masl.), Sumbawa Islands. Mt. Tambora was declared a national park in 2015, with a total park area of71,645.74 ha [10]. Administratively, the settlement belongs to the Dompu Regency. Geographically, it is located at 08°11'12.58" S and 117°48'34.55" E. The community settlement in Pancasila Village is located at altitude 1560 masl, surrounded by a tropical mountain forest and community plantation on the slope of Mt. Tambora. Recent local community in Pancasila Village was dominated by people from Bima and Dompu.Some Javanese, Balinese and people from Lombok live in Pancasila Village. At the end of 2017, Mt. Tambora and its surrounding villages were declared as Tambora Geopark, with the objectives to enhance preservation of geological sites, biodiversity conservation, education and prosperity of human life surrounding Mt. Tambora. Tourism development in Pancasila, therefore, is relevant to the objectives of the declaration of Mt. Tambora as a national park and geopark. Tourism development in Mt. Tambora and its surrounding villages was stated as a goal in the Tourism Regional Planning document 2013-2028 of West Nusa Tenggara province (*Rencana Induk Pembangunan Kepariwisataan Daerah Tahun 2013- 2028*).

The geological history shows there was a huge eruption of Mt. Tambora in 1815that was recorded as one of the greatest volcanic eruptions on earth and the eruption was reported to influence climate changes in Europe [11]. The last eruptions of Mt. Tambora have created numerous outstanding landscapes, including a wide crater, savanna, caldera, river, and waterfalls. Recently, these natural objects became a famous nature-based tourism attraction in Mt. Tambora. Research has confirmed that Mt. Tambora has a high value of biodiversity. Tambora research expedition held by the Indonesian Science Institute (LIPI) found 348 species of fauna and277 species of plant. The expedition recorded some new species candidates, including two species of Cyrtodactylus, two species of *Stylocellus* sp. and *Sarax* sp. There were also two candidates of new species of *Ernolatia* sp. and *Xyleutes* sp. The climates of Pancasila settlement are mostly similar with many regions in Dompu, in which climates are classified as semi-arid. Mt. Tambora is located in a semi-arid climate region with basic climate parameters given in Table 1.

Floristic surveys were performed in home gardens in the community settlement in Pancasila Village,

Table 1. Climate status in Dompu Climate stations, Sumbawa Island

Parameters	*Minimum*	*Maximum*
Temperature (°C)	23.2	32.9
Humidity (%)	72	85
Rainfall (mm per days)	0	287.0
Rain days per month	0	18

Source: *Badan Perencanaan Pengembangan Daerah and Penelitian Pengembangan*, Dompu Regency 2015 [12].

Dompu Regency. Twenty-five local houses were selected randomly for flora analysis. In each visited garden, flora identification was done through morphological recognition. Data of plant species in each garden was documented in a field notebook. In order to get information about the value of species in home garden ecosystems, in-depth interviews with six informants were performed.

A Raunkiaer plant life forms evolution of the flora in Pancasila was conducted to evaluate the normal spectrum of plant distribution based on climate characteristic. Plants were classified into Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes, Therophytes, Epiphytes, and Aerophytes [13]. Distribution of plant origins was described following the Germplasm Resources Information Network (GRIN) through the online data on https://www.ars-grin.gov. Plant origins were evaluated using Takhtajan's phytogeographical system Level 1 (botanical continents). In this system, plant origins were grouped into botanical continents, namely Europe, Africa, Asia-Temperate, Asia-Tropical, Australasia, Pacific, Northern America, Southern America and Antarctic [14]. Data were analyzed descriptively.

RESULTS AND DISCUSSION

Home gardens species spectrum

Home gardens in the local community in Pancasila Village are integral parts of the family house. Structurally, they often contain an open space with numerous plant species grown by family members. The house area and its garden are often protected by a bio-fence, with *Gliricidia sepium*. Informants stated that the size of house areas and their gardens range from 10 × 10 m to the 20 × 25 m. These land sizes offer opportunities for gardening. Females played an important role in home garden management, while males only on some occasions were included in home garden management.

There were 87 plant species planted in home gardens in Pancasila. These species belong to 46 families. Based on the number of species diversity, gardens can be classified into simple, medium and complex home gardens. The simple home garden has fewer numbers of species. One garden had only a banana species and other gardens had only rambutan and mango. There was no vegetation stratification in simple home gardens. Informants stated that the limited number of species in their garden was caused by goat disturbance. According to Raunkiaer plant life forms, there are Phanerophytes, Chamaephytes, Hemicryptophytes and Cryptophytes species grown in home gardens. There were no Therophytes, Epiphytes or Aerophytes recorded (Figure 1).

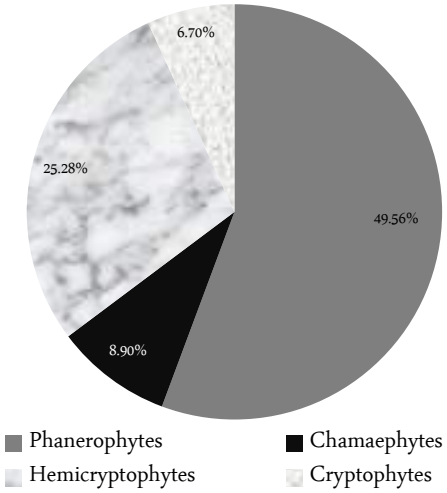

Figure 1. The composition of plants according to Raunkiaer plant life forms classification

The proportion of Phanerophytes species in home garden ecosystems in Pancasila Village indicated the existence of woody and shrubs plants in home garden ecosystems, which provide numerous benefits for soil and biota conservation [15]. The high proportion of Phanerophytes was also indicative of the location of Pancasila Village in the range of lower to upper mountain tropical forest, in which some woody trees still exist as a component of the tropical mountain forest [16].

According to Takhtajan's phytogeographical system, exotic plants came from Europe, Africa, Asia-Temperate, Asia-Tropical, Australasia, Pacific, Northern America and Southern America, all continents except the Antarctic. The phytogeographical analysis found 24.41% of the species were exclusively Asian-Tropical species (Table 2). There were 31 plants species with origins from the American continents (36%) of the total species found in home gardens); of these, 19 species had origins from North to South America. The contribution of Asian-Temperate species in home gardens was 20 species of the total identified species, in which 12 of these had origins both in Asian-Temperate and Asian-Tropical continents. Seven species exclusively had origins in Africa. The *Fragaria vesca* was the only plant that originated from Europe. These species' phytogeographical origins spectrums show that home gardens in Pancasila were influenced by anthropogenic aspects. Human perception of plants influenced numerous attempts for introduction experiments. According to informant, in the past, there were a few ornamental species found in their home garden. The introduction of numerous plants from numerous areas are intensely found in tourism home stays, public offices, and building facilities. Some

Table 2. Asian-Tropical species in home gardens

Family	Species	Local, English name
Anacardiaceae	*Mangifera indica*	*Mangga*, Mango
Annonaceae	*Annona squamosa*	*Srikaya*, Custard-apple
	Annona muricata	*Sirsat*, Zuurzak
	Annona squamosa var. San-pablo	*Menuo*
Araliaceae	*Polyscias scutellaria*	*Mangkokan*, Dinnerplate-aralia
Arecaceae	*Areca catechu*	*Pinang*, Areca palm
Balsaminaceae	*Impatiens balsamina*	*Pacar air,* Rose balsam
Clusiaceae	*Garcinia mangostana*	*Manggis*, Mangosteen
Cannaceae	*Canna hybrida*	*Bunga tasbih*, Canna lily
Cyatheaceae	*Cyathea contaminants*	*Paku pohon*, Fern tree
Euphorbiaceae	*Acalypha hispida*	*Ekor kucing*, Red-cattail
Fabaceae	*Caesalpinia pulcherrima*	*Kembang merak,* Peacock flower
Malvaceae	*Hibiscus rosa-sinensis*	*Kembang sepatu*, Chinese hibiscus
	Durio zibethinus	*Durian*
Moraceae	*Artocarpus heterophyllus*	*Nangka*, Jackfruit
	Artocarpus altilis	*Sukun*, Breadfruit,
Moringaceae	*Moringa oleifera*	*Kelor*, Moringa
Musaceae	*Musa paradisiaca*	*Pisang*, Banana
Oxalidaceae	*Averrhoa carambola*	*Belimbing*, Starfruit
	Averrhoa bilimbi	Bilimbi, belimbing *Wuluh*
Pandanaceae	*Pandanus* sp.	*Pandan*
Zingiberaceae	*Curcuma longa*	*Kunir*, turmeric

families are interested in gardening and introduce numerous plant species. Scholars point out that human activity, especially trading, agriculture and landscape gardening are contributors to exotic plant species introduction to remotes area, in which they create future problems for the native ecosystem with huge biodiversity [17, 18].

Among plant species found in home garden ecosystems, *M. paradisiaca* and *Codiaeum variegatum* showed the most diverse cultivars. *M. paradisiaca* is an edible fruit species with numerous cultivars including *pisang raja*, *pisang susu*, *pisang nona*, *pisang gajih*, and *pisang hijau*. *Puring C. variegatum* is an ornamental plant with various cultivars. Locally it is known as *Puring Bali*, *Puring bulu ayam*, *Puring manik maya*, *Puring koi*, and *Puring Timun*. The informant pointed out that *C. variegatum* has high leaf variation, color and, importantly, very easy to grow in home gardens. The cultivars of *puring* have been widely grown in home gardens for the beautiful leaf color and morphology [19].

Some invaders grow wild in home gardens, especially in gardens with poor management. These include *Stachytarpheta jamaicensis*, *Senna tora*, *Ricinus communis*, and *Ruellia tuberosa*. Exotic plant species often grow in open space areas with high sunlight intensity in abandoned lands. Thus far, informants state that these species have less function in the daily life of local people, and if it grows rapidly the species become serious weeds. There are costs to clearing the weeds. The invasion of such species was also stated to be able to disturb other cultivated species in home gardens. This is similar with other reported impacts of exotic-invasive species throughout the world [20].

The value of species

Species in home gardens offer numerous roles. According to informants, however, the main value of numerous plant species can be classified into five major aspects, including plants as staple food, spice-vegetables, fruits, shading trees and ornamental plants. There is potential value of numerous plants as material in traditional medicine, but it seems that the use of plants as traditional medicine was very limited. From all species grown in home gardens, some plants have high frequency, including *Nephelium lappaceum* (52%), *Bougainvillea spectabilis* (40%), *Mangifera indica* (36%), *M. paradisiaca* (36%), and *Coffea* sp. (32%). These species contribute to the local community settlement's landscape in Pancasila. The frequency of selected species in the home garden according to the specified value are given in Figure 2.

A number of staple food species were limited. Only four species were cultivated as staple foods, including *Zea mays*, *Manihot esculenta*, *Ipomoea batatas*, and *Colocasia esculenta*. Corn *Z. mays* are the main staple food among communities in the East Nusa Tenggara Islands chain, including people in Sumbawa Island [21]. While it is considered as an important staple food, corn is rarely found cultivated in home gardens. One informant stated that the corn was cultivated in orchards beyond the settlement area.

Most of the ornamental plants cultivated in home gardens because the plant shows beautiful leaf morphol-

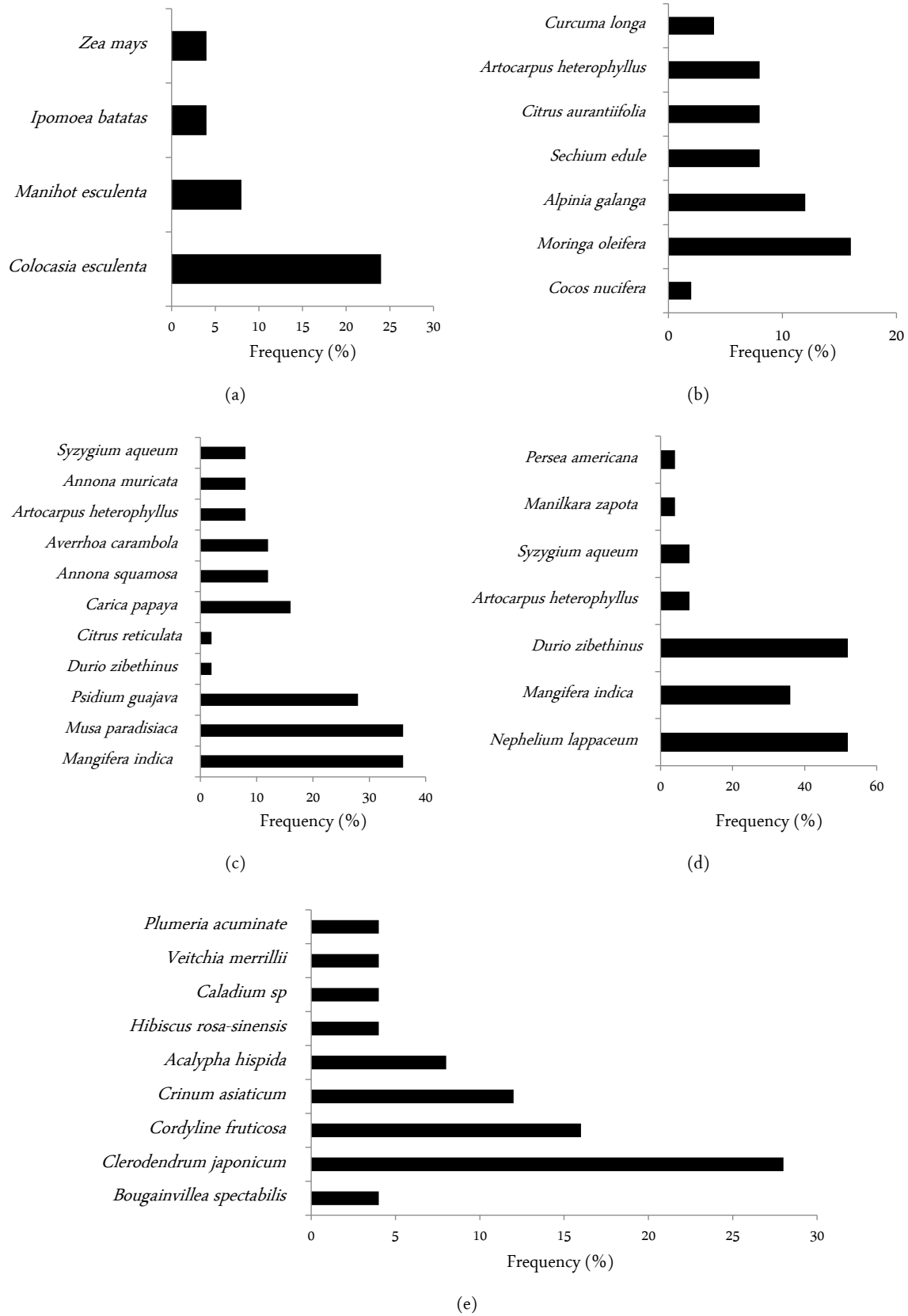

Figure 2. The occurrence frequency of selected plant in the home garden based on the main function: (a) staple food, (b) spice and vegetables, (c) fruit trees, (d) shading trees, and (e) ornamental plant

ogy and color produce beautiful flower and plant architecture is unique. *B. spectabilis* was commonly found in home gardens (40%) because this plant can produce colorful flowers without intensive management. Surprisingly, most of the ornamental plants showed a similar frequency distribution, in low frequency. It is shown by ornamental plants such as *Acalypha hispida*, *Antigonon leptopus*, *Caladium* sp., *Mirabilis jalapa*, *Hibiscus rosa-sinensis*, *Rosa multiflora*, *Syzygium oleana*, *Caesalpinia pulcherrima*, and *Cyathea contaminant*. It seems there wasno common ornamental plant grown in home gardens. Compared to the other mountain villages in East Java, however, the number of ornamental plants in Pancasila was lower [22].

The main fruit trees with economic value include *N. lappaceum* (*rambutan*), *M. indica*, (mango), and *M. paradisiaca* (banana). Compared to other fruit plants, these species had relatively high frequency and were commonly found in home gardens in Pancasila. An informant stated that *Durio zibethinus* (*durian*) and *Garcinia mangostana* (mangosteen) were newly introduced species in their home garden ecosystem. The old durian, which was grown in the home garden, was introduced from seedlings from Mataram (Lombok Island) by Javanese 15 – 20 years ago. Less than 15 productive durian trees found were in Pancasila Village. New seedlings recently were introduced in some gardens and a coffee orchard plantation. Similarly, mangosteen was introduced a few years ago, and there were no productive individuals found in home gardens.

Coffee is an important economic plant, but itsexistence in home gardens was low (32%). An informant pointed out that there is no technical assistance to cultivate coffee properly to produce high-quality coffee from Tambora. Coffee was introduced to Tambora in 1930 by a Swedish company under G. Byorklund. The first organic coffee plantation was open in Labuan Kenanga 80.000 ha [23]. Some plant seems to be multi purposes tree species, including *N. lappaceum*, *M. indica*, *D. zibethinus*, *Artocarpus heterophyllus*, *Syzygium aqueum*, *Manilkara zapota*, and *Persea americana*.

Consequences for rural tourism area development and conservation

Recent species diversity in home gardens has a significant role in the development of Pancasila as ecotourism destination sites. It is especially crucial in the perspective of a geopark, in which original geological sites should be preserved and protected from numerous disturbance, including exotic plant invasion. Floristic data shows that there should effort to increase tropical species number, minimize species beyond the tropical area, and eradicate potential invasive plants species. The authentic eco-accommodation in a rural area ideally should be able to present the authentic landscapes [24, 25]. Therefore, increasing and strengthening tropical images through the introduction and preservation of native tropical countries is important. An exploration of the local plant species is needed for the enrichment of home garden species composition. It is especially important to provide an educational aspect of the visitor in Pancasila settlement area.

Some notable potential invasive species was found in the home garden ecosystem. Lantana camera has been known as a noxious weed. Lantana able to decrease native ecosystem, including dryland ecosystem [26, 27]. *R. tuberosa* able to tolerate and strive in a wide range of environmental conditions. *R. communis* able to grows rapidly in poor soil condition and grows fatly in open area. This species is invasive in Brasilia [28]. The eradication of potentially invasive species is important steps in protecting ecosystem and biodiversity within Tambora Geopark.

Coffee is an interested plant to be improved in the home garden, both its number and plant quality. Fact that Tambora coffee has been known as one of the high-quality coffee should be put as one of the considerations in coffee plant improvement in home gardens ecosystem [23]. In such a case, the sustainable coffee cultivation practices through the farming should be promoted with the objective to increase coffee productivity and quality.

There are trends in plant introduction. Some of the attempts at introduction seem to be irrational, including apple *Malus domestica* and strawberry *F. vesca* introduction in home gardens. New ornamental plants were also introduced, such as *S. oleana*. According to informants, motives for such introductions were trial.

Home gardens in Pancasila are ideal sites for biodiversity conservation. Home gardens in Pancasila provide ideal spaces for numerous plants to grow, including local species. There are, however, opportunities to increase numbers and diversity of species. Increasing the number of species in home gardens is important, but there are limitations for such cases. Cattle and goats are everywhere, without intense management practices. Previously, there was an agreement within the community to keep animals in specific cages and to promote an intensive animal rearing system. These commitments were effective for several weeks, but not effective for a long time. People are back to the past tradition to release an-

imals. The animals destroy many seedlings and plant trees.

CONCLUSION

Home gardens in Pancasila Village contain numerous plant species, with Phanerophytes species as dominant. Species in home gardens come from numerous biogeographical continental, including Africa, Asia-Temperate, Asia-Tropical, Australasia, Pacific, Northern America, Southern America and a few species from Europe. Home gardens in Pancasila Village contain some exotic species, which have the potential to become invasive species in Tambora Geopark. Therefore, management aspects of home gardens to support biodiversity conservation and reduce invasiveness threats of particular exotic plant species urgently needs to be conceptualized. There are opportunities to increase the role of home gardens as sites for local biodiversity conservation. Empowering local communities to increase home gardens to support conservation and sustainable tourism in rural area is crucial. It is not only important to reduce threats of exotic plant species invasiveness but is also crucial to enhance social and economic benefits from home gardens.

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