

Species variation in home garden agroforestry system in South Sulawesi, Indonesia and its contribution to farmers' income

S A Paembonan¹, S Millang¹, M Dassir² and M Ridwan³

¹ Lab. of Silviculture, Fac.of Forestry, Hasanuddin University, Jalan Perintis Kemerdekaan KM. 10, Makassar, 90245, Indonesia.

² Lab. of Forest Policy, Fac.of Forestry, Hasanuddin University, Jalan Perintis Kemerdekaan KM. 10, Makassar, 90245, Indonesia.

³ Lab. of Forest Economic, Fac.of Forestry, Hasanuddin University, Jalan Perintis Kemerdekaan KM. 10, Makassar, 90245, Indonesia.

E-mail: samuelap@unhas.ac.id

Abstract. Home-garden is one of the types of agroforestry which is commonly practiced by rural communities in South Sulawesi, Indonesia. The study aimed to determine the diversity levels of the species constituting the home-gardens and their contribution to the farmers' incomes. The variables used in the study were the widths variation of the land owned as the home-gardens and the socioeconomic backgrounds of the community. The study results indicated that in small land, the community cultivated annual crop plants interspersed with agricultural commodities, and the trees as the boundary, while in the wider land they integrated various species plants within the area. The diversity index of the home-gardens was categorized as moderate with a value of 1.25 to 2.18, while species uniformity index was ranging from moderate to high with values of 0.49 to 0.77. The total incomes from home gardens varied greatly from one community to another, and it was largely determined by the composition and density of the constituent species. The contribution of the home-gardens to the income of the farmers amounted to 43.27%–49.06%. The sustainable management of the home-garden agroforestry can give a significant contribution to the farmers' incomes and the preservation of biodiversity and environment.

1. Introduction

Agroforestry is a land-use system that combines trees and crops or animals simultaneously or sequentially to increase overall crop and livestock production on a common land under technological conditions and management measures that are appropriate to the culture of the local community [1, 2].

The agroforestry system consists of several combinations of forestry products and plantation crops with various advantages of each community which in turn is expected to improve the welfare of the community [3]. One of the agroforestry systems that can increase the income of farmers that is widely practiced by the community is home-garden, which is planted with forestry crops and commodity crops simultaneously in a field around the house of village community [4, 5].

The Economic aspect is a critical consideration in applying agroforestry system that is how significant role of agroforestry can give an advantage by utilizing resources and technology owned. In addition, it should also be noted how far agroforestry provides sustainability of the results needed to meet the needs of life.



The home garden has multi species in one site with different stratum [6, 7, 8] and has the ability as a source of biomass energy for its owner [9, 10]. The presence of home garden agroforestry can also be significant in the context of climate mitigation [11, 12, 13]. In addition, the proper management of home garden can ensure environmental sustainability [7, 14].

Many studies have been reported about the species variability in the home garden and its contribution to farmer income [2, 4, 5, 6, 8, 9, 14]. However, none of the studies have discussed and compared with different cultural background. In this study, we observed the variation of agroforestry species in different locations and different culture in South Sulawesi province, Indonesia. There are two ethnicities in South Sulawesi namely Ethnic Toraja and Ethnic Bugis-Makassar. These two ethnicities with different cultures also have different habits in selecting species developed in the home garden. Based on the above reasons, this study aims to determine the variety of species is grown by the community in South Sulawesi in the home garden agroforestry system and how much its contribution to farmer's income.

2. Research Methods

2.1. The Study Site

The study was conducted in South Sulawesi Province, Indonesia. Determination of observation plot based on two ethnics in South Sulawesi that is in Tana Toraja regency for Toraja ethnic and in Regency of Bone and Bulukumba for ethnic Bugis-Makassar (figure 1).

A total of 45 plots were observed to determine species composition and describe species diversity at each site. Each regency consists of three Districts and is represented by 15 plots chosen purposively. Observation and data collection was done in the plot with a size of 20 m x 50 m.

Interviews with the farmers were conducted to obtain the history of home-garden management and its contribution to total farmer's income.



Figure 1. Map of Indonesia and South Sulawesi Province (enlarge).

2.2. Methods of Data Collection

The primary data collection techniques were carried out as follows:

1. All plant species in the plot of 20 m x 50 m were recorded by their species name and numbers.
 2. Conducting interviews to farmers to obtain data on the history of home-garden management and income earned by the home-garden if assessed with money.
 3. Calculate the contribution of home-garden income to total farmer's income.
- Supporting data, in the form of socioeconomic data and other information were collected from the local government and previous related study results.

2.3. Data Analysis

2.3.1. *Important Value Index (IVI)*. Important Value Index was analyzed to determine the dominance level of a species the home- garden, by using the formula of Mueller-Dombois and Ellenberg [15]:

$$IVI = RD + RF + RDo \quad (1)$$

where: RD is Relative Density (RD); RF Relative Frequency; and RDo is Relative Dominance

2.3.2. *The diversity index*. Calculated by the Shannon-Wiener formula [16]:

$$H' = - \sum P_i \ln P_i \quad (2)$$

where H' = Index of diversity; $P_i = \frac{n_i}{N}$; n_i = the number of individual species of i

N = total number of individuals

2.3.3. *The uniformity index*. Calculated by the following formula [16]:

$$J' = \frac{H'}{H'_{\max}} \quad (3)$$

where, J' = uniformity index; H' = index of diversity; $H'_{\max} = \ln S$; S = number of species.

2.3.4. *Income Analysis*. The analysis is used to know the income obtained from the home garden agroforestry system using the formula:

$$I = TR - TC \quad (4)$$

where: I = Income (IDR/ha/year); TR = Total Revenues (IDR/ha/year);

TC = Total Cost (IDR/ha/year).

2.3.5. *The contribution to the total incomes of the Farmer*. The contribution of home garden income to the total income of farmers was obtained through comparison as follows:

$$CI = \frac{Hg}{TI} \times 100\% \quad (5)$$

where CI = Contribution of home garden Income (%); Hg = Income in home garden;

TI = Total Farmers Income

The analysis for each of the different cultures is done descriptively to identify the selected plant species and the reason for choosing the species to be planted in the home garden.

3. Results and Discussion

3.1. Composition of Species and Important Value Index (IVI)

Field observations showed that the composition of plant species in home-garden in different places varies from one site to another. The number of species and species specifications at each location differed according to the culture of the local community and the consideration of economic needs. There were about 47 species have been found in home garden in South Sulawesi Province (table 1).

The composition of constituent plant species in each district has its specific characteristics. This difference in composition is influenced by the economic background, customs, and culture of the local community. Toraja society predominantly chooses certain tree species that are linked to cultures to build traditional houses and other traditional ceremonies such as *Casuarina junghuhniana*, *Elmerillia pubescens*, *Palaquium obovatum* and *bamboos*. While the Bugis-Makassar community is more likely to choose plant species associated with traditional wedding ceremonies, building common houses and for daily consumption habits.

Various kinds of home garden production found on the site of this study is in line with the opinion of Widiyanto *et al.* [5] that the products from the agroforestry system are also diverse, such as fruits, wood for building, firewood, sap, feed, vegetables, tubers, and grains. Variations of species in the home-garden occurred according to the site conditions and wishes of the farmer. Nair [14] explain that the selection of plant species in agroforestry is influenced by economic needs, family preferences, the availability of complementary food or substitutes for staple foods. Sometimes the selection of species is also determined by the market trend without considering the specific land suitability factors or because of the support programs from the local government [4].

The predominant species of agricultural commodities grown by the community are cocoa, coffee, and cloves because they provide a high income and can bear fruit several times a year. This product can significantly increase the income of rural communities.

Table 1. The highest Important Value Index (IVI) of six species in each regency and districts.

Species	Bulukumba			Bone			Tana Toraja		
	1	2	3	1	2	3	1	2	3
<i>Casuarina junghuhniana</i>							76.53	82.65	57.09
<i>Pinus merkusii</i>							-	64.24	85.72
<i>Arenga pinnata</i>			18.25		12.75		15.42		
<i>Gmelina arborea</i>				31.72		22.87			
<i>Elmerillia pubescens</i>							72.37	28.17	21.62
<i>Paladium obovatum</i>							11.91		
<i>Tectona grandis</i>	56.26	73.69							
<i>Swietenia macrophylla</i>		15.09							
<i>Mangifera indica</i>		13.49							
<i>Toona sureni</i>	14.39								
<i>Gliricidia sepium</i>		36.51	21.13	32.54	35.93	35.72			
<i>Albizia sp.</i>			23.87						
<i>Aleurites moluccana</i>				47.63		22.54			
<i>Artocarpus heterophyllum</i>	45.67								
<i>Arthocarpus altilis</i>				15.23					
<i>Musa paradisiaca</i>					14.55				
<i>Nephelium lappaceum</i>	17.98								
<i>Durio zibethinus</i>	13.93	23.92			26.24				
<i>Syzygium aromaticum</i>			20.11		21.53	18.75		20.40	42.48
<i>Coffea robusta</i>	104.74		100.52	85.74	56.41	65.26			20.03
<i>Coffea Arabica</i>							22.11	15.42	
<i>Theobroma cacao</i>		79.51	38.25	45.34	-	57.27	44.86	21.99	38.52

3.2. The Species Diversity (H') and Uniformity Index (J')

The diversity index of the home garden ranging from low to moderate level, with a value of 1.25–2.18. Thus, the species selected by the community are not very diverse, where only species that needed by the community to be planted. On the other hand, the Uniformity Index (J') in all districts was ranging from moderate to high with values of 0.49–0.77. In this category, the species composition was quite similar across districts and regency (table 2).

Table 2. Species Diversity Index (H') and Species Uniformity Index (J').

District	H'			J'		
	Bulukumba	Bone	Tana Toraja	Bulukumba	Bone	Tana Toraja
District 1	1.25	1.53	1.79	0.49	0.64	0.69
District 2	1.89	2.05	1.87	0.72	0.71	0.70
District 3	1.51	1.72	2.18	0.54	0.57	0.77

The selection of species was heavily influenced by human activities and determines the value of the diversity of these communities.

3.3. Distribution of crops based on the width of land ownership

The results show that the composition of plants within the area was influenced by width area of land ownership. The total area of home-garden ownership varies widely in rural communities, ranging from 0.2 ha to ≥ 1.5 ha. In small land, the community cultivated annual crop plants interspersed with agricultural commodities, and the trees as the boundary, while in the wider land they integrated plants within the area, such as the annual crops, agricultural commodity crops, fruit trees, and timber trees.

The more land owned by the farmer, the greater the proportion of tree crops to annual crops. The planted trees in home gardens do not need further maintenance, while seasonal crops and agricultural

commodity crops require intensive maintenance. In general, farmers who have 1 - 1.5 ha of land earn the highest income contribution from home-garden because of the large proportion of agricultural commodity crops. The area of land ownership in this study is not a limiting factor in determining the types of crops grown by farmers, but more closely related to the habits and livelihood needs of local farmers. The result of the study shows that vertical structure of mixed home-garden consists of four strata. The upper stratum is occupied by trees with intolerant species while in the middle stratum of other tree species is partial light demanders, the third stratum by commodity plant, and the rest occupied by shrubs and herbs.

3.4. Contribution to Farmer's Income

The contribution of home garden income is the percentage of the proportion of farmer's income from home garden to total farmer's income. In general, farmers in this study are rural farmers who are not civil servants or private.

The results showed that in addition to the home-garden plantation business, some farmers also have paddy fields and livestock. Annual crops and other commodity crops for livestock were cultivated within the home-garden area. The contribution of the home garden to total income varies widely depending on the composition of plant species being cultivated. Huge contributions were obtained when most types of agricultural commodities are developed such as coffee, cocoa, and cloves.

The income contribution by the home garden to the total income of farmers in average was 49.06%, 43.27%, and 48.5% in Bulukumba, Bone, and Tana Toraja regency, respectively. The contribution has no significant difference of one to another. The contribution of income from home-garden aside determined by the composition of the mixture of plant species was also identified by the size of land ownership (figure 2).

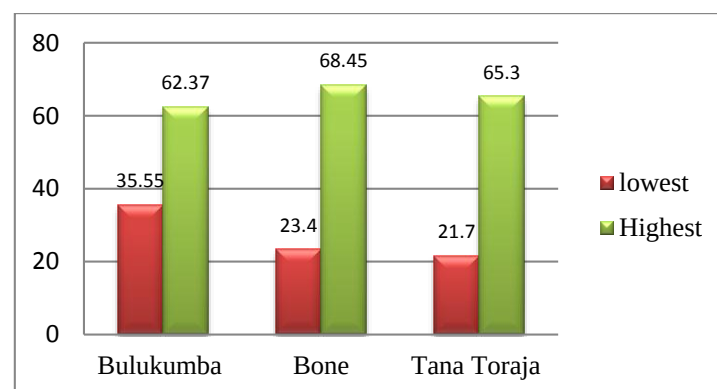


Figure 2. The contribution income of home-garden to the total income of farmers

According to Hartoyo *et al.* [6], the development of agroforestry is one of the models of community land management that can support the survival and welfare of the community, even in some places serves as saving that will be the basis to sustain the life. In the field of economic, agroforestry can increase the income of farmers through the diversification of commodities, and in the field of ecology, people can improve environmental quality.

4. Conclusion

- The home-gardens in South Sulawesi Province have a moderate species diversity index, with high-level species uniformity index.
- The contribution of income from home-garden, besides was determined by the composition of the mixture of plant species, was also influenced by the size area of land ownership.
- The average economic contribution of home-garden agroforestry system to total farmers' income is in the range of 43.27% to 49.06%.

- The selection of tree species to be planted in the home garden is influenced by the culture of the community, that is: in Toraja society to be used as building material of custom house and other traditional customs ceremony, whereas in Bugis-Makassar society to be used in building ordinary house, traditional ceremony of marriage and for daily consumption habits.
- The sustainable management of the home-garden agroforestry can give a significant contribution to the farmers' incomes and the preservation of biodiversity and environment.

References

- [1] Hairiah K and Rahayu S 2007 *Pengukuran 'karbon tersimpan' di berbagai macam penggunaan lahan Bogor* [in Indonesian] (Indonesia: World Agroforestry Centre - ICRAF, SEA Regional Office, University of Brawijaya, Unibraw, Indonesia) p 77
- [2] Paembonan S A 2013 *Model Agroforestri Berbasis Tongkonan yang Berwawasan Konservasi Lingkungan di Kabupaten Tana Toraja* in Kuswantoro et al. (eds) *Agroforestry for Food and Better Environment-National Seminar of Agroforestry* [in Indonesian with English summary] *Proc. of National Seminar on Agroforestry* 21 May 2013 Malang pp 494–498
- [3] Mbile P, Stolle F, Boundzanga G, Mane L, Loumeto J, Homb M, Ifo S, et al 2013 Readiness for reducing emissions from deforestation and forest degradation under uncertain, national circumstances *Int. J. of Eco. and Dev.* **24** (1) 27–48
- [4] Kumar B M and Nair P K R 2004 The enigma of tropical home gardens *Agr. Syst.* **61** 135–152
- [5] Widiyanto, Hairiah K, Suharjito D and Sardjono MA 2003 *The Function and Role of Agroforestry* [in Indonesian] (Bogor: World Agroforestry Centre (ICRAF))
- [6] Hartoyo A P P, Siregar I Z, Supriyanto, Prasetyo L B and Thelaide I 2016 Biodiversity, Carbon Stocks and Community Monitoring in Traditional Agroforestry Practices: Preliminary Results from Two Investigated Villages in Berau, East Borneo. *Procedia Environ. Sci.* **33** 376–385
- [7] Mattsson E, Ostwald M, Nissanka S P and Pushpakumara D 2015 Quantification of carbon stock and tree diversity of home gardens in a dry zone area of Moneragala district, Sri Lanka *Agrofor. Syst.* **89** 435–445
- [8] Utomo B, Prawoto A A, Bonnet S, Bangviwat A and Gheewala S H 2016 Environmental performance of cocoa production from monoculture and agroforestry systems in Indonesia *J. Clean. Prod.* **134** 583–591
- [9] Ali A and Mattsson E 2017 Individual tree size inequality enhances aboveground biomass in home garden agroforestry systems in the dry zone of Sri Lanka *Sci. Total Environ.* **575** 6–11
- [10] Stas S M, Rutishauser, Chave J, Anten N P R and Laumonier Y 2017 Estimating the aboveground biomass in an old secondary forest on limestone in the Moluccas, Indonesia: Comparing locally developed versus existing allometric models *For. Ecol. Manage.* **389** 27–34
- [11] Dhillon R S and von Wuehlisch G 2013 Mitigation of global warming through renewable biomass *Biomass and Bioenergy* **48** 75–89
- [12] Mandal S A, Dutta I C, Jha P K and Haque S M 2013 Potential carbon offset in public plantation: offering an opportunity for REDD+ and soil fertility *Int. J. of Eco. and Dev.* **25** (2) 21 – 31
- [13] Yamamoto Y, Kubota N, Ogo T and Priyono 1991 Changes in the structure of home gardens under different climatic conditions in Java Island *Japan. J. Trop. Agric.* **35** 104–117
- [14] Nair P K R 2012 Carbon sequestration studies in agroforestry systems: A reality-check. *Agrofor. Syst.* **86** 243–253
- [15] Mueller-Dombois D and Ellenberg H 1974 *Aims and Methods of Vegetation Ecology* (Canada: John Wiley and Sons Inc.) p 547
- [16] Magurran AE 1987 *Ecological Diversity and Its Measurement*. (London: Chapman and Hall) p 179