Agrisilviculture management and productivity system in Timusu village, Liliriaja district, Soppeng Regency

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Abstract. Agroforestry can become one of the solutions in the land management system to overcome problems arising from the land-use change. The study purposes were to know the technical form of agrisilviculture management system and to know the productivity of the agrisilviculture system. Data of agrisilviculture management systems were obtained from observation results, interviews, questionnaires, and literature study, which then being analyzed descriptively with a qualitative approach. This study was conducted in Timusu Village, Liliriaja District, in Soppeng Regency. In total, 15 farmers were selected as respondents. Data on the productivity of agriculture systems were obtained from interviews and vegetation surveys. The land area classified into three categories, such as the land area less than 0.6 Ha, 0.6 to 1 Ha, and more than 1 Ha. The data were analyzed quantitatively. The results showed that the agrisilviculture management system in Timusu Village consists of land preparation, seedling procurement, planting, maintenance, and harvesting. The average amount of agrisilviculture productivity in the land area classification of more than 1 Ha was equal to Rp 23,167,389/Ha/year, the land classification of 0.6 to 1 Ha was Rp15,333,366/Ha/year, and land area classification of less than 0.6 was Rp18,455,483/Ha/year

1. Introduction

Conversion of forest land into agricultural land has caused many problems such as a decrease in soil fertility, erosion, extinction of flora and fauna, drought, flooding, and global environmental changes. This problem has worsened over time due to increasing areas of forest that have been converted into other business areas. Therefore, agroforestry can be a solution to overcome problems arising from the land-use change as well as to overcome food problem. Agroforestry also means planting trees on agricultural land.

In this system, interactions between trees, soil, and annual crops will be formed. Each type of component will cause both negative and positive effects on other components [1]. Land use pattern with the agroforestry system is essential for a farmer with limited agricultural land. With this pattern, harvest intensity will increase, and it can provide additional output both in the form of production and financial value. Agroforestry, as a model of farming, has increased its role, especially for rural communities who have limited land. This farming pattern can provide the possibility for landowners to increase the intensity of harvesting per unit area [2].

Different agroforestry management formulation is needed for each land and community condition [3,4]. Therefore, it is necessary and vital to conduct research to find out about the...
process of selecting and determining a management method that is suitable for agroforestry practices in order to achieve maximum results.

2. Research Methodology

2.1. Research Time and Location
This research was conducted from 12 to 26 February 2018 in Timusu Village, Liliriaja District, Soppeng Regency.

2.2. Research Proportion and Sample
The respondents were selected with a purposive sampling method. Respondents must be farmers who applied agroforestry on their land. In total 15 farmers were selected consisting of 5 farmers as representing the land area that less than 0.6 Ha, 5 farmers as representing the land area of 0.6 to 1 Ha, 5 farmers as representing the land area that more than 1 Ha. For each different land area, 5 sample plots were taken. The sample size of each plot is 50 x 20 m.

2.3. Observation Variable
1. Type of component and production which planted by farmers
2. Height and diameter of the tree to determine the potential of wood, if the wood can be utilized

3. Research Procedure

3.1. Management System
Each respondent was interviewed to obtain information related to the respondent's identity, land ownership, type of plant, and the number of plants per Ha. Also, data about ways of managing land, including data on seed procurement, land preparation, planting, maintenance, amount of production during harvest, and the number of harvests for one year were collected.

3.2. Agroforestry Productivity
1. Each land area was surveyed to collect data on types of vegetation that cultivated and utilized by farmers.
2. The wood potential was measured if forestry plants that can be utilized available in the plot. This was be done by measuring the diameter and height of the tree
3. The observation plot was made as shown in Figure 1

![Figure 1. Data collection plot models](image-url)
3.3. Data Analysis
Data on agroforestry system management were obtained from observations, interview notes owned by respondents, questionnaires, and literature studies that were being analyzed descriptively with a qualitative approach. While data on agroforestry productivity were obtained from primary data and being analyzed quantitatively.

3.4. Volume
The measurement result of tree growth dimension was analyzed to determine the actual condition of tree potential by calculating the volume of wood in the land. Tree volume can be calculated by using the formula:

\[ V = SBA \times \frac{D}{4} \times TH \times F \]

Note:
- \( V \) = Tree volume
- \( SBA \) = Stand basal area \((\frac{1}{4} \pi D^2)\)
- \( D \) = Trunk diameter (height = 1.30)
- \( TH \) = Total height
- \( F \) = Form factor (0.8)

**Mean Annual Increment**

\[ MAI = \frac{V}{t} \]

Note:
- \( V \) = Tree Volume at Time \((t)\)
- \( t \) = Age
- \( MAI \) = Mean Annual Increment

**Total Cost**
The total cost is all of the cost that was spent during the production process, starting from planting, maintenance, and harvesting that stated in \((Rp)\). The formula used is shown below:

\[ TC = TFC + TVC \]

Note:
- \( TC \) = Total Cost \((Rp/\text{Ha/year})\)
- \( TFC \) = Total Fixed Cost \((Rp/\text{Ha/year})\)
- \( TVC \) = Total Variable Cost \((Rp/\text{Ha/year})\)

**Revenue**
Revenue is all the result of each component in the agroforestry system that stated in \((Rp)\). The formula used is shown below:

\[ TR = P \times Q \]

Note:
- \( TR \) = Total Revenue \((Rp/\text{Ha/year})\)
- \( P \) = Price \((Rp)\)
- \( Q \) = Quantity of product

**Income**
Income analysis is used to determine the income earned in the agroforestry business. The formula used is shown below:

\[ I = TR - TC \]

Note:
- \( I \) = Income \((Rp/\text{Ha/year})\)
- \( TR \) = Total Revenue \((Rp/\text{Ha/year})\)
- \( TC \) = Total Cost \((Rp/\text{Ha/year})\)
4. Results and Discussion

4.1. Description of Agroforestry System Management
The agroforestry system management activities carried out by farmers in Timusu Village, Liliriaja District, Soppeng Regency were land preparation, seedling procurement, planting, maintenance, and harvesting.

4.2. Land Preparation
Land preparation included land clearing and tillage. It was found that all respondents conducted land preparation by cleaning the area from shrubs with machete, hoe, crowbar, and sickle. Land preparation activities conducted to eliminate competition of saplings with wild plants, including unwanted trees in the area [5]. Land clearing activities usually end with land management activities, which can be done manually by digging a planting hole. However, farmers did not add fertilizer during this stage.

4.3. Seedling Procurement
Most of the farmers planted their plantations with cacao and pangi because of high selling values. Propagation of cacao plants was done vegetatively with side grafting, while pangi can produce many fruits during one harvest. Farmers obtain seeds from three sources, such as government assistance through the local forestry service, non-governmental organization, and obtained directly from the forest. Seeds given from the government were teak and candlenut seeds. Seedlings from non-governmental organizations in the form of chocolate, mango, bitti, mahogany, sugar palm, pineapple, banana, jackfruit, pumpkin, orange, and chili. While pangi seeds were obtained directly from the forest by planting seeds directly in the field.

4.4. Composition of Planting Types and Patterns
There were 16 types of plants found in agroforestry system land management in Liliriaja District, Timusu Village.

| Table 1. Composition of Type of Plant at the Study Site |
|--------------------------------------------------------|
| Type of Plant                                         | Area (Ha) |
|                                                      | >1 Ha     | 0.6-1 Ha | <0.6 Ha |
| Pangi (Pangium edule Reinw)                          | ✓         | ✓        | ✓        |
| Cacao (Theobroma cacao)                               | ✓         | ✓        | ✓        |
| Candlenut (Aleurites molluccanus)                     | ✓         | ✓        | ✓        |
| Sugar palm (Arenga pinnata)                           | -         | ✓        | ✓        |
| Gmelina (Gmelina arborea)                             | -         | ✓        | ✓        |
| Teak (Tectona grandis)                                | ✓         | -        | ✓        |
| Mahogany (Swietenia mahagoni)                         | ✓         | -        | -        |
| Mango (Mangifera indica)                              | -         | ✓        | -        |
| Bitti (vitex cofassus)                                | -         | ✓        | -        |
| Tamarine (Tamarindus indicus)                          | -         | -        | ✓        |
| Jackfruit (Artocarpus heterophyllus)                  | -         | -        | ✓        |
| Banana (Musa paradisiaca)                             | -         | -        | ✓        |
| Pineapple (Ananas comosus)                             | -         | -        | ✓        |
| Chili (Capsicum frutescens L.)                        | -         | -        | ✓        |
| Big orange (Citrus maxima)                             | -         | -        | ✓        |
| Pumpkin (Cucurbita moschata)                           | -         | -        | ✓        |
Coconut (Cocos nucifera)

From table 3, it can be seen that there were 17 types of plants found in the agroforestry management system land. The composition of species that most commonly found were pangi (Pangium edule Reinw), cacao (Theobroma cacao), and candlenut (Aleuritas molluccana). Other crops developed by farmers were sugar palm, gmelina, teak, mahogany, mango, bitti, tamarine, jackfruit, banana, pineapple, chili, big orange, pumpkin, and coconut.

Based on observations and data obtained in the field, 15 respondents applied a random mixture method to their land, which the spacing of each forestry and agricultural crop looked irregular. Candlenut and pangi as the earliest plants which being developed had spacing that was 10 to 15 meters in irregular patterns, while the rest was planted with fruit-producing plants such as cacao [4] and other annual crops. Planting by farmers was done at the beginning of the rainy season or the end of the dry season, good times for soil to produce enough moisture.

4.5. Plant Preservation and Protection

Plant preservation is an effort to maintain and protect plants by meeting the resources for their survival. Three primary resources for plant survival are water, nutrients in the soil, and sunlight. Then, plant protection is an effort made by farmers to prevent plants from the plant-destroying agents and to treat plants from infection or damage caused by the plant-destroying agent [6].

The maintenance and protection of plants include weeding, fertilizing, pruning, and controlling pests and diseases. Weeding can be done by cleaning the area around the plant from weeds using a sickle. A high density of weeds will increase competition to obtain nutrients and sunlight and can reduce the production of plants [7].

Fertilization is done to maintain the availability of nutrients. From the data, it was known that type of fertilizer that commonly used by farmers in Timusu Village, namely NPK, Urea, and Za. Respondents only used fertilizer for cacao and teak, while other plants were left to grow on their own to produce. The type of fertilizer for teak plants was NPK, which used for 50 grams per tree and done twice per year by making grooves as deep as 5 cm around the canopy. While the use of NPK fertilizer for cacao was 250 grams per tree and given three times per year, the groove around the trunk was 10 cm.

Pruning is an activity to eliminate tree branches. Pruning was a maintenance activity carried out by farmers in Timusu Village, mainly because many farmers planted cacao, which required pruning. For cacao plants, pruning is an attempt to increase production and maintain the economic life of the plant [8]. However, some farmers were no longer conducting pruning for maintenance of plants. Control of pests and diseases was done by spraying insecticides for fruit borer pests in cacao.

4.6. Harvesting

Harvesting can be done alone or in collaboration with other people. Landowner farmers share the yields as wage costs for laborers from maintenance and harvesting activities carried out by them. However, harvest times vary depending on the type of plant.

Candlenut harvesting was done twice a year, around August to October and November to January. Candlenut was harvested by picking up fallen fruits. This also applied with brown candlenut and pangi, which harvested two times per year. All harvesting activities were carried out in the morning until the afternoon with the help of laborers, who picked up fruit and delivered it to the owner with a wage of around Rp50,000 to Rp80,000. Meanwhile, pangi and candlenut trees wood commonly used as fence material or as temporary poles during house construction.
4.7. Agroforestry Land Productivity
Agroforestry land productivity can be known after analyzing cost, revenue, and income. Although most products consist of more than one type, the overall analysis of the farm must be measured in one size. Thus the various products must be counted in one size. The value of the product is usually the best for expressing the various products produced in a farming business [9]

4.8. Cost Analysis
Cost analysis can be determined by adding up all types of costs incurred by farmers, such as land taxes, tools, maintenance costs, including spending on fertilizers and pesticides, as well as workers' wages. Table 2 shows the total costs incurred by farmers based on the land area classification:

**Table 2. The Cost Analysis Based on The Land Area Classification in The Agroforestry System**

| Respondent | Area (Ha) | Total Cost (Rp/Year) | (Rp/Ha/Year) |
|------------|-----------|----------------------|--------------|
| 1          | 2.5       | 5,365,000            | 2,146,000    |
| 2          | 1.8       | 2,589,167            | 1,438,426    |
| 3          | 1.5       | 3,312,167            | 2,208,111    |
| 4          | 1.5       | 2,220,833            | 1,480,555    |
| 5          | 1.5       | 2,171,000            | 1,447,333    |
| **Average** |           | **3.131.633**        | **1,744,085** |
| 1          | 0.75      | 3,804,334            | 5,072,445    |
| 2          | 1         | 2,869,334            | 2,869,334    |
| 3          | 0.6       | 3,321,000            | 5,535,000    |
| 4          | 0.6       | 1,631,000            | 2,718,333    |
| 5          | 0.6       | 3,196,833            | 5,328,055    |
| **Average** |           | **2.964.500**        | **4,304,633** |
| 1          | 0.4       | 1,603,500            | 4,008,750    |
| 2          | 0.5       | 1,240,167            | 2,480,334    |
| 3          | 0.4       | 1,660,083            | 4,150,208    |
| 4          | 0.4       | 903,083              | 2,257,708    |
| 5          | 0.5       | 679,750              | 1,359,500    |
| **Average** |           | **1.217.317**        | **2,851,300** |

On the land classification of more than 1 Ha, the average cost incurred by farmers was Rp1,744,085/Ha/year. While respondents in the land area classification 0.6 to 1 Ha spent an average cost of Rp4,304,633/Ha/year and respondents in the land area classification of less than 0.6 Ha spent an average cost of Rp2,851,300 /Ha/year.

The respondent who spent the greatest cost for the land area classification of more than 1 Ha was respondent 1 with 2.5 Ha land area. The respondent spent Rp5,365,000 a year because the respondent employed 5 people to manage the land for 8 days. While the respondent who spent the least cost in the land area classification of more than 1 Ha was respondent 5 with an amount of Rp2,171,000 for a year. This was because the respondent paid the least cost with a worker to manage the land for 5 working days per year.
In the land area classification of 0.6 Ha to 1 Ha, the respondent with the highest cost spent was respondent 1 with 0.75 Ha land area, spent Rp3,804,334, which due to the high maintenance cost compared to respondent 4, who spent the least cost which was Rp 1,631,000 per year.

In the land area classification of less than 0.6 Ha, the respondent who spent the greatest cost was respondent 3 with Rp1,660,083 for one year; this was because the respondent incurred cost for seedlings while the other respondents in this land classification did not spend any money for seedlings.

4.9. Revenue Analysis
Revenue analysis can be used to analyze all the results that will be obtained by the farmer for a year in managing their land where all results can be valued in money. The revenue analysis was obtained from the product price times the number of products. However, the results of the analysis here showed the potential revenues that can be obtained if the forestry components have been sold. The total revenues received by farmers based on their land area classification shown in Table 3 below:

Table 3. The Revenue Analysis Based on The Area of Land Ownership in The Agrisilviculture System

| Area (Ha) | Responder | Area (Ha) | Revenue | Total Revenue (Rp/ Ha/year) | Average Revenue (Rp/ Ha/ year) |
|-----------|-----------|-----------|---------|---------------------------|-------------------------------|
|           |           |           | Forestry | Agriculture               |                               |
| 0.6-1     | 1         | 2.5       | 43,250,000 | 3,232,000               | 46,482,000                   |
|           | 2         | 1.8       | 29,880,000 | 8,426,445               | 38,306,445                   |
| >1        | 3         | 1.5       | 18,000,000 | 9,935,000               | 26,935,000                   |
|           | 4         | 1.5       | 12,900,000 | 3,700,667               | 16,600,667                   |
|           | 5         | 1.5       | 2,160,000  | 2,812,000               | 4,972,000                    |
|           | 6         | 0.75      | 1,302,000  | 11,963,000              | 13,265,000                   |
|           | 7         | 1         | 13,600,000 | 4,876,000               | 18,476,000                   |
| <0.6      | 8         | 0.6       | 11,460,000 | 7,618,000               | 19,078,000                   |
|           | 9         | 0.6       | 4,320,000  | 9,419,333               | 13,739,333                   |
|           | 10        | 0.6       | 12,840,000 | 14,091,000              | 26,931,000                   |
|           | 11        | 0.4       | 7,120,000  | 5,290,000               | 12,410,000                   |
|           | 12        | 0.5       | 6,750,000  | 10,200,000              | 16,950,000                   |
|           | 13        | 0.4       | 4,760,000  | 7,246,000               | 12,006,000                   |
|           | 14        | 0.4       | 10,560,000 | 29,590,000              | 40,150,000                   |
|           | 15        | 0.5       | 8,650,000  | 8,198,000               | 16,848,000                   |

Total revenue of farmers obtained from forestry and agricultural products. Revenues from forestry earned from revenue of timber value where the price of wood per cubic meter multiplied by the number of trees in the plot and the Mean Annual Increment (MAI). MAI can be obtained from the average volume (m³) divided by the age of the tree. Then, revenue from agricultural acquired from multiplication result between the selling price per kilogram with the number of products produced.

The respondent with the highest revenue from the land area classification of more than 1 Ha was respondent 1 with 2.5 Ha of land area. The revenue amount was Rp 46,482,000 for one year. This value was obtained from 4 types of plants divided into forestry plants, which amount was Rp 43,250,000, and agricultural crop amount was Rp 3,232,000 for one year. While the lowest revenue in this land area classification was respondent 5 with 1.5 Ha land area with
revenue amount Rp 4,972,000 for one year, this value came from forestry plants with the amount of Rp 2,160,000, and agricultural crops with the amount of Rp 2,812,000.

The respondent with the highest revenue from the land area classification of 0.6 to 1 Ha was respondent 10 with 0.6 Ha of land area, with revenue amount was Rp 26,931,000 for one year, this value was obtained from 6 types of plants developed in the land area, and divided into forestry plants as much as Rp 12,840,000 and agricultural crops amount was Rp 14,091,000. The lowest revenue in this land area classification was respondent 6 with 0.7 Ha of land area, which amount was Rp13,265,000. This value was obtained from 5 types of plants divided into forestry plants with the amount of Rp 1,302,000 and agricultural crops with the amount of Rp 11,963,000.

The respondent with the highest revenue from the land area classification of less than 0.6 Ha was respondent 14 with 0.4 Ha of land area. The revenue amount was Rp 40,150,000 for one year. This value was obtained from 9 types of plants divided into forestry plants with amount was Rp29,590,000 for one year. While the lowest revenue in this land area classification was respondent 6 with 0.7 Ha of land area, which amount was Rp 13,265,000. This value was obtained from 5 types of plants divided into forestry plants with the amount of Rp 1,302,000 and agricultural crops with the amount of Rp 11,963,000.

4.10. Income Analysis

The net income from each land classification calculated based on the revenue received by farmers from the production of various types of plants on the farmer's land, which reduced by the costs incurred by farmers during the land management process. Income analysis of each respondent based on the area of land ownership in the agroforestry system can be seen in Table 4.

Table 4. The Income Analysis Based on The Area of Land Ownership in The Agroforestry System

| Group Area (Ha) | Area (Ha) | Revenue (Rp/Ha/year) | Cost (Rp/Ha/year) | Income (Rp/Ha/year) | Average Income (Rp/Ha/year) |
|-----------------|-----------|----------------------|-------------------|---------------------|----------------------------|
| 2.5             | 0.6       | 25,200               | 679,000           | 133,000             | 231,666                    |
| 1.8             | 1.6       | 27,935,000           | 5,365,000         | 3,151,000           | 20,514,714                 |
| 1.5             | 1.5       | 16,600,667           | 2,220,833         | 14,379,834          | 23,167,389                 |
| 1.5             | 1.5       | 4,972,000            | 2,171,000         | 2,801,000           | 4,643,656                  |
| 1.5             | 1.5       | 13,265,000           | 3,804,334         | 9,460,666           | 15,333,366                 |
| 1.5             | 1.5       | 18,476,000           | 2,869,334         | 15,606,666          | 25,179,389                 |
| 1.5             | 1.5       | 19,078,000           | 3,321,000         | 15,757,000          | 15,333,366                 |
| 1.5             | 1.5       | 13,739,333           | 1,631,000         | 12,108,333          | 18,455,483                 |
| 1.5             | 1.5       | 26,931,000           | 3,196,833         | 23,734,167          | 42,179,514                 |
| 1.5             | 1.5       | 12,410,000           | 1,603,500         | 10,806,500          | 15,333,366                 |
| 1.5             | 1.5       | 16,950,000           | 1,240,167         | 15,709,833          | 25,179,389                 |
| 1.5             | 1.5       | 12,006,000           | 1,660,083         | 10,345,917          | 18,455,483                 |
| 1.5             | 1.5       | 40,150,000           | 903,083           | 39,246,917          | 58,491,980                 |
| 1.5             | 1.5       | 16,848,000           | 679,750           | 16,168,250          | 58,491,980                 |
Table 4 shows that the highest and lowest average income, respectively, were Rp 23,167,389/Ha/year obtained from the land area of more than 1 Ha, then Rp 18,455,483 from the land area of less than 0.6 Ha, and Rp 15,333,366 Ha/year from the land area of 0.6 to 1 Ha. Furthermore, the result of farmer income on the land area of more than 1 Ha was higher than other land area classifications because farmers in this area planted high-value forestry plants such as teak and mahogany. Then, the result of farmer income on the land area of less than 0.6 Ha was higher than the income on the land area of 0.6 to 1 Ha because the farmers utilized the planting space in the land area classification of less than 0.6 Ha more efficient than the land area classification of 0.6 to 1 Ha.

5. Conclusion
1. The management of the agrisilviculture system carried out by farmers in Timusu Village, Liliriaja Subdistrict, Soppeng Regency began with land preparation activities, which included land clearing and land management. After land preparation, the farmers conducted seedling procurement, where farmers obtained seeds from three sources, such as government assistance through the local forestry service, non-governmental organization, and obtained directly from the forest. Next, the maintenance was done by pruning and giving fertilizers and pesticides. The last activity conducted was harvesting activity.
2. Average productivity from the land area classification of more than 1 Ha was Rp 23,167,389/Ha/year, then average productivity in the land area classification of 0.6 to 1 Ha was Rp 15,333,366/Ha/year, and for the land area classification of less than 0.6 Ha was Rp 18,455,483/Ha/year.

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