Study of agroforestry system management in Pitumpanua District, Wajo Regency

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Abstract. This study aims to determine the management of agroforestry systems, structure, and composition of agroforestry constituent components and agroforestry constituent components' income. This research was conducted in October - November 2019 in Pitumpanua district, Wajo Regency. The method used is purposive sampling with respondents farmers who have a land area of ≥ 0.5 ha and implement agroforestry systems. To determine the volume of wood, structure, and composition of plant species, we created 15 sample plots. To find out the form of agroforestry management and productivity, 30 respondents were interviewed. The data were processed and analyzed using descriptive and quantitative methods. The results showed the management conducted in three villages in the Pitumpanua district is land preparation, seed sourcing, planting, crop maintenance, and harvesting. The composition of plant species contained in each plot as many as 13 species of plants. Productivity can be known after analyzing cost, revenue, and income. Farmers' income in Jauh Pandang Village is higher at Rp. 39,880,341/ha/year, compared to marannu village farmers' income of Rp. 31,415,334/ha/year and farmers' income in Ale Lebbae Village is Rp. 28,718,248/ha/year.

1. Introduction

Instead of forest land being farmland is realized to cause many problems such as decreased soil fertility, erosion, extinction of flora and fauna, floods, droughts, and even changes in the global environment. This problem gets heavier over time as the area of forest is converted into other businesses. Agroforestry is one of the land management systems that may be offered to overcome problems arising from the land transfer above and also to overcome food problems [1].

Agroforestry system is a combination of various types of trees with seasonal plants with/without livestock or animals. Agroforestry systems have been implemented since time immemorial by farmers in various regions with a variety of climatic conditions and soil types as well as various evasion systems. Management of agroforestry systems includes soil processing, fertilization, weeding, pruning, and eradication of pests/diseases, often varying between locations and even between farmers. The different systems can be caused by differences in biophysical conditions (climate and soil), differences in the availability of capital and labor, and differences in socio-cultural background.

Therefore the products produced from agroforestry systems also varies, for example fruits, building wood, firewood, sap, feed, vegetables, tubers, and grains [2], while suggests agroforestry is optimal and sustainable land use management by combining forestry and agricultural activities in the same land management unit by paying attention to the environmental, socioeconomic and cultural conditions of the participating communities [3].
Agroforestry can be clarified based on its constituent components. The main constituent components of agroforestry are forestry, agriculture, and/or livestock components [4]. If reviewed from its components, agroforestry can be clarified as agrisilviculture (combining forestry components with agricultural components) [5], silvopasture (combining forestry components with livestock components) and agrosilvopastura (combining the three main constituent components which are components, forestry, agriculture, and/or livestock).

Pitumpanua is a district in Wajo Regency where there are several villages that implement or develop agroforestry systems, one of which is Jauh Pandang Village. The people of Jauh Pandang village mostly depend on their lives from agricultural businesses, both seasonal and yearly crop farming. This can be seen from the mixed garden developed by the community on a plot of land. There are several species of plants such as durian, pepper, Gamal, banana, cocoa, rambutan, cloves, langsat other plants. This research is an approach in studying the management of agroforestry systems by the surrounding community in this case Jauh Pandang Village, Marannu Village, and Ale Lebbae Village in Pitumpanua district, Wajo Regency.

2. Materials and methods

2.1. Study area
This research was conducted in October - November 2019 in three villages, those are Jauh Pandang Village, Marannu Village, Ale Lebbae Village in Pitumpanua District, Wajo Regency.

2.2. Research tools and material
Tools and Materials used in this study:

2.2.1. Tools. The tools consist of the following:
1. Global Positioning System (GPS) to determine the geographical location of the research site.
2. Compass is used to determine the direction in the observation plot.
3. Rollmeters, ropes, and stakes are used to create research plots.
4. A ribbon meter is used to measure the circumference of the tree.
5. Abney level is used to measure the height of trees.
6. Cameras are used to document all activities in research.

2.2.2. Materials. The materials consist of the following:
1. The tally sheet is used to record observations in the field.
2. Stationery Writing is used to record the results of observations.
3. Questionnaire as a list of questions for interviews to respondents (farmers/landowners).

2.3. Data collecting
This study uses two types of data, those are:

2.3.1. Primary data. Primary data obtained through observation activities and direct interviews in the field to farmers as respondents as many as 30 respondents with details of 10 respondents each village to obtain data on agroforestry system management, as well as data collection to obtain the structure and composition of agroforestry constituent types.

2.3.2. Secondary data. Secondary data, i.e., data or information obtained from various relevant agencies, such as data collection of general conditions of research sites, socioeconomic circumstances, population data and library literature that supports the theory in research.

2.4. Research procedure
The working procedures performed in this study are:
1. We are choosing respondents using purposive sampling method as many as 30 farmers who apply agroforestry system pattern (Farmer who has a land area of 0.5 ha) in Jauh Pandang Village, Marannu, Ale Lebbae, Pitumpanua District with details as many as ten respondents in each village.

2. Interviewing each respondent who applies the agroforestry system that has been chosen is based on questionnaires.

3. Create a plot with size 20 m x 50 m as much as five plots in each village that has been determined. All species of plants found in the sample plot are recorded.

4. The measurement plot model used for data retrieval is a rectangle with a size of 20 m x 50 m.

5. Measures the free height of branches, total height, a circumference of trees on all plants contained in the plot.

6. Then the data of interviews and observations are collected in the form of notes or tally sheets and then recapitulated in accordance with the objectives to be achieved.

2.5. Data analysis

The collected data is processed and analyzed using descriptive and quantitative analysis. Descriptive analysis is used to describe the management of agroforestry systems obtained from observation and questionnaire data. Quantitative analysis is used to obtain an overview of agroforestry system productivity.

2.5.1. Tree Volume. The results of measuring the dimensions of tree growth are analyzed to determine the actual condition of the potential of the tree by calculating the volume of wood on agroforestry land to be studied. The volume of the tree can be calculated by the formula:

$$V = Lbds \times T\text{tot} \times F$$

Where:

- **V** : Tree Volume
- **LBDS** : Area of Basic Field \(\frac{1}{4} \pi D^2\)
- **D** : Trunk Diameter (height = 1.30 m)
- **Ttot** : Total Height (m)
- **F** : Bar Shape Number \(0.8\)

2.5.2. Total height (m)

$$T\text{tot} = (\tan \alpha \times T\text{tot} \times observer \ distance) + observer \ height$$

2.5.3. Branch-free height (m)

$$Tbc = (\tan \alpha \times Tbc \times observer \ distance) + observer \ height$$

2.5.4. Diameter (cm)

$$D = \frac{K}{\pi}$$

Where:

- **D** : Diameter
- **K** : Circumference
- **\pi** : 3.14

2.5.5. Average increment

$$MAI = \frac{Vt}{t}$$
Where:

- MAI: Mean Annual Increment
- Vt: Volume of trees at t-age (m$^3$)
- t: Age (years)

2.5.6. Cost analysis. Cost analysis is a cost that can be assessed with money during the production process from planting, maintenance to harvesting. Commonly used formula as follows [3]:

$$ TC = FC + VC $$

Where:

- TC: Total Cost (Rp/ha/year)
- FC: Fixed Cost (Rp/ha/year)
- VC: Variable cost (Rp/ha/year)

2.5.7. Revenue analysis

Revenue is the amount of proceeds obtained from the sale of a certain amount of output or in other words constitutes any income obtained from the results of its production business or all proceeds that can be assessed by money obtained from agroforestry farming. The commonly used formula is [6]:

$$ Tr = \sum_{i=1}^{n} (Y \cdot Py) $$

Where:

- TR: Total Revenue (Rp/ha/year)
- Y: Production obtained in a farm
- Py: Price Y (Rp)
- n: Number of plants cultivated

2.5.8. Income analysis

Income is the difference in revenue with all costs incurred in production. Income analysis is done by looking at farmers' income from agroforestry businesses applied. The formula used is [7]:

$$ I = TR - TC $$

Where:

- I: Income (Rp/ha/year)
- TR: Total Revenue (Rp/ha/year)
- TC: Total Cost (Rp/ha/year)

3. Result and Discussion

3.1. Description of management and composition of plant species in agroforestry systems

3.1.1. Land preparation. In the agroforestry system of land preparation is the initial stage of agroforestrial management. Based on the results of the study by conducting interviews as many as 30 respondents, that all respondents do land preparation by clearing plants such as grass or shrubs and dead plants. At the time of land clearing, respondents use machetes or sickles to cut and clean grass or shrubs as well as dead plants that grow around the land, land preparation activities end with soil processing activities that are digging planting holes.

3.1.2. Seed source. Seedlings are one of the determinants of the success of crop cultivation. Cultivation of plants has actually begun since choosing good plant seeds, because seedlings are the main object that will be developed in the next cultivation process. In addition, seedlings are also a prospective crop that has undergone a seeding period, has been leafy or can already be planted in farmers' land. Based on the results of interviews from farmers, the origin of crop seeds used by farmers is they buy their own, but
some make their own and receive government assistance through the agriculture service and the local forest service.

3.1.3. **Planting.** The results of research in three villages showed that planting time by farmers is done at the beginning of the rainy season or at the end of the dry season on the grounds that plants get enough water during the rainy season. Breeding, planting holes and planting are the stages and methods of planting done by farmers obtained through generations in accordance with what their predecessors still applied to this day. The planting distance used by farmers varies depending on the type of crop they plant. For example in clove plants generally farmers use a planting distance of 6 m x 6 m and pepper 2 m x 2 m.

3.1.4. **Plant maintenance.** Plant maintenance is an effort to maintain and care for plants by fulfilling resources for their survival. Three resources for the survival of plants are water, nutrients in the soil and sunlight while crop protection is an effort or effort made by farmers to prevent crop destruction agents and treat crops from infection or damage due to attacks of plant destruction agents [8].

Maintenance for agricultural and forestry plant components is carried out after planting until the harvest of crops. Plant maintenance activities include several activities, namely plant watering, crop weeding, pruning, fertilization and pest and disease control. Plant cultivation is an activity carried out by farmers by fattening the soil around the stems of plants, so that the process of transportation of water, nutrients or nutrients can take place effectively, while weeding plants is the activity of plucking grass, shrubs or weeds that interfere around plants. Based on the interviews of all farmers in Jauh Pandang Village, Marannu, and Ale Lebbae conducted both activities, they used mechanical tools in the form of hoes, machetes or sickles and also performed manually by hand.

Pruning is the activity of removing unproductive branches, twigs or leaves. Pruning is done by using machetes on branches that are old, dead or growing too tightly with each other which is done once a year by farmers and if deemed necessary can be done more than once. Pruning is also done to provide light intake for plants that are under the shade so that growth can be maximized and prevent crop damage due to pests and diseases. Twigs or tree branches resulting from pruning can be used as firewood by farmers.

Fertilization is to add nutrients to the soil to adequately nutrients needed by plants. Fertilization is carried out to maintain crop durability, increase production and quality of yields and maintain high stable production. Like other crops, fertilization in general must be on time, the dose and type of fertilizer and the way of administration must be in accordance with the plants cultivated, in addition to fertilizing pest and disease control also needs to be done by farmers by using pesticides. Based on the interviews of farmers in research villages, fertilizers and pesticides used by farmers are different, fertilizers used are organic fertilizers, NPK, urea, SP, ZA, lime, KNO3, KCL, while the pesticides used are regen, alika, insecticidal, matador, and chloromit. The time of fertilization and spraying of pesticides is done two to three times a month, fertilizer administration is done by sowing fertilizer around the plant and pest control is done by spraying crop pesticides.

3.1.5. **Harvesting.** Harvesting activities carried out by farmers in Jauh Pandang Village, Marannu Village and Ale Lebbae Village are generally done alone or in cooperation with families, but there are also some farmers who hire workers to harvest. Harvesting time depends on the type of plant, for example in clove, durian, rambutan and langsat plants can be harvested once a year, while bananas, cocoa, and pepper are harvested twice or more in a year. The harvest is used directly by farmers to meet their needs. Harvesting is done by climbing, picking, picking and cutting.

3.2. **Description of type composition**

The composition of a type is a variation of the type of plant constituent a community. From the composition of this type can be known the main types of constituents of an establishment as well as types that are rarely found. The composition of plant species in each different area is taken by identifying
each type at the research site. Based on the results of identification shows that the composition of the species of pants found in the agroforestry system in the Village Jauh Pandang, Marannu, and Ale Lebbae District Pitumpanua Wajo district is as many as 13 species of pants. Judging from the constituent components, the agroforestry system applied in the respondent's land is agricultural [9].

3.3. **Agroforestry system productivity**

Productivity can be known after conducting cost, revenue and revenue analysis. Most products produced from a farm, consisting of more than one kind, for the analysis of the entire farm, the various products must be calculated or measured in one size. The value of the product is usually the most to state the various products produced in a farming business [10].

3.3.1. **Cost analysis.** Based on interviews conducted on 30 different respondents as a source of data to be studied at the research site, farmers obtained costs. Cost is money sacrificed or spent to carry out the distribution and production process. A goods or services if produced requires sacrifice in the form of costs to be paid. The fee is divided into two parts including fixed and non-fixed costs. Fixed costs include land taxes and tool shrinkage, while non-fixed costs include fertilizers and pesticides, as well as workers' wages.

The cost analysis can be seen in appendix 7 and details of land tax costs, tool depreciation, fertilizer costs and workers' wages can be seen in annexes 5 and 6. Here is an explanation of the costs incurred by farmers based on the area of land ownership owned by landowner farmers.

| Village          | Average Cost (Rp/ha/year) |
|------------------|---------------------------|
| Jauh Pandang     | 2,164,455                 |
| Marannu          | 1,776,533                 |
| Ale Lebbae       | 1,634,288                 |

Table 1 shows that the costs incurred by agroforestry farmers vary. These costs are derived from costs incurred for land taxes, shrinkage of tools, fertilizer and wages of workers. This research was conducted in three villages, namely Jauh Pandang Village, Marannu Village and Ale Lebbae Village. The average cost incurred by respondents in Remote Village amounted to Rp. 2,164,455/year. The average cost incurred by respondents in Marannu Village amounted to Rp. 1,776,533/year. And the average cost incurred by respondents in Ale Lebbae Village amounted to Rp. 1,634,288/year. The average cost incurred is the largest in Remote View Village. This is influenced by the use of fertilizers, where from these three villages the use of fertilizers and pesticides is very important for growth and increasing crop production.

3.3.2. **Revenue analysis.** Revenue analysis is analyzing all the results obtained by farmers during the year in managing their land where all proceeds can be assessed with money. Total farmer revenue is sourced from forestry and agricultural products. The revenue from forestry comes from the revenue of the value of wood, the price of wood per cubic meter multiplied by the number of trees in the plot and the annual average increment (MAI) obtained from the average volume (m³) divided by the age of the tree. Agricultural revenue are the product of between the selling price per unit and the amount of production produced. Here is the total revenue received by farmers based on the area of land ownership owned by landowner farmers.
**Table 2. Analysis of agroforestry farmer acceptance.**

| Village      | Average admission (Rp/ha/year) |
|--------------|--------------------------------|
| Jauh Pandang | 42,044,795                     |
| Marannu      | 33,191,867                     |
| Ale Lebbae   | 33,191,867                     |

Table 2 shows the average admissions received by farmers in the three research villages. The average revenue per ha per year of farmers is Rp. 35,220,697/ha/year from a total of Rp. 105,662,090/ha/year. In Remote Village, the average revenue obtained amounted to Rp. 42,044,795/ha/year, in Marannu Village the average revenue obtained amounted to Rp. 33,191,867/ha/year, and in Ale Lebbae Village the average revenue of respondents was Rp. 33,191,867/ha/year.

**3.3.3. Income analysis.** The value of income is derived from the difference in revenue with the costs incurred. This statement is supported by Soekartawi which states income is the difference between revenue and all costs [6]. Income obtained by farmers is a criterion to determine the success rate of businesses in running the production process. The results of the analysis of farmers' income at the research site can be seen in the following figure.

**Table 3. Analysis of income of agroforestry farmers.**

| Village      | Average income (Rp/ha/year) |
|--------------|-----------------------------|
| Jauh Pandang | 33,191,867                  |
| Marannu      | 33,191,867                  |
| Ale Lebbae   | 28,718,248                  |

Table 3 shows the total income of agroforestry farmers is Rp. 1,000,139,221/ha/year with an average of Rp. 33,337,974/ha/year. The average income obtained from Jauh Pandang Village amounted to Rp33,191,867/ha/year, from Marannu Village of Rp. 33,191,867/ha/year and Ale Lebbae Village amounted to Rp. 28,718,248/ha/year. Based on several studies related to the management of the agroforestry system the average income obtained by farmers including high and sufficient to meet the needs of farmers' daily lives.

The highest income obtained in Jauh Pandang Village is Rp. 39,880,341/ha/year. The difference in income in the three villages in Pitumpanua sub-district is more due to the intensification of land use, selection of types and number of crops. Crop maintenance factors such as pruning, fertilization and pest control also affect farmers' income because it can increase production. This is in line with Mahrizal et al. (2013) that pruning is done to provide a gap so that sunlight can enter so that air circulation occurs under the heading of plants. It can also reduce pest and disease attacks, form tree headers, maintain crops, and increase production [11].

**4. Conclusion**

Agroforestry system in three villages in Pitumpanua District, Wajo Regency provides sufficient income for farmers, agroforestry land can be maximized by applying regular planting patterns to make use of planting space to be more efficient. Productivity can be known after conducting cost, revenue and income analysis. Farmers' income in Jauh Pandang Village is higher at Rp. 39,880,341/ha/year, compared to marannu village farmers' income of Rp. 31,415,334/ha/year and farmers' income in Ale Lebbae Village is Rp. 28,718,248/ha/year.

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