Inventory and Evaluation of Agroforestry Systems in Laguboti District, Toba Regency, to Support Farmers' Income

Fitra Syawal Harahap[1,2], Rahmawaty Rahmawaty[1,3*], Abdul Rauf[1,4], Rahmanta Rahmanta[1,5]

[1]Natural Resources and Environmental Management Study Program, Postgraduate School, Universitas Sumatera Utara, North Sumatra Indonesia
[2]Agrotechnology Study Program, Faculty of Science and Technology, Labuhanbatu University, North Sumatra, Indonesia
[3]Forestry Study Program, Faculty of Forestry, Universitas Sumatera Utara, North Sumatra, Indonesia
[4]Agroecotechnology Study Program, Faculty of Agriculture, Universitas Sumatera Utara, North Sumatra Indonesia
[5]Agribusiness Study Program, Faculty of Agriculture, Universitas Sumatera Utara, North Sumatra, Indonesia
rahmawaty@usu.ac.id

Abstract. The agroforestry system is expected to optimize land productivity depending on how big the variation is. The methods observation methods in the field and interview methods to obtain information related to farmers' socio-economic data, types of filler plants, and land. Results: The agroforestry system owned by farmers in Laguboti District in Toba Regency predominantly applies the agrosilvopastoral, agroaquaforestry, and agrisilvicultural types to their land. The agroforestry system with the agrisilvicultural type provides the highest economic benefits compared to the agrosilvopastoral and agroaquaforestry types for farmers in Toba Regency, with income ranging from Rp. 4,387,500 to Rp. 1,875,000.

Keywords: Agroforestry system, economic benefits, land productivity, Toba Regency

1 Introduction

Planting models by mixing between perennials and seasonal crops in planting deliberately between trees and agricultural crops and/or livestock on the same land unit in various forms of mixing, and there must be real interactions, both ecological and economic (positive and negative) between woody and non-woody plant components, are referred to as agroforestry. The existence of forests is very important for living beings; their usefulness can be felt either directly or indirectly. Forest utilization needs to be maintained through good development and management to realize sustainable forest management to support the life and welfare of the community [1]. One way to

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realize sustainable forest management can be done with an agroforestry system. On the other hand, agroforestry can also be defined as a land use system (farming) that combines trees with agricultural crops to increase profits, both economically and environmentally. Agroforestry can be applied to marginal and critical land.

With the application of appropriate technology and management systems, such as agroforestry, the potential of the land can be increased to be more productive. One example of land that has been included in the critical category in Toba Regency is the Lake Toba catchment area (DTA) ecosystem. An area of 116,424 hectares, or 40% of the catchment area, is classified as critical. Toba Regency has an area of 202,180 ha, consisting of 16 sub-districts, 13 villages, and 231 villages. Based on its geographical location, Toba Regency is located between five districts, namely on the northern border with Simalungun Regency, the east with Labuhan Batu Regency, and Asahan; to the south, it is bordered by North Tapanuli Regency; and to the west, it is bordered by Samosir Regency. When viewed based on geographical conditions, Toba Regency is located at 2 °03' - 2° 40' LU and 98 °56' -99°40 BT and is located at an altitude of 900–2200 masl and classified as a wet climate where the temperature ranges from 170 °C–290 [2]. This condition causes a decrease in land productivity and limited resources for people's livelihoods.

Agroforestry systems are expected to optimize land productivity so that people can harvest their produce continuously, depending on how many variations of types are combined in one land and management system. The selection of the composition of plant species and how to manage them is very important in determining the success of this agroforestry system. Given the importance of data and information updates regarding the type of distribution of agroforestry, the contribution of agroforestry to community income, and the profitability of agroforestry commodities in Toba Regency, this study needs to be done. The results of this study are expected to provide data and information on Toba Regency government land development and agroforestry in the region of work in order to improve the economy, community, and forest sustainability.

The agroforestry system is expected to optimize land productivity so that the community can harvest the results continuously, depending on how much variation there is types combined in one land and their management system. Election of the composition of plant species and how to manage them are very important in determining the success of this agroforestry system. Reference [3] research states that agroforestry on marginal land supported by farmers, communities, and the government can increase people's income, as well as implementing agroforestry as an effort to rehabilitate critical land. Based on research from reference [4], agroforestry has various ecological functions, including providing a source of air and stopping erosion and landslides from trees managed on land. Reference [5] stated that agroforestry also has economic benefits in the long and short term. The combination of forestry components and agricultural components in intensive management is known as agroforestry, which can be beneficial for environmental sustainability and increase productivity with diverse crop yields.

2 Literature Review

2.1 Inventory and Evaluation of Agroforestry Systems

Agroforestry is a land use system that combines timber crops (trees) with food crops or livestock simultaneously and alternately in the same management and in which there is an ecological, social, and economic interaction. Agroforestry is a system of optimal land use based on environmental sustainability that involves cultivating or combining forestry and agricultural crops (plantations, livestock) so that it can improve the economy of farmers in rural areas [6]. Taking into account various definitions and practices of agroforestry, it can be concluded that agroforestry has two main functions. First, the socio-economics function, which is the human effort to meet social needs and their economy [7]. This involves the production of various products, such as forest products, food crops, livestock, and so on. Second, environmental function involves important components in agroforestry, which include hydrological function, ecological function, and conservation function [8]. This function involves provision of environmental services that can be measured using certain parameters. Agroforestry has a role in preventing soil erosion by protecting the land and canopy structure, stores groundwater reserves, and binds carbon to reduce greenhouse gas emissions, as well as providing habitat for conservation [9]. In addition, agroforestry can be applied in various land conditions, such as steep slopes, rocky land, marshy land, or even marginal land, where other land use systems are less suitable or inefficient [10]. Many studies have been conducted on farmers' decisions in planting and managing types of crops in agroforestry, as revealed in research conducted by reference [11, 12]. According to reference [11], farmers around Hutan Raya Wan Abdul Rachman must consider several factors in adopting agroforestry planting patterns, such as the economic value of the selected plant species, land ownership, availability of funds, and mastery of technology. On the other hand, reference [12] explained that agroforestry farmers in Bangladesh consider the factors of biophysical conditions and the socioeconomic value of crop types when making decisions about the selection of appropriate crop types and planting patterns.

2.2 Economic Value of Agroforestry

The income of agricultural enterprises can be calculated as the difference between income and expenses. Income is an increase in equity without additional capital contributions that occurs due to an increase in assets or a decrease in liabilities during a certain accounting period. In addition to economic benefits, the application of a mixed garden agroforestry system has a positive contribution to social and environmental aspects, as conveyed in reference [13] research in Arjowinangun village, Malang regency, in the field of land resources. The concept of agricultural area development is based on the concept of land evaluation. With this concept, utilizing land resources can be done optimally, purposefully, efficiently, and sustainably. The ratio of input and output in a production process over a period of time in a particular condition is known as productivity. Agricultural inputs and outputs have a significant impact on

productivity. Apart from productivity [14], agriculture is closely related to the socio-economic elements that surround it. Inputs from agriculture include labor, agricultural land, technology, and capital, while output from agriculture includes controlled agricultural products. The use of technology in this case is an economic variable [15]. Research related to the economic value and income of farmers from the agroforestry system has been carried out in several regions, as conducted by previous study with research related to income obtained from agroforestry, where agrosilvopastura management practices in Maluku provide benefits for improving the economy and welfare of farmers, with contributions from agrosilvopastura land of around Rp. 274,882,000 per year for farmers. It is known that the income from agrosilvopastura is higher in comparison with the implementation of ordinary farms. Previous study shows that community forests with agroforestry planting patterns can increase farmers' income by 5–12% and support food security by 12–19%.

3 Methodology

This study was conducted in Laguboti District, Toba Regency, North Sumatra Province in February 2023. The priority for selecting research land is to choose areas managed by farmers over the past one year. This includes both private community-owned agroforestry land and agroforestry land within the Social Forestry scheme, specifically Community Forest (HKM) areas. The map of the distribution of agroforestry research locations in Toba Regency is presented in Figure 1 below. The tools used in this research are stationery, books, and gadgets: hardware, namely a personal computer and a global positioning system, (GPS). Software such as Microsoft Word, Microsoft Excel, Statistical Products and Services Solutions (SPSS) and ArcGIS 10.8 are also used. Meanwhile, the materials used are calculation sheets and questionnaires. Interviews, and the SHP administrative map of Toba Regency Research began by conducting field surveys to obtain information about field conditions. Next, an inventory of composition of agroforestry by collecting land distribution point data agroforestry in the field, recording the constituent plants, and calculating the economic value of agroforestry. The stages of research activities are as follows: Data collection techniques, collection of data related to land that implements agroforestry systems conducted through field surveys and interviews with agroforestry farmers. To observe the structure of agroforestry applied, the descriptive method used with the aim of taking inventory of existing components in agroforestry land, including forest tree groups and plant groups annual, vegetable crop group, tree group/fruit crop/industry, livestock raising and fish farming on farm ponds owned by farmers.

Fig. 1. Administrative map of Toba regency, North Sumatra

Analysis of Agroforestry Income Farm analysis is designed to assess the costs of farming and the income received by the farmer's family based on the results of farming. The calculation below can be used to determine how much net income is received by farmers [16].

$$T = \sum_{i-1}^{n} yiPyi - \sum_{i=1}^{n} xiPxi \quad (1)$$

T = net income
yi = total commodity output to-*i*
Pyi = local price of commodity output to-*i*
x = number of inputs
Pxi = local price of the input

4 Findings

4.1 Inventory and Evaluation of Agroforestry Systems in Laguboti District

The results of the inventory and evaluation of land owned by agroforestry farmers in Laguboti District are presented in Table 1. The results of the table of existing land components can determine the type or classification of the farmer's agroforestry. Based on the results from Table 1, looking at the components that make up farmers' agroforestry land, it is known that of the 10 agroforestry farmers used as research samples, they apply 3 types or classifications of agroforestry on their land. Most farmers (five person) apply the agrisilvicultural type, while the remaining four and one farmers apply agrosilvopastoral and agroaquaforestry types respectively.

Table 1. Inventory and Evaluation of Agroforestry Systems in Laguboti District

No.	Farmer's Name	Forestry Plants/ MPTS	Annual Plants	Agricul-ture Plants	Cattle	Fish pond	Honey bee	Agroforestry Type
1	Sondang Sinaga	√	-	√	√	-	-	*Agrosilvopastoral*
2	Elim Simanjuntak	√		√	√	-	-	*Agrosilvopastoral*
3	Christina Siagian	√	-	√	√	-	-	*Agrosilvopastoral*
4	Biduan Sibarani	√	-	√	√	-	-	*Agrosilvopastoral*
5	Rafles Siabrani	√	-	√	-	-	-	*Agrisilvicultural*
6	Tolas Sitorus	√	√	√	-	-	-	*Agrisilvicultural*
7	Monang Manurung	√	√	√	-	-	-	*Agrisilvicultural*
8	Haris Simamora	√	-	-	-	√	-	*Agroaquaforestry*
9	Prawira Panjaitan	√	-	√	-	-	-	*Agrisilvicultural*
10	Ima Simanuntak	√	-	√	-	-	-	*Agrisilvicultural*

4.2 Analysis of Farmers' Income Levels from Agroforestry Land in Laguboti District

Agricultural business income refers to the amount of income received by farmers after deducting production costs incurred for activities such as purchasing seeds, fertilizer, equipment, labor wages, and other factors in one planting season. The income of agroforestry farmers in Laguboti District for 1 year of land cultivation can be seen in Table 2. From the results of Table 2, we can see the income of agroforestry farmers in Laguboti District for the last year, namely with the highest income from agrisilvicultural land owned by Mrs. Christina Siagian, amounting to Rp. 4,387,500, and the lowest income from Mr. Biduan Sibarani's land, amounting to Rp. 1,255,000. Of all farmers' incomes, it can also be seen that income from land using the agrisilvicultural type provides the highest economic value when compared to the other two types. Based on observations and interview results, it is known that this happens because in the application of this agrisilvicultural type, all the farmers' plants, both forestry and agricultural plants, are used as a whole. Meanwhile, in the agrosilvopastoral system, livestock on the farmer's land has not been utilized. This causes the income of farmers who apply the agrosilvopastoral type to be less than optimal. Meanwhile, farmers who implement the agroaquaforestry type only rely on their ponds as a source of income for forestry plants, MPTS plants, and agricultural plants that are only for family consumption.

Table 2. Agroforestry Farmers' Income Over the Last Year in Toba Regency

No	Farmer's Name	Type of Agroforestry	Expenditure (*Input*) (XiPxi)	Income (Rp) (YiPyi)	Income (Rp)
1	Sondang Sinaga	*Agrosilvopastoral*	-	1,875,000	1,875,000
2	Elim Simanjuntak	*Agrosilvopastoral*	-	2,675,000	2,675,000
3	Christina Siagian	*Agrosilvopastoral*	390,000	4,777,500	4,387,500
4	Biduan Sibarani	*Agrosilvopastoral*	-	1,255,000	1,255,000
5	Rafles Siabrani	*Agrisilvicultural*	550,000	2,650,000	2,100,000
6	Tolas Sitorus	*Agrisilvicultural*	600,000	3,550,000	2,950,000
7	Monang Manurung	*Agrisilvicultural*	-	2,675,000	2,675,000
8	Haris Simamora	*Agroaquaforestry*	600,000	3,250,000	2,650,000
9	Prawira Panjaitan	*Agrisilvicultural*	400,000	2,850,000	2,450,000
10	Ima Simanuntak	*Agrisilvicultural*	350,000	2,650,000	2,300,000

5 Discussion

Based on this inventory and evaluation, farmers in Laguboti District implemented different patterns or types on the land. In this case, the first step is to understand the difficulties and advantages of implementing agroforestry, a planting method that combines annual and perennial plants on one land at the same time, so the annual plants selected must tolerate shade, have high economic and ecological value, and of interest to farmers.

Based on the results of field observations and interviews conducted, it is known that in their land use, respondents apply types of diverse agroforestry with various constituent components, so that on his land, economic, ecological, and social interactions are formed.

This matter is in accordance with the statement made by reference [10], who explains that economic, ecological, and social interactions in the system Agroforestry occurs through land use with various technologies. involving annual plants and livestock simultaneously or alternately at a certain time.

The goal of this system is to improve the quality of land productivity amidst the limited land owned by farmers agroforestry in an area. In adopting an agroforestry system, apart from providing benefits, quite a lot for farmers, and of course there will also be weaknesses in the system. this agroforestry. Therefore, its application must be considered, in which system. This is suitable for application on marginal land. Marginal land is a type of land that has low quality because there are several limiting factors. its use for a specific purpose. However, limiting factors that exist can be overcome by using additional inputs and incurring extra cost, one of which is the implementation of agroforestry. This is supported by a statement from previous study, which states that the nature of the land is the main priority in developing agroforestry, so that it can have a good impact.

Based on the data, this happened because in the last year farmers did not plant additional plant seeds on the land, and in the last year they did not carry out fertilization and herbicide spraying. So, there is no expense for purchasing these materials. There is also no expenditure for labor costs because there are workers in the family. However, in selecting plant types, apart from considering their economic value, their ecological value also needs to be considered. This is in accordance with the statement from reference [17,18] which states that the type of plant is one of the factors that influences income, where the more types of plants cultivated, the income earned also tends to be higher. For the results or output from farmers' agroforestry land, each land Of course, they each have their own main plants. However, from interviews conducted with landowners, it was discovered that not all plants were planted. The main crop on the land provides the largest yield or output due to certain reasons, such as the main plant being less fertile in its growth. and the main crops are not used for sale to generate income. The largest can come from existing companion plants. Therefore, it is important to create a balanced composition of agroforestry plants on land, so as to maintain ecosystem balance and at the same time increase farmer income.

6 Conclusion & Recommendations

Results The agroforestry system, with 10 observation fields owned by farmers in Laguboti District in Toba Regency, predominantly applies agrosilvopastoral, agroaquaforestry, and agrisilvicultural types to their land.

The agroforestry system with the agrisilvicultural type provides the highest economic benefits compared to the agrosilvopastoral and agroaquaforestry types for farmers in Toba Regency, with income ranging from Rp. 4,387,500 to Rp. 1,875,000 for one year, where farming experience and the education level of agroforestry farmers simultaneously influence the income level of agroforestry farmers in Toba Regency.

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