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Ethnoecologist and Land Management of Durian Plants under The Agroforestry System

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ABSTRACT

Ethnoecology is a science that studies the relationship between humans and the environment. This relationship is related to the use of natural resources around them to continue life using local wisdom, namely the agroforestry system. Ecologically, economically, and socially, the agroforestry system planting patterns can help reduce soil fertility degradation due to human activities that exceed the carrying capacity of the land. The aim of the research was to determine land management and manifestations of land management for durian plants that implement the agroforestry system. The research used qualitative methods with techniques namely collecting data, analyzing data, and drawing conclusions. Data collection used snowball sampling techniques. The results explain that (1) land management, tillage, fertilization, crop rotation, and fallow periods on durian plantations have not been managed optimally, resulting in the production of durian plants not being optimal; (2) the manifestation of land management is divided into two, namely traditional and semi-traditional agroforestry systems and these two systems have differences in land management, namely organic and non-organic.

Keywords: agroforestry systems, durian, ethnoecology, land management

INTRODUCTION

Ethnoecology is the study of how humans interact with their surroundings (Moñivas 2023). This study allows us to understand the interaction between humans and nature, whether we utilize nature to meet the requirements of endless life or to follow the laws of sustainability. Humans are adapting, restraining, and conquering nature by using their energy and science to preserve human existence (Weiskopf *et al*. 2020; Vandebroek *et al*. 2020; Sharma *et al*. 2020; Hurrell *et al*. 2019). Such ethnoecological knowledge can take the form of exploitation of natural resources without tolerance, which has an impact on human survival in the form of declining crop production that is not proportional to the production costs incurred to maximize the remaining natural resources that have been lost (Zhao *et al*. 2022).

System agroforestry is one of the choices for managing land and minimizing land degradation (Wang 2022; Ghorbani *et al*. 2021). Agroforestry is a land use strategy that includes both woody and non-woody plants, as well as horticultural species used as intercropping plants alongside staple crops. In some agroforestry systems, animals or cattle develop ecological and economic interactions with woody plants and other components (Huxley 1999). There are numerous agroforestry practices, including yard agroforestry and *tegalan* (garden not irrigated field near the rice fields but used for vegetables and other secondary crops). Yard agroforestry has a wider variety of plants since it is managed with fruit plants that may be gathered year after year to fulfill household needs. This method connects the house and the community to agriculture, allowing it to meet farmers' basic needs in the form of vegetables, medicines, and livestock, increasing farmers' revenue while they wait for the main crop to be produced (Gbedomon 2016). Farmers benefit from this condition because diverse ecosystems can provide many social and environmental benefits, such as ecosystem services that protect plants from pests and diseases while also maintaining soil fertility, water retention, and pollination (Norfolk 2013). According to Simon (2010), if the yard is part of the home, the garden (*tegalan*) is positioned a bit further out from the house and has a variety of tree species as well as bushes or grass that are typical of the garden.

Agroforestry in yards and gardens typically includes commercial staple plants and fruit trees. One of them combines tree and fruit trees with durian (*Durio zibethinus*) plants. Durian farming is regarded successful since the fruit is popular among the population, the price is reasonable, and farmers benefit

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considerably from durian cultivation. It is worth noting that the growth of durian production land in Indonesia has accelerated in recent years. From 2019 to 2022, Indonesia's durian production land area increased by an average of 1.713 tons in 2022 and 1.169 tons in 2019. Production was low during that period since durian had not yet been planted on a wide scale, only on garden and *tegalan* that were not yet commercially viable. As a result, the current average annual production increase was 13.58% (Ministry of Agriculture 2022). This indicates a sustained trend of increased production in the coming period.

Four villages (Papualangi, Cempaka Putih, Limbato, Atinggola) in Tolingula District and Atingola District are four communities on the slopes of Mount Polontalo that use the *tegalan* agroforestry system and yards. They have long practiced durian cultivation using local durian types combined with various types of plantation plants in an intercropping system with food crops, but for the past 20 years, they have been intensively cultivating imported durians with Mushaking and Monthong durian types, which are said to have a high selling value. Even though they have planted durian, the four villages have not established themselves as durian producing sites, despite being the primary supply of durian in the Gorontalo region. To find out, ethnoecology research was undertaken on local farmers and techniques of land management such as land clearing, upkeep, and crop rotation. This study is considered necessary because the practice of planting durian in the location has not fully implemented an intercropping agroforestry system, either food crops or medicinal plants, which can help increase biodiversity and be beneficial for soil fertility, prevent soil erosion, maintain soil moisture, and provide space for predatory insects to grow and develop, destroying pests that destroy durian fruits.

METHODS

This is a qualitative study, which consists of multiple stages beginning with the collection of information or data, followed by data reduction, data presentation, and conclusion drawing. The study was conducted from August 2021 to January 2022, in the villages of Papualangi, Cempaka Putih, Limbato, Atinggola, in Tolingula District and Atingola District, North Gorontalo Regency, Gorontalo Province. The rationale for selecting the area as the research site was that the local community has been so consistent in cultivating durian plants from the past till now, and it has become the area's key characteristic as the primary producer of durian.

This study was conducted in two stages: first, disclosing the community's ethnoecology in managing durian plantation land, and second, identifying modes of land management based on ethnoecology applied to the agroforestry system. Unlimited in-depth interviews with respondents were conducted utilizing the snowball sampling technique until satisfactory findings were obtained, with six people serving as key informants, particularly community leaders. Data collection also employs observation methods, with each activity documented in the form of photographs. The data analysis employs procedures provided by Miles and Huberman, including data reduction, data presentation, conclusion, and verification.

RESULTS AND DISCUSSION

Ethnoecology of durian farming communities about durian plantation land management

In-depth interviews with durian farmers and various informants in four villages in the region revealed that they were familiar with durian land management, which included six activities: land clearing, soil tillage, weeding, fertilization, crop rotation, and the fallow period. They handle two types of garden land: garden and house yard. Gardens or fields for the local community are areas behind the settlement where various types of commercial plants can be grown. The plantations that are handled are those that have been abandoned for a long period, and they are replanted with food crops and commercial local crops known as gardens or *kobong*. There were two types of durian planting patterns: mixed and monoculture patterns.

On the traditional agroforestry system, the land was planted with a variety of woody crops, including cocoa, durian, various fruits, and food crops including corn, vegetables, and tubers. Their planting path model takes three forms: a rowed (lined) planting system in the field, lined up along the edge like a garden fence, and randomized. When there was no tree or other plant impediment preventing the parent plant from growing, the rowed model was utilized; otherwise, a random model was used. The random model was carried out by placing durian trees amid other plants and weeding around them. Meanwhile, if the garden was overgrown with intercropping plants, the planting model on the garden's edge may resemble a fence. For the monoculture model, numerous gardens may be found in the yard of the house, and local farmers should plant the yard garden with one type of plant, namely durian, to make it easy to regulate and beautify the yard without shrubs. Imported durian varieties were planted at a 10-m spacing, with no empty space between each plant because they are concerned that the durian will not produce optimal fruit.

- **Land clearing**

There were two methods of land clearing: pruning the grass and spraying the grass with chemicals, specifically herbicides. Mowing the grass was done using a lawn mower or using machete as a grass mower to clean the shrubs. Figure 1 depicts the land

clearing model, which involves spraying grass with a chemical sprayer. Farmers typically used grass spraying on land that has a monoculture planting system for ease of management and to avoid harming other plants because it only considers the safety of one type of plant.

The cleaning process was completed by burning any residual grass that has dried up or has clumped together with the soil to serve as soil mulch. Durian farmers' soil tillage activities did not include land plowing or dredging because the trees planted were classed as plantation crops and not food crops such as corn, bananas, and tubers, which do not require soil treatment. Therefore, farmers merely tilled the ground surface to prepare planting space, removed weeds, enhanced air circulation, and increased the soil's ability for water absorption.

- **Weeding**

Monoculture plants were treated with chemical insecticides. Local farmers knew how to weed by cleansing the land of weeds that stick to trees or plants, which they keep under control by cutting weeds and applying pesticides. According to farmers, weeds could limit the growth of the plants they maintain, resulting in crop loss, hence weeding was required to achieve high crop yield. Farming operations were always carried out routinely when walking around the garden to monitor the development of the major crops and eradicate any potential weeds that may arise.

- **Fertilization**

Local farmers understood two types of plant fertilization: organic fertilizers (natural) and inorganic fertilizers (chemical). Farmers acquired organic fertilizer by following two steps: mixing the livestock manure with straw that has been combined and fertilized for one month, then mixing in the soil that has been loosened, planted, and then mixed again on the soil surface until equally dispersed. While the second approach involved leaving grass that has been hoed, cut, or flattened on the soil surface until it coalesces and decomposes into soil, transforming it into natural fertilizer. This method can also serve as soil mulch, retaining soil moisture and preventing erosion. This natural fertilizing method was used before planting and keeping plants. While fertilization used inorganic fertilizers (chemical), farmers used them when the plants were 10−14 days old after planting if planting corn with urea and then 30−35 days old again using

Table 1 Ethnoecological activities of durian farmers with agroforestry system

Land management	Tools and materials	
	Mixture	Monoculture
Clearing	Machete, mattock, lawn mower	Lawn sprayer and pest eradicator (chemical pesticides)
Weeding	Trimming (machete)	Spraying pesticides
Fertilization	Natural fertilizers (leaves and twigs)	Chemical fertilizers
Plant rotation	Nuts, vegetables, lemongrass, turmeric, ginger, basil	-
Fallow system	Untreated, allowed to grow grass	-

Figure 1 Land preparation by clearing the land using grass spraying using chemicals.

nitrogen and phosphate fertilizers. Intensive fertilization treatment was only carried out on certain types of plants, not on other crops such as bananas and fruit plants.

- **Plant Rotation**

Plant rotation occurred in the mixed crop, including corn, tomatoes, chilies, peanuts, corn, sweet potatoes, vegetables, and medicine plants such as lemongrass, ginger, turmeric, and basil. (Figure 2). Monoculture plantation (Figure 3) was left without rotation of plants under the tree, resulting in an open and clean landscape free of shrubs and grasses.

- **Fallow System**

In mixed crops, the fallow system was left on the farmland, meaning that the soil was allowed to rest before being rotated with different sorts of plants from the previous crop (Figure 4). If they did not have the funds to manage the land, it was temporarily cleared while they waited for planting season. There were monoculture plants that did not exist in the fallow

Figure 2 Intercropping system with durian plants.

Figure 3 Land use and management with one type of plant on a plot of land.

Figure 4 Land use and fallow system.

system; nonetheless, if the soil became overgrown with grass, chemical herbicides were quickly sprayed.

Manifestations of Land Management of Agroforestry Systems

The types of plants and their management models could be used to identify the many forms of land management observed in agroforestry systems, as shown in Table 2. Traditional agroforestry and semi-agroforestry were the two agroforestry land management models encountered. Traditional agroforestry system activities took place in farmers' gardens, and the management approach was still limited to the use of subsistence for home requirements and is not yet economically oriented. Therefore, the varieties of plants and their management were similarly limited when employing organic matter. These plants were also commercially accessible, although eco-friendly maintenance remains the norm. Traditional agroforestry systems commonly included plants such as coconuts, cloves, cacao, avocados, oranges, durian, bananas, corn, and kidney beans. These plants were found on farmers' garden land located behind the village, with land management using a grass mower or a machete to eradicate weeds. However, on traditional agroforestry system land, farmers did not use chemical grass eradicator because they were concerned about the spray results hitting sensitive clove plants (Figure 5).

Semi-traditional agroforestry was found in

Table 2 Manifestations of land management based on plant type classification

(A)	**Land management tools and materials**	**Fertilization**	**Planting pattern**
Traditional agroforestry 1 Nantu 2 Local durian 3 Corn 4 Banana 5 Ginger 6 Turmeric 7 Lemongrass 8 Clove 9 Coconut	1. Manchette 2. Mattock, 3. Grass mower	Natural fertilizer (leaves and twigs) left to accumulate on the ground	Random and dense
(B)	1. Grass mower 2. Pesticide sprayer	Chemical fertilizer	Random and spaced
Semi-traditional agroforestry 1. Nantu 2. Teak 3. Local durian 4. Monthong 5. Clove 6. Banana 7. Corn 8. Ginger 9. Turmeric			

Ethnoecologist ↑

Non ethnoecologist →

Figure 5 Traditional agroforestry forms.

commercially oriented garden land to maximize land usage with various sorts of plants such as teak wood, native durian, imported durian, cloves, bananas, corn, ginger, and lemon grass. In traditional agroforestry, the planting pattern was random and irregular, like an artificial forest. It was discovered that land management has adopted equipment that was time-efficient and simple to operate, such as spraying grass with insecticides and rarely utilizing machetes for land clearance chores. Soil maintenance with chemical fertilizers was carried out in this type since the usage of semi-traditional model land was economically oriented, thus management likewise follows the acceleration of growth, resulting in speedy output results.

The following plant classification indicates how traditional agroforestry based on plant types in figure A aligns with the ethnoecological field, namely in terms of land clearing, plant type selection, and maintenance that prioritizes ethnoecological principles. There were numerous types of plants that could not be treated with chemicals because, according to farmers, plants in traditional agroforestry have a rather thick crop density, making it impossible to spray the field because it could harm sensitive plants such as cloves. As a result, farmers maintain their ethnoecological expertise to avoid causing harm to other crops. While in the classification of plants, point B focuses less on natural processes, such as land clearing, maintenance, plant type selection, and the use of chemicals, because in a modern semi-agroforestry system, the type of plant has commercial criteria. Hence, farmers tend to use instant products to stimulate plant growth so that production is quick. Meanwhile, no other plants were found in the garden other than the durian plant, implying that the modern garden is a monoculture that is more commercially focused than sustaining the ecology around it.

Ethnoecological Analysis of Durian Plantation Management by Implementing an Agroforestry System

The function of ethnoecology in farming through the traditional agroforestry system focuses on the integration of diverse crops while considering local ecological conditions and indigenous knowledge (Southern *et al*. 2023; Hemel *et al*. 2024). This system has been maintained by residents until today by preserving biodiversity and adapting naturally (Prastiyo *et al*. 2020), resulting in ecological balance, stability, and land production (Jumiyati *et al*. 2020; Murti 2020; Khan *et al*. 2021). The use of straw, leaves, and twigs left to settle on the ground is a technique for organically increasing the amount of nutrients in the soil without spending money on land management and plant upkeep (Kaya 2013; Pane *et al*. 2014; Raj *et al*. 2022; Gupta *et al*. 2023).

Controlling weeds and pests on garden land with non-chemical techniques and materials will significantly help to ecological improvement and stability, while also preventing the emergence of new species that may harm durian plants. This ecological stability can help repel a swarm of fruit flies that destroy potential durian fruits via the sort of plant that smells bad. There are numerous varieties of intercropping plants in the form of spices, such as lemongrass. Basil leaves have a distinct odor and contain chemical components that operate as natural repellents (pesticides). This chemical has a strong odor and repels mosquitoes, ants, aphids, and fruit flies (Kedar *et al*. 2023; Desmiwati *et al*. 2021; Pratiwi and Suzuki 2019).

However, this differs from land management that uses chemicals in traditional semi-agroforestry plants that have used modern technology, in which land management is more concerned with plant productivity and ignores ecological functions, resulting in increased production costs, plant maintenance, and management (Pahalvi *et al*. 2021). According to Sulaeman and Erfandi (2017), to reduce the production cost of land management by using chemicals, such as weed spraying and non-organic fertilizers, the practice of land management and plant maintenance using chemical and organic materials must be combined to achieve plant production.

Durian farmers have used the traditional agroforestry planting pattern for a long time, and it has proven to be effective in meeting needs. Farmers' trust and confidence in optimizing land with varied crops is due to its multifaceted benefits, which include economic benefits, environmental benefits, erosion prevention, carbon providers, and soil conservation. According to Fahad *et al*. (2022), agroforestry is ecologically useful in reducing erosion, while Staton *et al*. (2022) stated that agroforestry is beneficial for increasing farmers' economies. The diversity of these plant species creates a more diverse ecology, which promotes soil health and contributes to durian crop yield. In contrast, monoculture plants, which consist of only one variety of plants, do not produce biodiversity.

Traditional semi-agroforestry is like traditional agroforestry in terms of maintaining ecological balance, even though the application and goal are different. In this approach, implementation is more planned and has more aims for increasing crop output and sustaining the economy. Traditional semi-agroforestry-based land management differs from traditional agroforestry in that crop selection planning is more intensive (Wattie and Sukendah 2023), and the latest technology in management is used, such as grass pruning and fertilization. This method necessitates appropriate field planning and management to avoid harming farmers. The usage of cutting-edge technology, such as chemical-based products, must be considered and cooperated with natural products. Land management that promotes the principle of sustainability will reap major long-term advantages in ensuring agricultural output sustainability (Tschora and Cherubini 2020).

CONCLUSION

Land management has not been maximized in the form of land clearing, tillage, weeding, fertilization, crop rotation, and the fallow period in the management of durian crop land, resulting in suboptimal durian crop yield. Land management manifested itself in the form of traditional agroforestry systems and traditional semi-agroforestry systems, both of which have distinct land management characteristics. In the traditional agroforestry system, organic management was used, however in the semi-agroforestry system, it was not.

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