



Spatial Distribution of Coffee-Based Agroforestry Lands in the Buffer Area of Bromo Tengger Semeru National Park (BTSNP)

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Abstract. Indonesia is a country that has high biodiversity. Deforestation in some areas causes habitat loss, damage/degradation, and fragmentation, which leads to a decline in biodiversity. A landscape-based approach is needed to address these problems. This approach seeks to facilitate multiple interests in managing areas at a landscape scale. This study aimed to analyze the spatial distribution along the corridor of coffee-based agroforestry in the buffer zone of BTSNP East Java. This research was conducted in January-December 2021 in the buffer village area of BTSNP in Poncokusumo (Sumberejo) and Wajak (Patokpicis and Bambang) Districts of Malang Regency, which is directly adjacent to BTSNP. This research was conducted utilizing a preliminary survey, identifying and analyzing the distribution of coffee based on agroforestry land along the corridor in the buffer zone of BTSNP with QGIS 3.26.3. Distribution of coffee plantations was analyzed based on the type of coffee and stood in the three buffer zones of BTSNP. The results of this study indicate that there are five types of coffee found, and the distribution between regions has different compositions and types of stands. Differences in land space provide other profiles of coffee types and frames.

Keywords: Coffee · Agroforestry · Landscape · BTSNP

1 Introduction

Indonesia is a country that has high biodiversity, so it is dubbed a mega-diversity country. Deforestation in some areas causes habitat loss, damage/degradation, and fragmentation, which leads to a decline in biodiversity. Several parties have made various efforts to minimize deforestation but have yet to show optimal results. Currently, most of the conservation and protected areas are experiencing fragmentation, so habitat connectivity both within and between areas is disrupted, causing a decline in biodiversity [1–4]. One area that has a very high and unique biodiversity is the Bromo Tengger Semeru National Park (BTSNP) in East Java. The BTSNP area stretches from the northern part of the Tengger plateau, Mount Bromo, and Mount Semeru in the south, which includes three

districts, namely, Malang, Pasuruan, Probolinggo, and Lumajang. BTSNP is a nature-based area for research and development, recreation, education/science, camping, and others. Visitors to this area come from domestic and international tourists [5, 6].

The preservation of the BTSNP area and the efforts to conserve biodiversity in BTSNP cannot be separated from the surrounding rural areas, especially in Malang district covering the sub-districts of Poncokusumo, Wajak, Jabung, Tirtoyudo, Dampit, and Ampelgading. Rural areas directly adjacent to BTSNP and Perhutani are an inseparable part of the buffer zone. The buffer zone in BTSNP is unique regarding vegetation, elevation, and soil topography [7, 8]. Pandansari and Sumberejo are villages located in the buffer zone of Bromo Tengger Semeru National Park; the two villages have a significant role in supporting biodiversity conservation and the local economy in developing home garden-based tourism [9].

However, in recent years several areas, especially in rural areas directly adjacent to BTSNP, have experienced a lot of land use change in their management and the existence of sand mining which will pose an indirect threat to the biodiversity conditions that exist in BTSNP. The impacts include land degradation, deforestation, forest clearing for agricultural land conversion and sand mining, as well as global climate change, which has an effect on the agricultural productivity of the surrounding community and will also directly have a potential impact on the threat of biodiversity in conservation areas [10–12].

The limited agricultural land encourages the community/farmers to open new ground in the forest area by cutting and dismantling forest plants and burning the remains of plants and shrubs, resulting in critical land. One effort to overcome this problem is by applying a coffee-based agroforestry system. Farmers have practiced coffee-based agroforestry in various regions in Indonesia, including in West Lampung (community forest and village forest patterns), West Java, and Central Java (with community forest management patterns) [13]. The application of agroforestry is one form that can be carried out in the National Park's buffer zone. This system can be essential in providing animal feed, soil fertility, and vegetation diversity [14]. A landscape-based approach is needed to address these problems. This approach seeks to facilitate multiple interests in managing areas at a landscape scale. But on the other hand, many people still do not know the nature of the landscape and its relation to biodiversity conservation [4]. Activities that can be done to overcome the above problems are to carry out Area Restoration based on an agroforestry system.

The community has started to develop agroforestry systems; for example, the Tenggerese people adopted an agroforestry system by planting *Toona sureni*, *Melia azedarach*, *Bambusa* sp., *Gigantochloa* sp., *Swietenia mahagoni*, *Albizia falcata*, and *C. junghuhni-ana* trees in their gardens [15]. Coffee-based agroforestry in several areas in Indonesia has been carried out by farmers, including West Lampung (in the form of community forests and village forests), West Java, and Central Java (community-based forest management). Agroforestry systems can also increase the abundance and diversity of soil invertebrates [16]. The application of the agroforestry system in several areas faces several obstacles, namely: (1) the level of knowledge of farmers is still low in cultivating

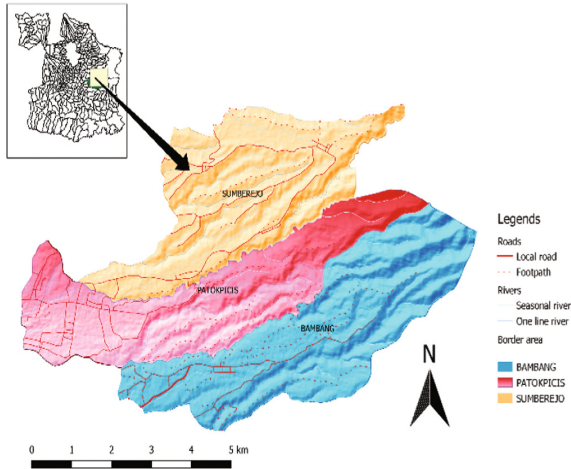


Fig. 1. Map of the research study along the corridor of coffee-based agroforestry land in the buffer area of Bromo Tengger Semeru National Park (BTSNP).

coffee-based agroforestry, (2) lack of business capital, and (3) uncertainty of land ownership status [13] and also influenced by people's behavior [14]. Agroforestry systems could be more efficient if applied in a vast scale area [17].

Only a few studies have been conducted to assess and evaluate such opportunities; leading data and information on agroforestry development in rural environments still need to be undertaken. In such a case, identifying causes of land degradation has been considered essential to design a proper approach to land management [18]. Therefore, a more in-depth study is needed in managing an area, especially a buffer zone (village directly adjacent to BTSNP), to obtain an area restoration strategy based on agroforestry coffee-based in the BTSNP buffer area by integrating aspects of the regional landscape.

2 Methodology

2.1 Study Sites

This research was conducted in January-August 2022 in the BTSNP buffer village area in Poncokusumo (Sumberejo) and Wajak (Patokpicis and Bambang) Subdistricts, Malang Regency, which is directly adjacent to BTSNP (Fig. 1). Maps are made and analyzed at the Laboratory of Geographic Information Systems, Department of Soil, Faculty of Agriculture, Universitas Brawijaya.

2.2 Methods

A field survey was conducted in January-August 2022 to inventory the coffee plantation site present along the corridor of Sumberejo, Patokpicis, and Bambang subdistrict, Malang, East Java, Indonesia, exploratively. Direct identifications were subjected to recognize well-known species of coffee, and GPS marking was carried out on the location

points found to obtain coordinates of the location of coffee plantations. The data on the location points of the coffee plantations include the type of coffee and the type of stand. The data is made in a shapefile to be input in a GIS application (QGIS software 3.26.3.) so that a shapefile is obtained in the form of points. Then the data is overlaid with map data of the study area to become a profile map of the distribution of coffee plantations obtained along the corridor of Coffee-Based Agroforestry Land in the Buffer Area of Bromo Tengger Semeru National Park (BTSNP).

3 Result and Discussion

Based on the results of the study, the distribution of coffee plantations along the corridor of Coffee-Based Agroforestry Land in the Buffer Area of Bromo Tengger Semeru National Park (BTSNP) at Sumberrejo village was found to be 19 points, Patokpicis village 12 points and Bambang village 25 points (Fig. 2).

The results above show that Bambang village has more coffee plantations along the corridor, while Patokpicis has the fewest coffee plantations than other areas. Based on the type of coffee planted, there are five types of coffee, namely: *Coffea arabica*, *Coffea liberica*, *Coffea robusta*, *Coffea robusta* (Lancur), and *Coffea robusta* (Pruning), while the types of stands in the coffee plantation are two types, namely polyculture and monoculture.

Distribution of coffee plantations in Sumberrejo village (Table 1) there are five types of coffee grown with nine variations in the composition of coffee species and varieties of polyculture and monoculture stands. Types of *Coffea arabica* with a monoculture system and *Coffea robusta* (lancur) with a polyculture system were the most found in this location, each in 5 areas. The composition of the coffee species *Coffea robusta* (Lancur), *Coffea arabica* with monoculture system and *Coffea robusta* (Lancur), *Coffea liberica* with polyculture system each found 2 locations. While the blend (*Coffea liberica*-*Coffea*

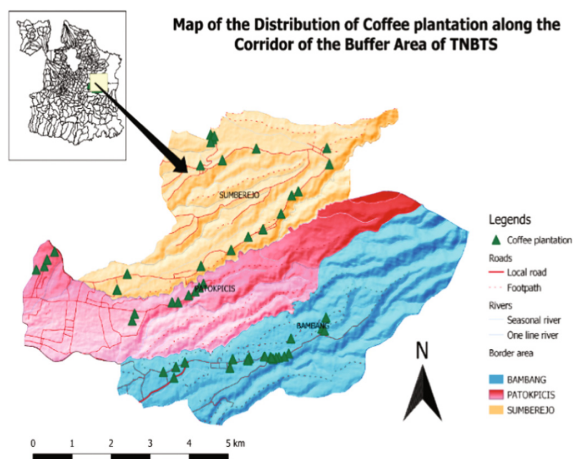


Fig. 2. Distribution of coffee plantations along the corridor of Coffee-Based Agroforestry Land in the Buffer Area of Bromo Tengger Semeru National Park (BTSNP).

robusta) with a polyculture system, *Coffea robusta* (Pruning) with a polyculture system, *Coffea robusta* (Pruning), blend (*Coffea liberica-Coffea robusta*) with a monoculture system, *Coffea robusta* (Pruning), blend (*Coffea liberica-Coffea robusta*), *Coffea arabica* with monoculture system; and *Coffea robusta* (Pruning), *Coffea robusta* (Lancur), *Coffea arabica* with polyculture system each found in 1 location.

The distribution of coffee plantations in the village of Patokpicis (Table 2) there are three types of coffee grown with two variations in the composition of coffee species and the kind of stand polyculture and monoculture. The type of *Coffea robusta* (Lancur) with the most polyculture system was found at this location as many as 9 locations. While the composition blend (*Coffea liberica-Coffea robusta*) with a monoculture system of 3 areas.

In the distribution of coffee plantations in Bambang village (Table 3), there are two types of coffee grown with three variations in the composition of coffee types and types of stands. *Coffea robusta* (pruning) was found in as many as 19 locations with the most polyculture system. While the composition of *Coffea robusta* (Lancur) with a polyculture system and *Coffea robusta* (Pruning) with a monoculture system of 3 areas each.

Table 1. Distribution of coffee plantations by type and type of stands found in Sumberrejo village, Malang

The type of coffee	The type of stand	Sum of the stand
<i>Coffea Arabica</i>	Monoculture	5
Blend (<i>Coffea liberica-Coffea robusta</i>)	Polyculture	1
<i>Coffea robusta</i> (Lancur)	Polyculture	5
<i>Coffea robusta</i> (Lancur), <i>Coffea Arabica</i>	Monoculture	2
<i>Coffea robusta</i> (Lancur), <i>Coffea liberica</i>	Polyculture	2
<i>Coffea robusta</i> (Pruning)	Polyculture	1
<i>Coffea robusta</i> (Pruning), Blend (<i>Coffea liberica-Coffea robusta</i>)	Monoculture	1
<i>Coffea robusta</i> (Pruning), Blend (<i>Coffea liberica-Coffea robusta</i>), <i>Coffea Arabica</i>	Monoculture	1
<i>Coffea robusta</i> (Pruning), <i>Coffea robusta</i> (Lancur), <i>Coffea Arabica</i>	Polyculture	1

Table 2. Distribution of coffee plantations based on the type and type of stands found in the village of Patokpicis Malang

Type of coffee	Type of stand	Sum of the stand
<i>Coffea robusta</i> (Lancur)	Polyculture	9
Blend (<i>Coffea liberica-Coffea robusta</i>)	Monoculture	3

Table 3. Distribution of coffee plantations based on the type and type of stands found in the village of Bambang Malang

The type of coffee	The type of stand	Sum of the stand
<i>Coffea robusta</i> (Lancur)	Polyculture	3
<i>Coffea robusta</i> (Pruning)	Polyculture	19
<i>Coffea robusta</i> (Pruning)	Monoculture	3

The profiles of coffee plantations in different locations have different characters of the three villages that have variations in the composition, Sumbererejo village compared to other areas. This is possible because of supporting factors such as biodiversity, economic aspects, and social support for the existence of coffee plantations. To increase the contribution of agricultural land in rural biodiversity conservation to the economy and parks, encouraging coffee-based agroforestry and agro-tourism are essential [18]. Applying the coffee agroforestry system with a polyculture system shows that the community is concerned with the conservation and value of biodiversity following research [20] which states that coffee agroforestry can help solve the problem of biodiversity conservation and ecosystem services.

4 Conclusions

This research was conducted utilizing a preliminary survey, identifying and analyzing the distribution of coffee based on agroforestry land along the corridor in the buffer zone of BTSNP with QGIS 3.26.3. The distribution of coffee plantations was analyzed based on the type of coffee and stood in the three buffer zones of BTSNP. The results of this study indicate that there are five types of coffee found, and the distribution between regions has different compositions and types of stands. Differences in land space provide other profiles of coffee types and frames.

Acknowledgments. Financial support from the Indonesian Endowment Fund for Education/Lembaga Pengelola Dana Pendidikan (LPDP) is gratefully acknowledged.

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