Sustainability and lives of coffee farmers in Magetan Regency, East Java, Indonesia

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Abstract. The lack of knowledge of farmers about efforts to manage coffee plantations with environmental and conservation views is believed to have the effects of microclimate change which are likely to impact coffee farmers in the future. The purpose of the research is to (1) identify ecological aspects on the sustainability of coffee cultivation patterns in the Magetan region, (2) find ecological factors on coffee production, and (3) describe the lives of coffee farmers related to ecological aspects. The research method was carried out by *a multistage sampling method* starting from the determination of subdistricts, villages, farmer groups, farmer group members, and coffee farmer samples. The data used are primary data, with a method of collecting direct survey data on 80 coffee farmers randomly in two districts of Panekan and Poncol. An analysis method to see the relationship of environmental variables to coffee production with multiple linear regression analysis and descriptive analysis for ecological aspects. he results showed that the ecological factors significantly affecting coffee production included the number of protective trees, the application of manure, and farmers' knowledge of conservation practices. Conversely, pruning and the eradication of coffee borer pests were found to have an insignificant impact. The study concludes that while efforts toward coffee sustainability have been initiated by farmers, they have not yet achieved full success. Sustainability efforts include protecting the environment through the use of manure, planting shade trees, and adopting conservation-oriented coffee cultivation practices.

Keyword: coffee, preservation, conservation farming, the lives of farmers

1 Introduction

The dominant factor in sustainability is the vulnerability of the region to climate change. The growing population in the cultivation area has an impact on the extension of coffee land, which is marked by land clearing and a 1,56% increase in the number of coffee plants from 2019 to 2023 [1]. To increase the readability, please consider rewriting the sentence as follow: "With population growth, the inheritance system still practiced in the study area remains in effect, perpetuating a process of land fragmentation. As a result, the distribution

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of coffee plantation tenure among descendants has become increasingly narrow". This condition causes the size of coffee land to be small business scale, and economically, it is a business with a narrow business land for coffee cultivation that has an impact on household income. The subsequent impact, fueled by a lack of knowledge by farmers in efforts to manage eco-minded and conservation-minded coffee farms, is believed to have an effect on the impact of microclimate change, which will be felt by coffee farmers in the future. This condition complies with Budidarsono & Wijaya's (2004) study on the ecological benefits of multistrata coffee cultivation, which concludes that multistrata coffee cultivation has a conservation function for biodiversity and may also suppress erosion to an acceptable level. Several factors causing microclimatic changes are the narrowness of the business land area with a diversity of coffee cultivation patterns that have an impact on coffee production. Previous study on the ecological benefits of multistrata coffee cultivation concluded that multistrata coffee cultivation has a conservation function for biodiversity [2]–[4], and is capable of suppressing erosion to an acceptable level [5], [6]. The study results indicate that reduction in the number of coffee trees, shade trees, labor, seeds, fertilizers, pest and disease control, and a narrow land area will have an impact on coffee production and productivity in Magetan Regency. This phenomenon is intriguing to study regarding the preservation and the lives of coffee farmers in Magetan Regency, East Java. The purpose of the research is to (1) identify ecological aspects on the sustainability of coffee cultivation patterns in the Magetan region, (2) find ecological factors on coffee production, and (3) describe the lives of coffee farmers related to ecological aspects.

2 Methodology

The research employed a *multistage sampling* method that included five stages of sample determination: (1) sub-districts, (2) villages, (3) farmer groups, (4) farmer group members, and (5) farmer samples. The research was carried out from April to July 2024. Data on ecological and economic aspects were gathered from primary data with survey methods on 80 coffee farmers who were chosen at random from two districts with the greatest coffee production, namely Panekan sub-district and Poncol sub-district, which has the largest land area and number of coffee plants in Magetan Regency. Two villages were chosen from the sub-district, Sukowidi village and Alastuwo village, from these two villages were chosen from Sri Bedono Farmers Group and Gunung Tambal Farmers Group. This method relies on [7]. Data were gathered utilizing questionnaires with trained enumerators. The characteristics of coffee farming were analyzed descriptively and based on three aspects: the quantity of protective plants, land conservation activities, robusta coffee farming patterns, and the utilization of organic fertilizers. Determinants of coffee production were analyzed quantitatively employing Ordinary Least Squares (OLS) with multiple linear regression models processed using the SPSS program.

3 Result

3.1 Magetan Regency Situation Analysis

Magetan Regency is located in the western part of East Java Province, positioned at 7°30'34" - 7°47'49" South latitude and 111°10'54" - 111°30'46" East longitude. Magetan Regency, with an area of 688,85 km^2, is East Java's second smallest regency after Sidoarjo. Magetan Regency consists of 18 sub-districts, 207 villages, and 28 urban villages. Magetan Regency is one of the regencies located on the slopes of Mount Lawu, which has an altitude ranging from 60 to 1.660 meters above sea level. The administrative location of Magetan Regency,

to the north, is bordered by Ngawi Regency, to the east by Madiun Regency, to the south by Ponorogo Regency, to the west by Karanganyar Regency and Wonogiri Regency, Central Java Province. The population of Magetan Regency in 2022 is 678.343 people. The elevation of the area in Magetan Regency will affect the climate. The climate in Magetan Regency is similar to that of Indonesia in general; the only distinction is the region's variable height, as well as the high temperatures and rains. From 2014 to 2016, the region experienced low rainfall, followed by high rainfall from 2017 to 2021, before returning to a low rainfall cycle in 2022 and 2023.

The greatest average rainfall from 2014 to 2023 was 3.868,28 mm in January, with the lowest at 97,32 mm in August. The highest rainy day in 2023 is February, with 24 rainy days. June has the fewest rainy days, with only one. The Magetan Regency is characterised by a diverse topography, comprising mountains, hills and lowlands. This has significant implications for the region's carrying capacity and overall capacity. The area exhibits a range of landforms, including sloping terrain and mountainous regions. The majority of the flat regions are located in Karangrejo and West, Maospati, Bendo, Kawedanan, and Takeran sub-districts. Undulating areas may be located in the Panekan and Poncol sub-districts. Plaosan sub-district is mostly known for its steep or hilly terrain. In accordance with the Central Bureau of Statistics of Magetan Regency, the population of Magetan Regency is 691.618 in 2023, with 339.769 men and 351.849 women. The population density in 2023 reached 1.004 people/km^2 with the level of population density in 18 sub-districts being quite diverse with the greatest population density located in Magetan sub-district with a density of 2.112 people/km^2 and the lowest in Poncol sub-district at 621 people/km^2.

The lowland-to-highland landscape offers significant agricultural potential. The Poncol and Panekan sub-districts are notable for their coffee production. Three types of coffee are cultivated: Arabica, Robusta, and Liberica. Among these, Arabica and Robusta are the dominant varieties, widely consumed due to their ease of cultivation and broad popularity. Liberica coffee (*Coffea liberica*) is a coffee with a distinctive taste and a bigger shape than other varieties of coffee. The geographical condition of Magetan Regency allows for the cultivation of various types of coffee, which is well used by the surrounding community and supported by the local government. Seeing the potential of coffee varieties in Magetan Regency, this research aims to examine coffee agribusiness from the environmental aspects and coffee preservation for the lives of farmers.

3.2 Analysis of Environmental Aspects and Coffee Preservation in Magetan Regency

In this research, the ecological aspects analyzed were the variables of the number of coffee trees, the number of shade trees, the use of fertilizer, the use of manure as organic fertilizer, pruning coffee trees, dummy borer pest eradication, and conservation farming patterns. The number of shade trees in each farming area was calculated without regard for the type of shade tree and then converted to hectares. Farmers' land conservation activities are coffee planting patterns in accordance with the contour of the soil, making *rorak* (water-retaining dead-end trenches), individual terraces, and bench terraces. Coffee farming patterns are monoculture coffee, sheltered coffee, intercropping coffee, and multistrata coffee. Table 1 shows the results of the descriptive analysis for each variable.

Table 1. Variable Descriptive Results.

Variable	Mean	Std. Deviation
Quantity of Coffee Production	189,16	205,677
Conservation Activities	0,83	0,382
Pest Handling	0,18	0,382

Pruning	0,65	0,480
Manure	184,71	166,562
Number of Shade Trees	29,71	17,585

Source: Primary Data Analysis, 2024

Coffee production is 189,16 kg/Ha wet, the number of coffee trees is 162,41 trees/Ha, the number of shade trees is 29,71/Ha, manure is 184,71 kg/Ha, and the number of shade trees in Magetan Regency is 29,71 trees/ha, this condition is far from the normal standard.

1.1.1 Regression Function Model

The relationship among factors was analyzed with the function model of multiple linear regression, as the *independent* variable in this research is the quantity of coffee production, whereas the *dependent* variable consists of conservation activities, pest handling, pruning, manure, and the number of shade trees. The functional model derived from the multiple linear regression analysis is as follows:

$$Y = 35{,}494 - 86{,}977\ X_1 - 20{,}390\ X_2 + 13{,}286\ X_3 + 0{,}860\ X_4 + 2{,}072\ X_5 + e$$

Description:
Y = Quantity of Coffee Production (kg)
a = Constants
$b_1 – b_5$ = Regression Coefficient
X_1 = Conservation Activity dummy, implementing conservation = 1, not implementing =0
X_2 = Pest Handling dummy, perform pest handling =1, not implementing = 0
X_3 = Pruning dummy, perform pruning =1, not perform = 0
X_4 = Manure
X_5 = Number of shade trees
e = Standard error

1.1.2 Classical Assumption Test Results

The results of the classical assumption test were carried out using the following tests: a) normality, b) heteroscedasticity, and c) multicollinearity. Normality test results are utilized for graphical and statistical analysis. The histogram graph is considered normal if the data distribution resembles a bell (*bell-shaped*) and does not lean to the left or right [8]. The results of this test show that the histogram graph resembles a bell and does not lean to the right or left, indicating that it is normally distributed. The normality test utilizes statistical analysis seen from the P-Plot graph. Based on [9], it is stated that it does not meet the requirements of the normality assumption if the items are spaced out along the diagonal line and do not follow the diagonal line's direction. The results of the analysis demonstrate the P-Plot form around the regression line, as well as how the data spreads around and follows the diagonal line's direction. Thus, the regression model is normally distributed or meets the requirements of the classical assumption of normality. To detect the presence or absence of heteroscedasticity in this analysis, it is used by looking at the pattern of dots on the *scatterplots*. It is known that the pattern of dots does not form a certain pattern. The dots spread randomly and are scattered above and below the number 0 on the Y axis, it may be concluded that the regression model has no heteroscedasticity, indicating that it is suitable for prediction.

1.1.3 Regression Analysis Results

Determination coefficient test (R^2)

The coefficient of determination (R^2) is utilized to measure the extent of a model's ability to explain the independent variable, which includes conservation activities, pest handling, pruning, manure, and the number of shade trees, to the dependent variable (coffee production), as indicated by the *Adjusted R Square* coefficient of determination, which can be seen in the *Model Summary* output.

Table 2. Determination Coefficient Test Results (R^2).

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0,751[a]	0,564	0,535	140,303

Source: Primary Data Analysis, 2024

Based on Table 2, it obtained an *Adjusted R Square* value of 0,535. According to [10], an *Adjusted R Square* value close to one indicates that the independent variables provide nearly all of the information required to predict variations in the dependent variable. The adjusted R-squared value of 53.5% shows that the number of shade trees, manure, pest control, pruning and conservation activities affect coffee production. This model is good, but there is room for improvement.

F-Test

The f-test is used to test whether the independent variables jointly affect the dependent variable. The f-test results can be seen in Table.

Table 3. The F-Test Results on Environmental Aspects of Coffee Production.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1885252,067	5	377050,413	19,154	<0,001***
Residual	1456680,820	74	19684,876		
Total	3341932,887	79			

Source : Primary Data Analysis, 2024
Description
*** : Significant at the error level 1%

The significance value (<0,001) in Table 3 implies that the regression model used is statistically significant in explaining the variation in the amount of coffee production. In other words, the independent variables jointly have a significant effect on the amount of coffee production.

T-Test Results

The t-statistical test is used to determine the extent to which the effect of the independent variables individually can explain the variation in the dependent variable. In this research, the t-test shows the extent of the effect to which the independent variables individually explain the income variable of the amount of coffee production. The t-test results can be seen in the *coefficient* table 4.

Table 4. T-Test Results.

	Unstandardized Coefficients	**t**	**Sig.**
	B		
(Constant)	35,494	0,558	0,578
Conservation Activities (X1)	-86,977	-1,891	0,063*)
Pest Handling (X2)	-20,390	-0,484	0,630
Pruning (X3)	13,286	0,387	0,700
Manure (X4)	0,860	8,935	<0,001***
Number of Shade Trees (X5)	2,072	2,035	0,045**

Source : Primary Data Analysis, 2024

Description

*** : Significant at the error level 1%

** : Significant at the error level 5%

*) : Significant at the error level 10%

According to the regression analysis results, it is obtained that coffee preservation in Magetan Regency is only influenced by ecological factors such as conservation, the use of manure (organic fertilizer), and the number of shade trees, while ecological aspects such as pest handling and pruning are not significant. The ecological variable of manure has a significance value of <0,001 <α, it can be concluded that H_0 is rejected and H_1 is accepted, implying that manure (X_4) affects the amount of coffee production (Y). Manure has a regression coefficient of 0,860 with a positive value, indicating that every 1% increase in manure use enhances coffee production by 0,86%. The results of this study imply that employing manure as an organic fertilizer may raise coffee production. This study complies with research [11], which found that organic fertilizers obtained from chicken, goat/sheep, and cow dung (waste from cages) may increase organic coffee production. Additionally, the usage of organic fertilizers attracts consumers to consume organic coffee [11]. However, the usage of organic fertilizer is not optimal, and the practice is combined with urea fertilizer in order to get the value of C-organic for coffee plant growth and the effectiveness of this type of organic fertilizer. However, it is acknowledged that this organic fertilizer is most suited to enhancing coffee plant growth. Previous study revealed that chicken manure treated with MPF improved P-availability and vegetative growth of coffee plants better than other manures [12]. In contrary to Asegaf's (2018) research, having higher organic fertilizer costs and less chemical fertilizer costs does not significantly enhance production. These results are aligned with research [13], which discovered that applying organic fertilizer to coffee plants did not result in significant differences in the variable in the number of production branches when compared to coffee plants without organic fertilizer.

The number of shade trees has a significance value of 0,045 < α. So, it can be concluded that H_0 is rejected and H_1 is accepted, implying that the number of shade trees (X_5) influences the amount of coffee produced (Y). The shade tree has a regression coefficient value of 2,072 with a positive value, implying that every 1% increase in the number of shade trees raises coffee production by 2,072%. Shade trees will lessen the intensity of sunshine, creating a microclimate. The results of this study are in accordance with research [14], which stated that shade trees determine coffee fruit productivity through their roles as litter producers and nutrient cycles in agroecosystems, as well as their role in shading coffee plants. The positive role of shade trees on coffee plants is also stated in the research results [15]. Mixed system coffee farming (multistrata) has a better effect on soil quality compared to monoculture systems. (Directorate General of Plantation, 2019) stated that shade plants are required in planting coffee commodities for optimal production. Shade plants can tolerate wind, defend against the scorching sun, and shield coffee plants from high rainfall intensity. Another

benefit of shade trees is that produce litter, which protects the soil and helps the availability of nutrients. Ecologically, the role of shade trees for coffee plants has numerous positive impacts [17]. Shade trees may reduce soil temperature, resist wind force and heavy rains, control erosion on sloping land, control weed growth, produce organic matter, recycle soil nutrients, reduce nutrient leaching, prevent over-fertilization and shoot death due to reduced light intensity, provide additional revenue from shade trees (board, firewood, and fruits), potentially reduce leaf blight, improve cup quality, particularly in coffee regions with high temperatures that are ecologically suboptimal [17] [18].

Conservation activities have a significance value of -86,977 < α. So, it can be concluded that H_0 is rejected whereas H_1 is accepted, implying that conservation activities (X_1) have an impact on the amount of coffee production (Y). This variable is used as a dummy variable; the negative sign of the regression coefficient indicates that if coffee farmers do not engage in conservation activities in coffee cultivation, coffee production will drop; otherwise, if conservation activities are implemented in coffee cultivation, production will rise. Conservation activities have a regression coefficient of -86,977, indicating that if conservation activities are not implemented in coffee cultivation, production will drop by 86,977 units. Coffee farmers in Magetan conduct conservation activities in compliance with the slope of the land, which is the local term for the "*nyabuk gunung*" planting system, which means that the coffee planting system follows the slope of the land and circles around the waterways to retain water with bench terraces. Thus, conservation, namely the development of coffee agribusiness from the perspective of land conservation and agroforestry, enhances coffee production. The results of this research differ from research [18], which stated that land conservation is a practice undertaken by farmers to maintain land preservation, specifically by mulching, creating *roraks*, and creating individual or bench terraces. This result demonstrates that land conservation does not have a direct impact on production, but rather seeks to preserve the land in order to support sustainable coffee production. Although the effect of land conservation on production is not significant, the results of this research are regarded as quite good to encourage farmers to increase land conservation. Bernas' (2011) research, conservation with terrace treatment can reduce runoff and soil erosion while also decreasing N, P, and K nutrient losses in the soil. As a result, conservation activities on coffee plants by farmers are a vital point to consider and implement in undertaken to improve soil quality.

3.3 The Role of Coffee Plants in Community Life

Coffee cultivation plays an essential role in the lives of farmers as a source of long-term income and at the same time improves the lives of farmers. Cultivation practices that offer high income and incentives tend to attract more individuals to engage in coffee farming. However, this increased interest poses a threat to the region's carrying capacity if environmental factors are not properly managed. The study results demonstrate that coffee cultivation as a business and source of revenue for the community in Magetan Regency generated an average monthly income of IDR 1.015.724,44. Therefore, coffee has become the primary source of income for the community. Given its contribution, coffee has become a source of the lives of the community. This study agrees with research that coffee farmers earn a lot of money from coffee beans and cherries. However, this study found different results. It said that the pandemic had a negative impact on coffee farmers in Pangalengan. Farmers had less income, lower coffee prices and fewer customers.

4 Conclusion & Recommendation

The preservation of protecting the environment in coffee plants in Magetan Regency is affected by the use of manure, planting of shade trees, and conservation of coffee cultivation patterns. However, two factors—coffee pruning and pest management—were found to be non-significant. This indicates that while coffee farmers have implemented preservation practices, these efforts have not yet achieved optimal success. Preserving coffee plants is critical since coffee cultivation is the primary source of income and the lives of farmers in Magetan Regency. It is recommended to reinforce coffee cultivation by placing an emphasis on pruning coffee plants to preserve the microclimate and eradicating coffee borer pests to ensure optimal coffee production considering that farmers do not understand the importance of this pruning and neglect in pest control that occurs, particularly in fruit borer pests.

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