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THE BENEFITS OF INTEGRATING COFFEE AND HONEY BEE CULTIVATION (INKOLEMA) ON INCREASING COFFEE PRODUCTIVITY, FARMER INCOME AND SUSTAINABILITY IN BENER MERIAH DISTRICT

Dedi Ikhwani[1], Fajri[2], Indra[3]
[123] Master of Agribusiness Study Program Universitas Syiah Kuala
Corresponding e-mail : dediikhwani.aceh@gmail.com

Abstract

A reduction in coffee productivity will have an adverse effect on farmers' income, and will be disruption the economy to potentially causating proverty. One strategy that farmers can employ to mitigate this impact is integration, which establishes a mutually beneficial relationship between the two agricultural practices. This study examines the potential benefits of integrating coffee and honeybee cultivation (Inkolema) for increasing coffee productivity, farmers' income and the sustainability of coffee farming in Bener Meriah Regency. The research was conducted over the period from October 2023 to September 2024, with a total of 65 coffee farmers who had implemented Inkolema, in addition to five key respondents. The method of analysis was descriptive. Initially, the difference test of coffee productivity and farmers' income was conducted using paired sample t-tests on the SPSS software. Subsequently, a multi-dimensional scale (MDS) sustainability analysis was performed with the Rapcoffee application, which is a modification of Rapfish. The findings indicated a notable disparity in coffee productivity and farmers' income on coffee farms prior to and following the implementation of Inkolema. The placement of 13 bee colonies on one hectare of coffee land has been found to increase coffee productivity by 2.87% and 4.44% has been increasing farmer income from the coffee sources. The implementation of Inkolema has been observed to positively impact crop pollination and pest control, thereby increasing the quality and quantity of production. The sustainability index analysis indicates that the implementation of Inkolema can be classified as moderately sustainable, with a multidimensional index value of 73.25%, encompassing ecological, economic, and social dimensions. The utilization of coffee skin waste, waste disposal, income comparison with district minimum wage, land area, education participation, and extension roles were identified as sensitive factors in sustainability. In finally the study concluded that Inkolema has the potential to improve farmers' economic welfare through resource efficiency, income diversification and contribute to the sustainability of coffee farming.

Keywords: coffee, integration, bee, productivity, income, sustainability.

INTRODUCTION

Coffee is one of the most traded strategic commodities in the world today. Coffee plants are produced from various countries, most of which are in the tropics, such as several Asian countries, Africa, and Latin America. Indonesia is listed as the 3rd largest coffee producing country in the world. In 2022 to 2023 Indonesia has produced 11.85 million bags of coffee. The details consist of 1.3 million bags of arabica coffee and 10.5 million bags of robusta coffee, each bag containing 60 kg of coffee (USDA, 2023).

The contribution of coffee commodities to the Indonesian economy is as a source of foreign exchange, a source of farmers' income, job creation, regional development, a driver of agribusiness and agro-industry, and a supporter of environmental conservation. International Coffee Organization [ICO] (2018). Sustainable and competitive coffee agribusiness should be characterized by the ability to respond to rapid and efficient market changes, oriented towards long-term interests, have technological innovation, use environmentally friendly technology and strive to conserve natural resources and the environment.

The Benefits of Integrating Coffee and Honey Bee Cultivation (Inkolema) on Increasing Coffee Productivity, Farmer Income and Sustainability in Bener Meriah District

The Directorate General of Plantation, Ministry of Agriculture of the Republic of Indonesia in the book Statistics of National Leading Estate Crops Commodity released data on Indonesia's coffee production and exports. In 2021, the foreign exchange value obtained from the Indonesian coffee commodity trade was USD 585.56 million with an export volume of 387,264 tons (Ditjenbun, 2022). This condition certainly makes Indonesia have a strategic opportunity for intensive and sustainable coffee development so as to spur increased productivity. Economically, an increase in coffee productivity is expected to encourage an increase in farmers' income, because the majority of coffee plantations in Indonesia are smallholder plantations. Coffee is the main livelihood for around 1.6 million farming households, of which 96% are smallholders with a land area of less than one hectare with various limitations (Ditjenbun, 2022; Mawardi, 2008). This challenge must be addressed so that the land assets owned by farmers provide sustainable economic benefits.

The United Nations Conference on Environment and Development (UNCED, 1992) interprets sustainability as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, taking into account environmental, economic and social aspects in a balanced manner. The importance of the concept of sustainability in a global context is now felt with increasing urgency. The problems of climate change, environmental crisis, and social inequality are increasing and demand serious attention from all parties. Therefore, the concept of sustainability must be the basis for every decision and action taken, both in government, industry and society. The application of integrated systems on production land is part of an integrated agricultural scheme that obtains environmental, economic and social sustainability benefits.

Bener Meriah Regency is one of the centers of coffee production from smallholder plantations. The cultivation pattern carried out is still relatively simple, so the production results obtained by farmers are still very low. Gayo Arabica coffee productivity currently ranges from 650-750 kg, still far from the potential yield of several existing varieties that reach 1.5-2 tons per ha (Jaya et al. 2011; 2014). This indicates a gap of around 850-1,250 kg per ha between the productivity of Gayo arabica at the farm level and the potential productivity of Gayo arabica coffee. The low productivity of Gayo arabica coffee is technically caused by the large number of old or unproductive plants, land saturation due to continuous cultivation, high intensity of pest and plant disease attacks, cultivation systems that are not carried out optimally (pruning production), global climate change that causes an increase in average temperatures in the Gayo highlands and the mandate from consumers for organic products, which affects productivity due to land fertility levels and pest and plant disease attacks (Dishutbun Bener Meriah, 2015).

The issue of crop productivity will have an impact on the income received by farmers in their cultivation efforts. Low income will make farmers economically weak, affecting their ability to manage their land. Not to mention the issue of low commodity selling prices due to decreased product quality or decreased world market demand. The economic condition of weak farmers will certainly have an impact on the poverty level.

BPS Aceh recorded that the poverty rate in Bener Meriah District until March 2023 was 18.31%, higher than the average poverty rate in Aceh, which was 14.45%. According to BPS (2016), poverty is the inability of a person seen in economic, material and physical terms to meet the needs of daily life both in terms of food and non-food as measured by expenditure. The issue of poverty should be the main focus of local governments to manage people's economic resources through improvements in coffee plantation centers.

Improvement efforts continue to be made to reduce the high difference between Gayo Arabica coffee and potential crop yields and cultivation technology engineering through plant rejuvenation, pruning productive branches, planting and pruning shade, controlling pests and diseases, and fertilizing to replace nutrients lost with crop yields. MPKG (Gayo Coffee Protection Society) through Kompas media said that the potential productivity of Gayo arabica coffee is 2,000 kg per ha if optimally treated (Ministry of Industry, 2015).

Ministry of Agriculture Regulation No. 49/Permentan/OT.140/4/2014 on Technical Guidelines for Good Coffee Cultivation (good agriculture practices). The implementation of coffee GAP must of course refer to the conception of sustainable agriculture, which has been intensively socialized in recent decades. Sustainable agriculture is the successful management of resources for agricultural businesses to meet changing human needs while maintaining or improving environmental quality and conserving natural resources. Other efforts to increase farmers' income are carried out with a pattern of business diversification on coffee cultivation land. The pattern of intercropping with young plants, can also be done intercropping with annual plants but will not disturb the main crop. A breakthrough can also be made by implementing an integration pattern of coffee plants with livestock in the cultivation area, this pattern can certainly be an alternative for farmers to increase income. According to research (Saepudin et al., 2011), one of the efforts that can be made to increase coffee production and honey production efficiently is to integrate honey bees with coffee plants. In addition to increasing coffee production, this integration system can also increase farmers' income.

The application of honey bee cultivation in coffee plantations has recently begun in Bener Meriah District, both organized and unorganized. DLHK Aceh has several fostered groups called Forest Farmer Groups (KTH). The groups that receive facilitation support from the government consist of several groups that cultivate honey bees on coffee fields spread across several villages in Bener Meriah District. The KTH that is classified as actively implementing integration consists of 7 groups with a total of 124 members.

The integration system in the agricultural sector is a strategic breakthrough that must be played by farmers in an effort to increase income. As a coffee plantation center, Bener Meriah Regency certainly has strategic prospects in implementing the integration of honey bee cultivation in coffee plantation areas. The utilization of coffee cultivation land to be integrated with honey bee cultivation certainly has elements of resource efficiency and effectiveness as mutial needs.

Research on the integration of coffee and honey bee cultivation has been conducted in Simalungun Regency, North Sumatra Province and Kepahiang Regency, Bengkulu Province. However, in Bener Meriah District as the center of arabica coffee production in Aceh Province, no research has been conducted related to the integration of coffee and honey bee cultivation. It is known that Aceh province has the largest Arabica coffee land area, namely 103,706 ha or comparable to 28.2% of the total Arabica coffee land area in Indonesia (Kementan RI, 2021).

The utilization of coffee plantation land that has been integrated with honey bees certainly needs scientific research so that the information presented later becomes more comprehensive so as to encourage farmers to apply it more widely. In addition, no scientific research has been conducted regarding the benefits of integrating coffee cultivation with honey bees in Bener Meriah Regency. The above assumptions became the author's interest to conduct research with the title of the benefits of integrating coffee cultivation with honey bees on increasing farmers' income, coffee productivity and sustainability aspects in Bener Meriah District.

RESEARCH METHODS

Place and time of research

Research on the integration of coffee and honey bee cultivation was conducted in Bener Meriah District, as the center of arabica coffee production in Aceh Province. As it is known that no research has been conducted related to Inkolema benefits coffee productivity, farmer income and sustainability index. Meanwhile, the implementation time of this research took place from October 2023 to September 2024.

Research approach

The approach taken in this research is qualitative and quantitative description. The qualitative approach was used to determine the existing situation and conditions at the research location through interviews. Meanwhile, the quantitative approach was used to assess the difference in coffee productivity and farmers' income before and after the application of Inkolema. The next step was to assess the sustainability index of coffee farms that have implemented Inkolema.

The quantitative approach focuses on proving hypotheses and understanding through various tests. The quantitative approach focuses on symptoms that have certain characteristics in human life which are referred to as variables, the relationship between variables will be analyzed using objective theory. There are several types of quantitative research based on how they are processed, namely descriptive, comparative, associative, influence and structural (Sujarweni, V.W, 2018: 19-20).

In implementation of research, the quantitative approach more often directs the problem into a causal relationship so that the formulation of the problem can be explained in the form of a relationship between various variables. This approach more often attempts to measure a concept (variable), so that it is easier to understand statistically. Based on the processing method in quantitative research, researchers use a comparative approach to determine whether between two variables there is a difference in one aspect under study. Data processing using different tests such as paired sample t-tests, anova, wilcoxon, sign, mann whitney, friedman (Mertha Jaya, I.M.L, 2020: 18).

Population and sample

Population is the whole of the data or individuals who later become the topic or center of attention of a researcher. According to Sugiyono (2009: 73) the sample is part of the number and characteristics possessed by the population. Margono (2024), how to determine the sample whose number is in accordance with the sample size that will be presented as the actual data source by taking into account the characteristics and distribution of the population in order to obtain a representative sample. Roscoe in the book Research Methods for Business (1982) cited by (Sugiyono, 2010) provides suggestions on sample sizes for research between 30 and 500. Arikunto (2016: 104) said that if the population is less than 100 people, the sample will be taken as a whole, but if the population is greater than 100 people, 10%-15% or 20%-25% of the population can be taken.

The sampling method in this study was conducted in a non-probability manner, where the determination was based on purposive sampling to group members. According to information obtained from forestry extension assistants, the number of farmers who have participated in beekeeping training is 124. However, not all of them carry out honey bee cultivation integrated in coffee plantations. Therefore, the researchers purposively selected a sample of 65 farmers who have integrated Arabica coffee plantations with honey bees. Meanwhile, for the sustainability analysis, 5 people were added as key samples from beekeeping associations and government extension assistants. For more details on the determination of the number of samples can be seen in Table 1 below:

Table 1. Determination of the number of research samples

Forest Farmer Group (FFG)	Number of farmers (People)	Sample Drawing Technique	Number of Samples	
			Analysis 1	Analysis 2
Tualang	20	50%	10	10
Markaz LM	15	50%	8	8
Ijo Pucok	20	50%	10	10
Maju Bersama	15	50%	8	8
Kulem Kolak	16	50%	8	8
Mutik	20	50%	10	10
Sari Bunga	18	50%	9	9
Beekeeping Association	-	-	-	2
Extention Staff	-	-	-	3
	124	-	65	70

Source: Secondary data processed (2024)

Types and methods of data collection

The overall type of data used in this study is in the form of primary data and secondary data. Primary data was obtained using a survey method on each respondent who had been determined. Data collection techniques were carried out by observation and structured interviews using questionnaire instruments to 65 respondents and an additional 5 people as key respondents for sustainability analysis.

Primary data obtained in this study did not use experimental studies with a span of two different times, also based on notes and memory recall of respondents. Meanwhile, secondary data was obtained from farmers' records, theoretical books, digital magazines, related journals, BPS Bener Meriah District, Aceh Agriculture and Plantation Office statistical books and KPH 3 reports in Bener Meriah.

Methods and data analysis

Determination of methods and data analysis in this study is divided into two stages, first conducting a different test analysis of coffee productivity and farmer income from the same sample source before and after the application of Inkolema in Bener Meriah District. The second stage analysed sustainability with variables of the ecological dimension, economic dimension and social dimension to the same respondents and the addition of 5 key respondents.

According to Daryanto (2012) productivity is a concept that describes the relationship between production results and resources in obtaining these results. Sudarmo, Sianturi, Kernalis and Aprollita, 2016, concluded that productivity is about the comparison of the results obtained with the economic resources used. However, many views state that productivity is not only the quantity, but also the quality of the products produced, which must also be used as a consideration to measure the level of productivity. To calculate productivity, we can use the following formula:

$$Produktivitas = \frac{Output}{Input} = \frac{Jumlah\ Produksi}{Luas\ Lahan}$$

The second step, researchers analysed the variable income of farmers before and after applying Inkolema, the calculation of farmers' income was carried out using the formula (Soekartawi, 1995).

$$\pi = TR - TC \ldots\ldots\ldots (1)$$

Description:

π : Coffee farm income (before and after Inkolema)
TR : Total coffee farm income (before and after Inkolema)
TC : Total costs (before and after Inkolema)

The revenue obtained from Arabica coffee farming and beekeeping is the multiplication of the production obtained by the selling price. The total revenue in this study was converted into a period of one year, systematically the revenue can be written as follows (Soekartawi, 1995).

$$\text{TR} = \sum_i^n \text{Yi} \,.\, \text{Pyi} \ldots\ldots\ldots (2)$$

Description:

TR : Total revenue (before and after Incolema)
Yi : Output produced by farmers (before and after Inkolema)
Pyi : Selling price of output produced by farmers (before and after Inkolema)
i : Arabica coffee beans and honey
n : Number of product types produced

Inkolema farmers' income is categorised into two analyses, namely the sum of Arabica coffee farming income alone before and after Inkolema and the sum of coffee and honey income before and after Inkolema. While before integrating coffee land with honey bees, farmers only obtained total revenue from Arabica coffee farming alone.

The normality test stage is carried out to test whether in the regression model in this grouping of two paired data, the confounding variables or residuals of the t and F tests have a normal distribution. If this hypothesis is not met, the statistical test results will be invalid, especially for small sample sizes. The normality test is carried out using SPSS software, which is often used, namely Kolmogorov-Smirnov because it is very reliable in testing samples> 200. Meanwhile, if the sample is < 200, the normality test precisely uses Shapiro-Wilk (Kolmogorov Smirnov adaptation). Determination of whether the data is normally distributed or not is based on the following hypothesis:

- If the probability value> 0.05 significant value, the data is normally distributed.
- If the probability value <0.05 significant value, the data is not normally distributed.

If the two paired data are normally distributed, then hypothesis testing (mean difference test) uses a parametric test, namely the paired sample t-test, on the other hand, if the two paired data are not normally distributed, hypothesis testing (mean difference test) uses a non-parametric test, namely the Wilcoxon signed rank test. The hypothesis put forward in testing the normality of the data is Ho stated that the data is normally distributed, while Ha stated that the data is not normally distributed. The decision-making criteria are sig. (p value) <0.05 (5%) then Ha is accepted, meaning that the data is not normally distributed. Conversely, if sig. (p value) > 0.05 (5%) then Ho is accepted, meaning the data is normally distributed.

Data processing was carried out with the SPSS application by entering data on coffee productivity and farmer income before and after the application of Inkolema. According to (Nuryadi, 2017) Paired Sample t-test to analyse the mean difference test of two paired samples to see whether there is a significant difference in coffee productivity and farmers' income before and after Inkolema with the formulation, as follows:

$$t = \frac{\bar{d}}{\frac{S_d}{\sqrt{n}}} \; ; \; S_d = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{d})^2} \; ; df = n - 1$$

Description :

t : Calculated t value

d_i : Difference before and after Incolema

$\bar{d}$: Average difference of data before and after Inkolema

n : Number of samples Inkolema

df : Degree of freedom

The calculated t value is then compared to the critical t value in the t distribution table with degrees of freedom (df) = n-1 and the chosen significance level (α). The value of α is the chance of making a type I error. Type I error is the error of rejecting Ho, even though Ho is true. The determination of this significance level varies according to the researcher's preference. Commonly used α value is 0.05 (5%), the value of α is a limitation in determining hypothesis test decision making.

The basis for making a decision on the paired sample t-test is to measure whether there is a difference in the average of the two groups tested by comparing t count with t table with a significance value as follows. If - t table ≤ t count ≤ + t table, then Ho is accepted and Ha is rejected (Ridwan, 2005).

H0 : There is no difference in coffee productivity and farmers' income before and after Inkolema.

Ha : There are differences in coffee productivity and farmers' income before and after Inkolema.

The second part of this research is to measure the sustainability index of Inkolema in Bener Meriah District. Reviewing literature obtained from interviews and field observations using descriptive qualitative and quantitative methods. The quantitative approach is used to find out the situation and exiting conditions at the research location through interviews. While the quantitative approach is used to assess the dimensions of the sustainability of Inkolema implementation which is then used as material for analysis so that it is known what dimensions are sustainable.

The method and analysis model used is Multi Dimensional Scaling (MDS), data analysis using Rapfish software (Rapid Appraisal for Fisheries) modified into Rap-Coffee (Rapid Appraisal for the Coffee) so as to produce sustainability index values from the ecological, economic and social dimensions. Rapfish was developed by the University of British Columbia fisheries centre in 1998, using MDS statistical techniques to rapidly assess the status of existence or sustainability. This technique is flexible enough to be able to applied to coffee plantation areas (Rap-Cofee) So that the researcher obtains an overall picture of the index and sustainability index of Inkolema's implementation.

The steps in conducting this analysis include several things, namely: (1) identification of problems and determination of assessment attributes obtained from observations and interviews, (2) ordinal scale assessment of each attribute based on the results obtained from the field and interviews, (3) Rap-Coffee analysis to determine the sustainability of each attribute, (4) assessing the sustainability of each attribute,

(5) determining sensitive attributes that affect sustainability through leverage analysis, (6) Monte Carlo Analysis.

The percentage of the sustainability index based on respondents' income corresponds to the attributes defined in the ecological, economic and social dimensions. In a good fit position indicated by a low stress value, the opposite condition is indicated by a high stress value. If the stress value is less than 0.25 and the R2 value is close to 1, the model is considered feasible (Zuhdi et al., 2021). The number of attributes used in examining a dimension can be said to be quite accurate if the R^2 value is close to 1 (Vatria, 2020). The run leveraging stage aims to determine the value of each attribute analysed, it can also see which attributes are the most influential and which attributes are the most sensitive.

Testing the error of this method is done with the Monte Carlo test, the results of data assessment are presented in the form of tables and kite graphs with the ordinal scale used is 0 for the worst condition and 3 for the best condition. Monte Carlo analysis is used to take into account aspects of uncertainty (Nurmalina, 2008). According to Kavanagh & Pitcher (2004), this analysis is intended if you want to know the error of scoring or attribute assessment. Errors in assessment can come from variations in scoring due to differences in respondent or expert opinions, insufficient knowledge of respondents or errors in understanding attribute assessment instructions. If the difference between the results of the MDS analysis and the Monte Carlo results is less than one, then the analysed programme is in accordance with real conditions (Kavanagh and Pitcher 2004; Fauzi and Anna 2013).

The farm sustainability index is measured by assigning values to each attribute in each dimension. The scoring of the attributes is based on the provisions set out in the Rap-Coffe method with each attribute scoring ranging from 0 to 3. The assessment is based on the scientific judgement of respondents, with a score of 0 bad and 3 good. Then analysed using Rap-Coffee software so as to obtain the results of the sustainability index value of each dimension. Based on Anna and Fauzi (2002) in Yusuf et al. (2022) the sustainability status of farming is determined into four categories with score intervals, as a guide in determining the sustainability status of Inkolema in Bener Meriah, can be seen in the following table:

Table 2. Interval score of coffee farm sustainability

Score Interval (%)	Category
0,00 – 25,00	Poor (Unsustainable)
25,01 – 50,00	Less (Less Sustainable)
50,01 – 75,00	Fair (Moderately Sustainable)
75,01 – 100	Good (Sustainable)

Source: Anna and Fauzi (2002) in Yusuf et al. (2022)

Sustainability attributes in this study totalled 26 attributes consisting of 8 attributes in the ecological dimension, 8 attributes in the economic dimension and 10 attributes in the social dimension. The scoring step for each attribute is made on an ordinal scale based on individual sustainability criteria. Scoring varies and is adjusted to a range between 0-3, starting from poor (0), moderate (1) good (2) and very good (3).

Table 3. Multidimensional attributes of sustainability

Sustainability Attributes	Indicator/Unit Measurement Scale *(0-3)*
Ecological Dimension	
1. Land suitability *(Pawiengla, et al., 2020), (Fauzi et al, 2018)*	(0) not suitable (1) less suitable S3 (2) suitable (S2) (3) very suitablei (S1)
2.Land elevation *(Elida,et all., 2012)*	(0) <800mdpl (not suitable) (1) 800 - 999mdpl(less suitable) (2) 1000 - 1200mdpl (suitable) (3) >1200mdpl (very suitablei)

3.Provision of shade plants *(Iqlima, et all., 2022)*	(0) none (1) little (2) medium (3) available/appropriatei
4. Coffee plant maintenance system *(Elida,et all., 2012)*	(0) <10% done without maintenance (1) 10%-25% (2) 25%-50% (3) >50%
5. Utilisation of coffee skin waste *(Iqlima, et all., 2022)*	(0) not utilised (1) a small part is utilised (2) most of it is utilised (3) entirely utilised
6. Intensity of pest attack *(Iqlima, et all., 2022)*	(0) high (1) medium (2) low (3) none
7. Pesticide use (Rasihen, et al., 2021)	(0) often use (1) some use (2) rarely use (3) do not use
8. Pembuangan limbah *(Elida,et all., 2012)*	(0) without process (1) a small part through the process (2) most of the process (3) entirely through the process
B. Economic Dimension	
1. Product price *(Iqlima, et al., 2023)*	(0) very low (1) low (2) as per (3) high
2. Market access *(Pawiengla, et al.,2020)*	(0) not accessible (1) difficult to access (2) easily accessible (3) very accessible
3. Contribution to farmers' income *(Iqlima, et al., 2023)*	(0) none (1) less (2) enough (3) a lot
4. Financial viability *(Sari, 2019)*	(0) not feasible (loss) (1) return of capital (break-even) (2) feasible (3) very feasible
5. Income comparison with Bener Meriah MSE *(Hidayat, et al. (2020)*	(0) none (1) less than the MSE (2) equal to the MSE (3) greater than the MSE
6. Meeting household food needs *(Listi,2019)*	(0) not met (1) moderately fulfilled (2) fulfilled (3) more
7. Land size *(Iqlima, et al., 2023)*	(0) < 0,5 ha (1) 0,5-0,99 ha (2) 1-2 ha (3) > 2ha
8. Competitiveness *(Pawiengla, et al.,2020)*	(0) less competitive (1) moderately competitive

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	(2) competitive (3) highly competitive
C. Social Dimension	
1. Age of the farme *(Iqlima, et al., 2023)*	(0) <20 years old (1) 20-30 years (2) 31-40 years (3) >41 years
2. Formal education level *(Iqlima, et al., 2023)*	(0) Elementary school / equivalent (1) Junior high school/equivalent (2) High school/equivalent (3) Higher education
3. Education participation	(0) none (1) only once (2) less (3) often
4. Coffee plantation knowledge *(Iqlima, et al., 2023)*	(0) do not know (1) less (2) good (3) very good
5. Existence of farmer groups *(Pawiengla, et al., 2020), Ruhimat, et al., (2015)*	(0) does not exist (1) exist, not active (2) active (3) very active
6. Legal entity of farmer group *(Elida,et al., 2012*	(0) does not exist (1) not running (2) not running well (3) existing and running well
7.Community role in coffee plantation *(Elida,et al., 2012, Ruhimat, et al., 2015)*	(0) none (1) not good (2) good (3) very good
8. The role of extension organisations *(Pawiengla, et al., 2020)*	(0) none (1) exists (2) sometimes (3) often
9. Social system *(Nuraina, 2021)*	(0) individuals (1) involves family members (2) involves family and several other people (3) Gotong royong
10. Land ownership status *(Iqlima, et al., 2023)*	(0) wage (labour) (1) rent (2) tenant (3) Private

Source: Secondary data processed (2024)

RESULTS AND DISCUSSION

Overview of the research area

Bener Meriah Regency is an area resulting from the expansion of Central Aceh Regency based on Law No. 41 of 2003 dated 18 December 2003 concerning the Establishment of Bener Meriah Regency in Aceh Province. The district was inaugurated by the Minister of Home Affairs on 7 January 2004 with boundaries to the north bordering North Aceh Regency and Bireuen Regency, to the east bordering East Aceh Regency, to the south and west bordering Central Aceh Regency and to the west bordering Central Aceh Regency.

Based on BPS Bener Meriah 2023 data, the area of Bener Meriah Regency is 1,941.61 km with a location between 4°33′50″-4°54′50″ north latitude and 96°40′75″-97°17′50″ east longitude. The coldest average air temperature occurs from January to June with an average temperature of 18°C and the highest temperature occurs in November and December reaching an average of 32°C. Air humidity ranges from 89% to 94%, with February, April, August, September, October and December having the lowest humidity at 89%.

There are 10 sub-districts in Bener Meriah Regency, consisting of Bandar, Bener Kelipah, Bukit, Gajah Putih, Mesidah, Permata, Pintu Rime Gayo, Syiah Utama, Timang Gajah and Wih Pesam. There are 233 villages or kampongs, with the largest number of kampongs in Bukit Sub-district with 40 kampongs and the fewest in Bener Kelipah Sub-district with 12 kampongs.

The population of Bener Meriah is 168,690 people, consisting of 85,526 men (50.70%) and 83,164 women (49.30%). Judging from the distribution, the largest population is in Kecamatan Bukit, totalling 30,970 people, equivalent to 18.36% of the total population of the Regency. Meanwhile, Kecamatan Syiah Utama has the smallest population at 2,344 people, equivalent to 1.39% of the total population.

Table 4. Area, number of villages and population by sub-district

District	Area (km^2)	Number of Villages	Total Population
Bandar	82,10	35	29.368
Bener Kelipah	26,75	12	5.180
Bukit	110,95	40	30.970
Gajah Putih	72,57	10	9.620
Mesidah	286,83	15	5.647
Permata	159,66	27	21.482
Pintu Rime Gayo	223,56	23	15.705
Syiah Utama	814,63	14	2.344
Timang Gajah	98,28	30	22.563
Wih Pesam	66,28	27	25.811
	1.941,61	233	168.690

Source : BPS Bener Meriah (2023)

The percentage of the population with the level of education over 15 years of age consists of not attending school 6.47%, elementary school graduates equivalent 18.03%, junior high school graduates equivalent 24.10%, public high school graduates equivalent 37.33% and 14.06% graduated from university. The percentage of poor people in Kabupaten Bener Meriah in 2023 was recorded at 30,887 people (18.31%), a decrease of 0.08% from the previous year (BPS Bener Meriah, 2023).

The majority of the community's livelihood is based on the agricultural sector, which is dominated by coffee plantations to the tune of 80%, with the rest being horticultural crops, food crops, livestock, fisheries and forestry. Government policy towards the community's economy should concentrate on coffee plantations. The Aceh Provincial Agriculture and Plantation Office in the Aceh Plantation Statistics book states that coffee productivity in Bener Meriah Regency in 2021 was 627 kg per hectare of green beans. The coffee in question is classified as arabica coffee and robusta coffee. More details can be seen in table 5 below:

Table 5. Land area, production and productivity of arabica and robusta coffee in Bener Meriah District

Type of Coffeei	Land (ha)	Production (ton)	Productivity (kg/ha)	Family Head (kg)
Robusta	1.890	1.028	544	1.250
Arabika	46.273	29.172	630	32.095
Total	48.163	30.200	627	33.345

Source: Distanbun Aceh (2022)

In the table above, it is stated that the area of coffee plantations in Bener Meriah Regency is 48,163 hectares, which is a smallholder plantation. There are 1,890 hectares of coffee plantations for the robusta type and 46,273 hectares for the arabica type. Coffee productivity for robusta type is 544 kg/hectare/year, while arabica type is 630 kg/hectare/year with a total annual coffee production value of 30,200 tonnes. The ownership status of the coffee land is managed by 33,345 households, where the average size of coffee plantation managed by the community is 1.4 hectares per household.

The condition of Inkolema in Bener Meriah

Research was conducted among 65 farmer respondents who implemented Inkolema in Bener Meriah District. The research was conducted using the survey method to obtain data directly with farmers and land. Farmer data and Inkolema application were obtained using interview and observation techniques based on questionnaire instruments. The target of the survey was to obtain data directly so as to measure the variables of coffee productivity, farmer income and sustainability index before and after Inkolema.

This research establishes the independent variable, namely integration (Inkolema) referred to as (X). Furthermore, calculating the dependent variable, namely measuring the value of coffee productivity (Y1) and the value of farmers' income (Y2), is done mathematically. The data will be presented descriptively in the form of diagrams (pictures) and accompanied by explanations. The final stage is proven by the data normality test and paired sample t-test to see any differences before and after the application of Inkolema. Measuring the sustainability variable (Y3), The parameters analysed were ecological, economic and social dimensions. Based on the survey results, primary data was obtained The data that has been processed to see the condition of coffee cultivation before and after Inkolema in Bener Meriah Regency.

Table 6. Coffee cultivation conditions before and after Inkolema

Variable Description	Before Inkolema	After Inkolema
Luas lahan kopi (hektar)	0,60	0,60
Jumlah tanaman Kopi (pohon/hektar)	1.000	1.000
Umur tanaman kopi (tahun)	11	12
Status kepemilikan lahan	Personal	Personal
Jumlah rata-rata kotak per hektar	-	10 Stup

Source: Inkolema primary data (2024)

In table 6, it is explained that the average coffee land area of Inkolema farmers is 0.60 hectares, which is close to the overall data on the average coffee land area owned by the community in Bener Meriah, which is 0.69 hectares (Distanbun Aceh, 2022). The average coffee population per hectare is 900 trees, whereas ideally the coffee population on 1 hectare of land is between 1,111 and 2,500 trees. If the gayo 1 and gayo 2 varieties follow a 3x3 metre spacing, the coffee population is 1,111 trees, the gayo 3 variety with a 2.5x2.5 metre spacing has a population of 1,600 trees and if it follows a 1x4 metre fence planting system, the population is 2,500 trees. The number of coffee plant populations decreased due to the majority of community gardens having huts, water storage areas, dead plant parts not being embroidered and planting several trees other than coffee.

Coffee plants have an average age before Inkolema of 11 years and after the application of Inkolema the average age is 12 years. This basis is because the research data is calculated one year before applying inkolema and one year after applying Inkolema. Farmers' land ownership status is privately owned, which is managed with the family. In each Inkolema field, farmers have an average number of bee colonies of 13 stups/hectare with Apis cerana bee colonies.

The average age of farmers who apply Inkolema is 39 years old, which is in the productive age category. According to WHO, the age that allows people to carry out daily activities and work efficiently and effectively is in the range of 15-64 years. The average education level of the research respondents showed that the dominant level of education was at the Senior High School (SMA / equivalent) level at 60%. Second at the junior high school level (SMP / equivalent) 18%, 12% undergraduate college, college diploma and elementary school each 5%.

Benefits of Inkolema on coffee and honey productivity

Coffee farmers in the research location as a whole calculate the amount of coffee production with units of bamboo (tumba) to cans, as a form of strengthening the value of local wisdom. The understanding of 1 can of coffee gelondong (cherry) amounts to 10 bamboos and the understanding of 1 bamboo of coffee gelondong weighs 1.2 kg. The process of determining the conversion is also carried out by weighing the weight of the coffee logs in 1 bamboo, which on average is 1.2kg. in general, the understanding of the coffee weight unit used is kilograms, so the unit in this research is kg. Calculation of Arabica coffee productivity value based on (Sudarmo, Sianturi, Kernalis and Aprollita, 2016) using the formula:

$$\text{Productivity} = \frac{Output}{Input} = \frac{Production\ Amount}{Land\ Area}$$

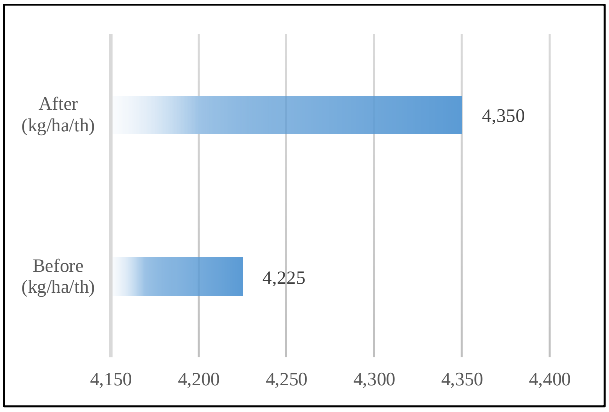

Figure 1. Cherry coffee productivity before and after Inkolema
(source: Inkolema primary data, 2024)

The results of the calculation of the productivity value of farmer's Arabica coffee beans before the application of Inkolema averaged 4,225 kg/hectare/year. After the cultivation of honey bees on coffee land, the average Arabica coffee productivity value rose to 4,350 kg/hectare/year, equivalent to an increase of 125 kg/hectare/year. These results increased after the integration of honey bees as many as 13 stups (colonies) per hectare. So it can be concluded that the application of Inkolema in Bener Meriah Regency provides real benefits in increasing coffee productivity by 2.87%. The increase is certainly higher than previous research by (Saepudin, 2013) in Kapihiang, Bengkulu Province, where the integration system of coffee plants with (Sinkolema) can increase coffee production by 10.55% with the use of 66 bee houses/hectare. Next research (Safrina, 2022) in Simalungun, North Sumatra Province, the number of bee houses 38 stup/hectare can increase coffee production by 5.95%.

The increased productivity of poppy coffee is influenced by the role of honey bees as pollination or coffee pollination. Pollination is an important event in the reproduction of seed plants, the process of pollen falling and meeting the stigma causes fertilisation. The mutual symbiosis between honey bees in assisting pollination and plants as a source of food provides excellent results for the ecosystem and increases crop yields. Slaa et al (2006) proved that bees can double agricultural production. The Department of Agriculture Food Western Australia (2009) reported that spreading bee colonies in agricultural areas can increase agricultural production with the number of bees spread. There was an increase in pollination in coffee plants placed 100 million worker bees during the flowering season so that coffee production increased by about 22%.

Honey bees also play a role as a reducer in pest control efforts on coffee plants, especially coffee fruit borers (PBKo). The attacked coffee fruit causes a decrease in the quality and quantity of coffee beans. The elevation of the coffee plantation location in this study is between 1,300 masl to 1,400 masl, so the level of PBKo pest attack is relatively small. Based on the observations of respondents and researchers, the PBKo pest attack after the application of Inkolema decreased by 1% from the previous average attack of 3%. Observations were made by taking samples of loose coffee fruit and putting them into water for soaking. Separating the floating coffee beans, then peeling the coffee fruit into wet coffee grains. This makes it easier for researchers to determine the number and weight of coffee beans infested with PBKo pests.

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The average number of bee colonies cultivated by farmers on Inkolema land is 13 stups/hectare. The total area of Inkolema land based on the number of samples in this study is 39.32 hectares. On this land, the amount of honey produced by farmers is 57.40 kg/hectare/year. So it can be concluded that the number of 1 bee colony (1 stup) on Inkolema land in Bener Meriah Regency can produce 4.42 kg of honey / year. In previous research by (Saprina, 2022) concluded that the honey production obtained on integrated land was 148 kg/ha/year or around 4 kg/colony/year. Another researcher (Ernawati, 2015) conveyed that honey production in Apis melifera in strawberry gardens before integration amounted to 25.55 kg / week and after integration 30.8 kg / week experienced an increase (17%). In the study (Saepudin, 2013), honey production from bee colonies placed dispersedly in the coffee plantation (4.08 kg/colony/year) was significantly higher than bee colonies placed centrally in the middle of the coffee plantation (2.60 kg/colony/year). This occurred as a result of heavy intraspecific competition for both food sources and places, especially mating places.

Benefits of Inkolema on farmers income

The calculation of farmers' income obtained from the sale of arabica coffee is in the form of logs. The aim is to obtain a homogeneous calculation so that it is easy to provide more targeted information. Likewise, the sales price of coffee logs before and after Inkolema was taken as the average price in 2023 and 2024, namely Rp.15,000 /kg. The price is based on the conversion of the purchase of coffee logs per bamboo, which is Rp.18,000. In accordance with the opinions of farmers and the results of field testing, the sampling of 1 bamboo of poppy coffee has an average weight of 1.2 kg after weighing.

Production costs consist of crop maintenance costs in the form of purchasing agricultural inputs and labour costs (HOK). Purchase of agricultural inputs in the form of fertiliser purchase costs and pesticide purchase costs. While labour costs (HOK) come from fertiliser application, pesticide application for weed eradication, pruning application, shade management application. Meanwhile, the cost or cost of harvesting coffee is calculated at a value of Rp.3,000 /kg of loose coffee.

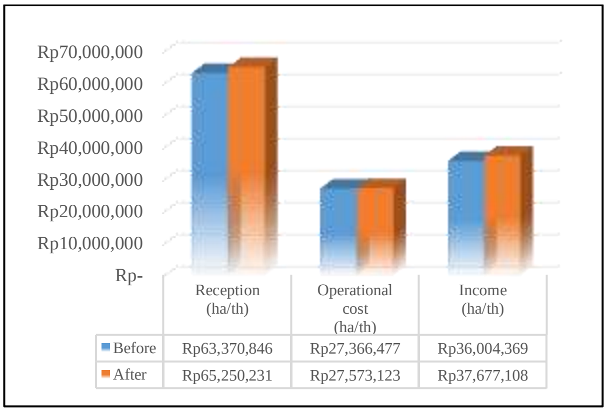


Figure 2. Income of coffee source farmers before and after Inkolema
(source: Inkolema primary data, 2024)

There is a difference in the income obtained by farmers from coffee sources alone before and after the implementation of Inkolema. Before the implementation of Inkolema, coffee farmers obtained income from coffee in the amount of Rp.36,004,369 /hectare/year. After the implementation of Inkolema, farmers' income increased by 4.44% to Rp.37,677,108 /hectare/year. The difference in the value of the increase in farmers' income before and after Inkolema is Rp.1,672,739 /hectare/year. Production costs incurred before Inkolema were Rp.27,336,477 /hectare/year, while production costs after Inkolema were Rp.27,573,123 /hectare/year. This condition is due to the addition of coffee harvesting costs on average of Rp.375,000 /hectare in accordance with the increase in coffee production volume after Inkolema, which is 125 kg/hectare.

Research (Saprina, et all., 2022) in Simalungun, the impact of the integration of coffee plants with beekeeping as many as 38 colonies can increase farmers' income by 5.55%. Financially, the income before integration was Rp.30,017,421 /hectare/year while after integration it was Rp. 31,682,087 /hectare/year. Calculation of farmers' income from honey is only calculated in conditions after Inkolema. The revenue obtained is based on the average amount of honey production of farmers 57.40 kg/hectare with the average price of honey sold at Rp.242,000 /kg. Meanwhile, the production costs of honey bee cultivation are only maintenance and harvesting, because most people get bee boxes and bee boxes from government assistance after attending training. Meanwhile, the cultivation location is already on their own coffee land, so farmers do not need to pay additional costs for the location of honey bee cultivation.

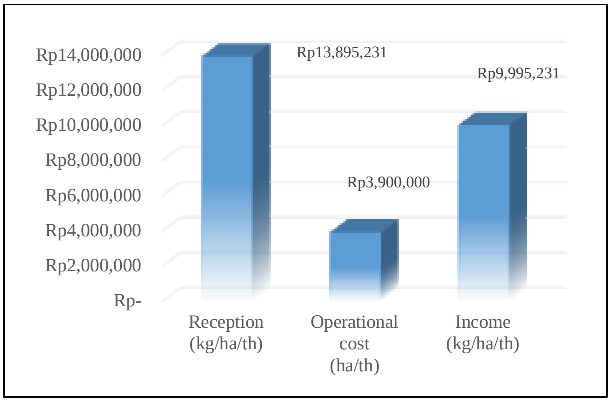


Figure 3. Income of honey source farmers on Inkolema land
(source: Inkolema primary data, 2024)

Farmer income obtained from the source of honey products averaged Rp.9,995,231 /year with an average receipt of Rp.13,895,231 /year and an average production cost of Rp.3,900,000 /year. Farmers' income after the application of Inkolema obtained from honey products is an added value of the coffee plant integration business with honey bees. In accordance with the objectives of the integrated farming scheme, which is an agricultural system that integrates the activities of crop, livestock, and fish sub-sectors to increase resource efficiency and productivity, increase independence and welfare of farmers in a sustainable manner (Arimbawa, 2015).

Inkolema's total income consists of revenue from coffee sales and honey sales. Production costs consist of total production costs of coffee production and total costs of honey production. Reduction is made with the production costs of coffee cultivation and honey bee cultivation. In the condition before Inkolema, revenue only comes from coffee sales only, as well as production costs only come from the total cost of coffee production. On the other hand, after Inkolema, revenues were obtained from coffee sales and honey sales. Next, production costs are sourced from coffee management and honey bee management.

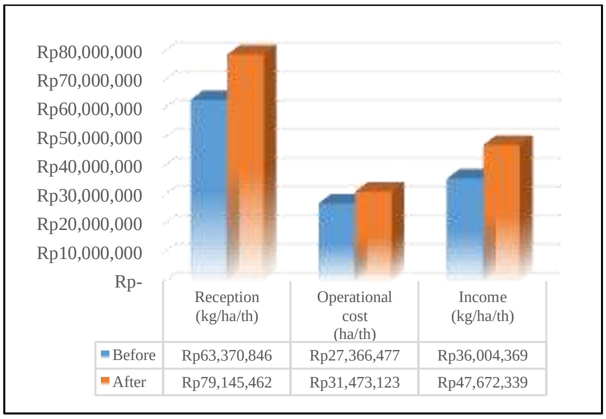


Figure 4. Farmers' income from coffee and honey sources before and after Inkolema
(source: Inkolema primary data, 2024)

Based on the figure above, it is clear that the total income of farmers before and after the application of Inkolema is very significant. After applying Inkolema with an average number of bee colonies of 13 stups/hectare, the total income of farmers increased by 24.48% from before applying Inkolema. The income obtained by farmers before Inkolema (only sourced from coffee) was Rp.36,004,369 /hectare/year. While the total income obtained after Inkolema increased to Rp.47,672,339 /hectare /year which is the result of selling coffee and honey. In the study (Saprina et all., 2022), the total income obtained by farmers before the application of integration was Rp.30,017,241 /hectare/year and after integration to Rp.66,165,702 /hectare/year with the number of bee colonies as many as 38 stups/hectare.

As stated by Sarah et al. (2019), to meet the needs of honey, Indonesia still imports from abroad reaching 2,117,424 kg / year, while the export position is only 206,990 kg/year. This condition is certainly a strategic potential for Bener Meriah Regency to take on the role as the archipelago's honey producer. Distanbun Aceh (2022) released that Bener Meriah has an Arabica coffee plantation covering 46,273 hectares, which is a smallholder plantation. If the government issues a policy for the application of Inkolema to 1% of the arabica coffee land area (4,627.3 hectares), it will be a great potential for new economic sources. It is certain that farmers will get added value from the source of increased coffee production and added value from the source of honey and other derivative products. The local government will also be able to increase its own revenue and the central government will earn foreign exchange from foreign transactions.

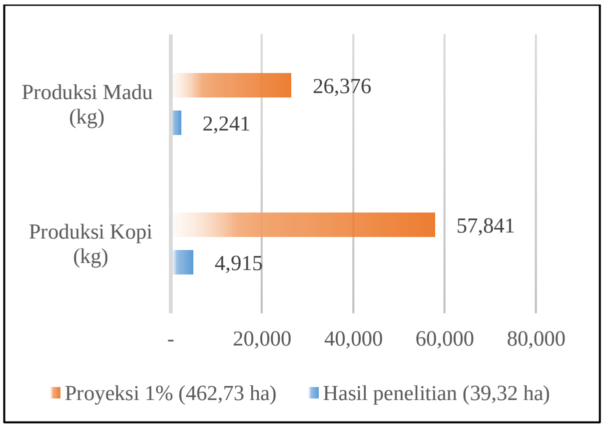


Figure 5. Projected opportunities for Inkolema in Bener Meriah Regency
(source: Inkolema primary data, 2024)

Figure 5 shows that the projection of 1% of Arabica coffee land for the application of Inkolema has the potential to increase the production of coffee logs by 57,841 kg/year and produce 26.376 kg/year of honey. If calculated according to the price (in the study) for the sale of log coffee and honey, the potential added value received by farmers in Bener Meriah is Rp.7,250,516,370 /year. In accordance with the research results, the application of Inkolema provides benefits to increase coffee productivity by 125 kg/ha/year and bees productivity 57,40 kg/hectare (13 stups), so that it benefits to increase farmers' income by Rp.11,870.231 /hectare/year.

Analysis of coffee productivity and farmer income

Data analysis on the normality test was carried out using SPSS software by selecting the analyse menu, select descriptive statistics, select explore. Move the two groups of data before and after Inkolema into the dependent list column, select plots, then activate normality plots with test, select continue and ok. The results of the data normality test from The four variables in the study are as follows:

Table 7. Normality test for data

Analysis Description	Shapiro-Wilk			Decision Making
	Statistic	df	Sig.	
Coffee productivity before Incolema	,977	65	,276	Data is normally distributed

Coffee productivity after Inkolema	,974	65	,180	Data is normally distributed
Farmer's income before Inkolema	,983	65	,523	Data is normally distributed
Farmer's income after Inkolema	,975	65	,271	Data is normally distributed

a. Lilliefors Significance Correction
Nilai = 0,05
Sig > 0,05 = data is normally distributed; Sig < 0,05 = data is not normally distributed

Source: Inkolema primary data (2024)

Based on the results of data normality testing in table 10 above, it shows that the results of the data normality test on coffee productivity before Inkolema sig. 0.276 and after Inkolema sig. 0,180. Likewise with farmer income before Inkolema sig. 0.523 and after Inkolema sig. 0,271. The above conditions show that the data normality test with the Shapiro-Wilk approach has a sig value. > than 0.05. So in this condition the researcher accepts H0 and rejects Ha, meaning that the data is normally distributed.

The paired sample t test is often referred to as the paired-sample t test, the test is carried out for paired sample data comparing two variables for a single sample group. This test also calculates the difference between the values of the two variables for each case and tests whether the average difference is zero. The data criteria for the paired sample t test are data for each pair tested on an interval or ratio scale and normally distributed data.

Data processing using SPSS, select the Analyze menu then the Compare Means sub menu and select Paired-Sample t-Tests. Move both data before in Variable 1 and after the Variable 2 Incolema in the Paired Variable column then select Ok.

Table 8. Paired sample t-test parametric statistical difference test

Analysis Description		Analysis Description		Paired Sample t-tes				
		Mean	N	Mean	t-hitung	df	Sig.	Decision
Pair 1	Coffee productivity before Inkolema	4.225	65	125	10.275	64	,000	Significantly different
	Coffee productivity after Inkolema	4.350	65					
Pair 2	Farmer's income before Inkolema	36.004.369	65	1.672.738	12.028	64	,000	Significantly different
	Farmer's income after Inkolema	37.677.108	65					

Source: Inkolema primary data (2024)

The first section shows the summary statistics of both pre-and post-incolema data. The average productivity before the application of Inkolema was 4.225 kg/hectare/year. Whereas after Inkolema the average coffee productivity increased by 2,87% to 4.350 kg/hectare/year. Secondly, the average farmer income before Inkolema was Rp. 36.004.369 /hectare/year, which increased after Inkolema application by 4,44% to Rp. 37.677.108 /hectare/year.

It can be seen that the application of Inkolema in Bener Meriah Regency can increase coffee productivity and increase farmers' income, so the first and second hypotheses in this study are correct. In the table above the results of t count on productivity before and after Inkolema sig value. 10,28 <0.05 and t count on farmer income sig. 12,03 < 0,05. So that the difference test of two paired data is stated to accept Ha because the average data before and after Inkolema is significantly different.

Sustainability benefits of Inkolema coffee farming

Measurement of the sustainability status of coffee plantations that have implemented Inkolema in Bener Meriah Regency in the ecological dimension is reviewed from 8 attributes. The results of the Rapcoffee analysis have determined the results of the mode value of the economic dimension presented in table 9.

Table 9. Mode values of ecological dimension attributes

No	Ecological Dimension Sustainability Attributes	Mode Value
1	Land suitability	3

2	Land elevation	3
3	Provision of shade plants	3
4	Coffee plant maintenance system	2
5	Utilisation of coffee waste	1
6	Intensity of pest attack	3
7	Pesticide use	2
8	Waste disposal	1

Source: Inkolema primary data (2024)

Based on the table above, the sustainability index result on the assessment of 8 attributes is 68.61%. These results mean that the ecological dimension of coffee plantations that apply Inkolema is quite sustainable. Next is the acquisition of a strees value of 0.14 and an R2 value of 0.95 which means that each attribute used in the environmental dimension is quite accurate. Research on the sustainability of coffee integration with honey bees in Kapahiang (Saepudin, 2013) showed a sustainability index in the ecological dimension of 84.20%, which means sustainable. Here The ordination diagram of the ecological dimension sustainability index based on respondents' answers is presented.

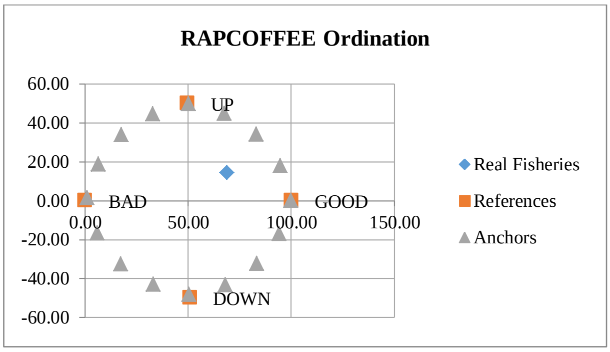


Figure 6. Ordination diagram of ecological dimension sustainability index
(source: Inkolema primary data, 2024)

The run-leverage test stage is carried out based on the mode value of each ecological dimension attribute that has been determined. The results of the ecological dimension analysis will show which attributes are most sensitive to the sustainability of coffee plantations that apply Inkolema.

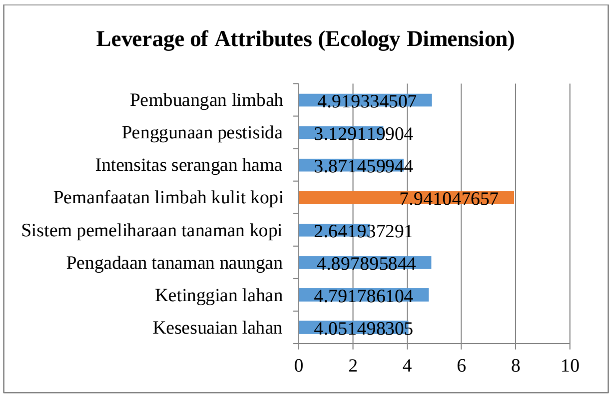


Figure 7. Sensitive diagram of ecological dimension sustainability
(source: Inkolema primary data, 2024)

The sensitive attribute in the ecological dimension of sustainability analysis is the utilisation of coffee skin waste. Coffee plants, apart from producing the main product in the form of coffee beans, also produce waste in the form of coffee skin, which is quite large. If coffee skin waste is not managed, it will become a source of spreading pests and plant diseases and potentially pollute the environment. Whereas coffee skin waste can be used as fertiliser for coffee plants as well as feed for ruminants including goats.

The content of nutrients contained in coffee fruit skins such as crude protein of 10.4% crude fibre of 17.2% and metabolic energy of 14.34 Mj/kg (Zainuddin and Murtisari, 1995).

Coffee skin waste should be managed so that farmers get added value in an effort to turn waste into rupiah. The utilisation of coffee skin waste must also ensure that the coffee skin waste has become compost. Avoid the use of coffee husk waste given directly to plants because it will make plants stressed to death. Apart from being useful as a plant fertiliser and source of animal feed, coffee husk waste also provides benefits. Other efficiencies towards reducing farmers' input production costs in terms of mobility (transport).

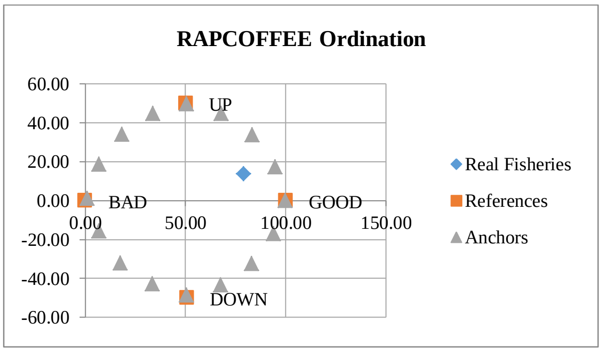
There are eight sustainability attributes studied in the economic dimension that describe the sustainability status of coffee plantations that have implemented Inkolema. The results of the accumulated scores in the form of mode values on each attribute of the economic dimension are presented in Table 10.

Table 10. Mode value of economic dimension attributes

No	Economic Dimension Sustainability Attributes	Mode Value
1	Product price	3
2	Market access	3
3	Contribution to farmer income	3
4	Financial viability	3
5	Income comparison with district minimum wage	1
6	Meeting household food needs	3
7	Land area	1
8	Competitiveness of coffee	3

Source: Inkolema primary data (2024)

The results of the run rap-coffee analysis show the results of the sustainability index in the economic dimension of 78.95%. The acquisition of a stress value of 0.14 and a determination value R2 of 0.94, so it can be concluded that all attributes in the economic dimension are declared accurate. The following can also be seen the ordination diagram of sustainability in the economic dimension of the coffee plantation application of Inkolema.



Gambar 8. Economic dimension sustainability index ordination diagram
(source: Inkolema primary data, 2024)

The results of run-leverage sustainability data for each economic dimension attribute can be seen in Figure 9 below:

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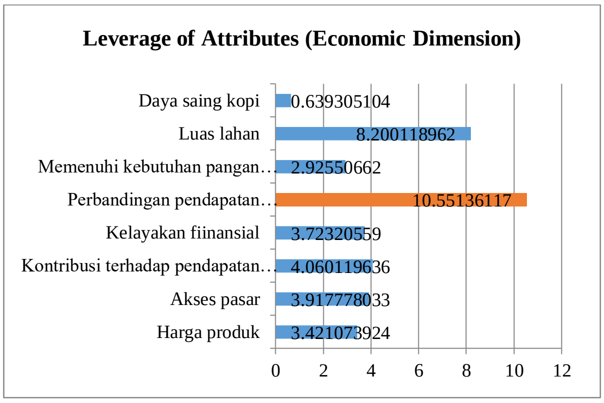

Figure 9. Dimensional sustainability sensitive attribute economic diagram
(source: Inkolema primary data, 2024)

Based on the results of run-leverage sustainability data on each attribute of the economic dimension, sensitive attributes are (1) income comparison with district minimum wage and (2) land area. Efforts to support sustainability in the economic dimension, the above attributes need to be a common concern. Research data on the average income earned by coffee farmers before the application of Inkolema Rp.2,072,750/month and after the application of Inkolema Rp.2,496,750/month after Inkolema. While the determination of the minimum wage of Bener Meriah district is Rp.3,413,666/month. There is a difference in value of Rp.916,916 per month between farmers' income and the stipulation of the MSE of Bener Meriah Regency. The average coffee plantation area owned by farmers in the research location is 0.6 hectares, while the number of farmer dependents is 3 people. This condition is certainly a factor constraining farmers to meet the economic needs of the family.

There is a government policy to meet the needs of life by cultivating narrow land (Miranda et all., 2020). Efforts to increase farmers' income can be made by increasing the area of production land, in this case, coffee plantations. Another strategy is to implement land integration which has become a global scheme. An agricultural system that integrates the activities of crop, livestock, and fish sub-sectors to increase the efficiency and productivity of resources (land, people, and other growing factors), increasing the independence and welfare of farmers in a sustainable manner (Arimbawa, 2015).

The UN Convention in 2015 has formulated the concept of sustainable development Goals (SDGs), the sustainable formulation consists of three main pillars that are mutually sustainable, namely economic, social and environmental. The economic pillar focuses on orderly economic growth, paying attention to efficiency, quality of life innovation, creating decent jobs, developing productive markets and saving resources and energy. According to Kathleen (2011), the benefits obtained from integrated cropping systems in the economic aspect are increased yield quality, reduced costs, and able to create product diversification.

Attributes or variables in the social dimension are the main factors that affect the social conditions of coffee farming communities. The determination of sustainability attributes in the social dimension is determined as many as 10 attributes. the following are the results of the attribute scoring presented in table 11 below.

Table 11. Mode value of social dimension attributes

No	Social Dimension Sustainability Attributes	Mode Value
1	Age of farmer	3
2	level of formal education.	3
3	Participation in education	1
4	Knowledge of coffee plantations	3
5	The formation of farmer groups	2
6	Legal entity of farmer group	2

7	Community role in coffee farming	3
8	The role of extension organisations	1
9	Social system	3
10	Status of land ownership	3

Source: Inkolema primary data (2024)

Table 11 above writes the results of the sustainability index analysis in the social dimension of 72.20%. So that the sustainability status of the application of Inkolema shows that the results in the social dimension are categorized as quite sustainable. The accuracy of scoring and inputting data on each attribute is evidenced by a stress value of 0.13 and an R value of 0.95. The following are the results of the analysis of the sustainability ordination diagram on the social dimension.

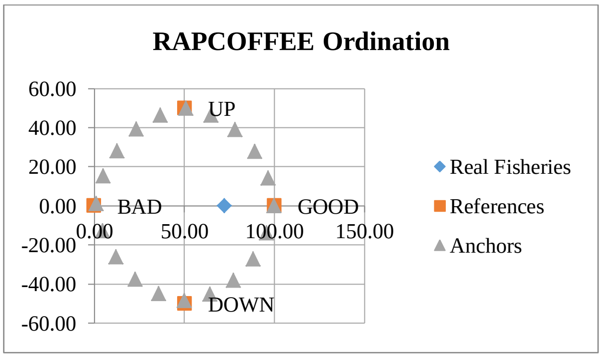

Figure 10. Ordination diagram of social dimension sustainability index
(source: Inkolema primary data, 2024)

In order to obtain the influential attributes and the most sensitive attributes, a data run-leverage test was conducted on each attribute. In the social dimension, the attribute that most supports the value of sustainability is the age of farmers. The average age of farmers who are respondents in this study is at a productive age of 39 years. According to WHO, the age that allows people to carry out daily activities and work efficiently and effectively is in the range of 15-64 years. So the age of farmers who apply Inkolema in Bener Meriah is still very productive so that they have good thinking and energy is still relatively strong. Meanwhile, the most sensitive attribute in the social dimension is the involvement of the world of education. The participation of the world of education in relation to education, research and service is needed by farmers to develop the Inkolema concept that has been applied.

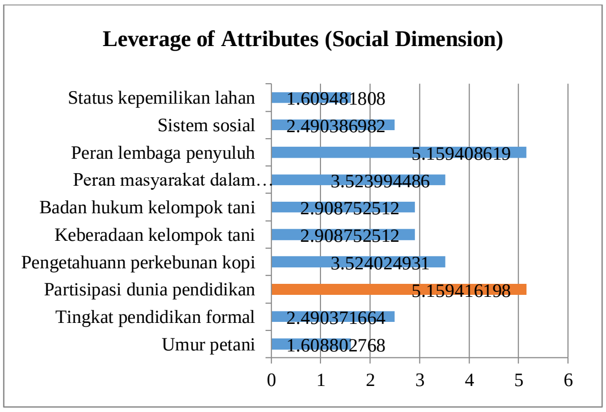

Figure 11. Diagram of the sensitive attributes of the social dimension of sustainability
(source: Inkolema primary data, 2024)

The leverage test results in Figure 11 show that in the social dimension there is a sensitive attribute in the form of education participation. The support of the world of education is an important factor, where the world of education is an instrument of study and publication for the progress of coffee plantations.

Multidimensional sustainability status of Inkolema coffee farming

Rapcoffee MDS testing is based on the sustainability index and an assessment of the possibility of uncertainty in the data and information obtained. The assessment was carried out with the Monte Carlo test, so this research has a confidence level at the 95% level. If the MDS analysis on the sustainability index of the Rapcoffee Test and the Monte Carlo Test results produce a value of less than one, then the data analyzed is in accordance with real conditions (Kavanagh and Pitcher 2004; Fauzi and Anna 2013).

Based on the results of the Monte Carlo test, the difference value in the ecological dimension is 68.61%, in the economic dimension 78.11% and the social dimension 71.33%. The difference in value between the sustainability index and monte carlo in the ecological dimension is 0.95, the economic dimension is 0.94 and the social dimension is 0.95. So it can be concluded that the difference between the MDS sustainability index and Monte Carlo is less than one. There is high trust in the system under study, it can avoid errors in the data input process and the information obtained from respondents is correct. In accordance with the submission (Kavanagh and Pitcher 2004; Fauzi and Anna 2013), if the difference between the results of MDS analysis and Monte Carlo results is less than one, then the programme being analysed is in accordance with real conditions. MDS analysis is considered adequate if the difference value between the two analyses is less than 5% at the 95% confidence level (Rasihen, 2021).

Table 12. MDF and monte carlo scores of sustainability categories

Dimensions of Sustainability	Indeks (%)	Monte Carlo (%)	Differen ce (%)	Stress	R^2	Status
Ecology	68,61	68,06	0,55	0,14	0,95	Moderately Sustainable
Economic	78,95	78,11	0,84	0,14	0,94	(Good) Sustainable
Social	72,20	71,33	0,87	0,13	0,95	Moderately Sustainable
Multidimensional Value	73,25%					Moderately Sustainable

Source: Inkolema primary data (2024)

The results of Rapcoffee with the MDS sustainability index ordination show that the status of coffee cultivation that applies Inkolema in Bener Meriah Regency is included in the moderately sustainable category at 73.25% (Yusuf et al., 2022). The sustainability index value is obtained based on an assessment of 26 sustainability attributes. The sustainability value in the ecological dimension is 68.61% with an assessment of 8 attributes, the economic dimension is 78.95% with an analysis of 8 attributes and the social dimension is 72.20% with an assessment of 10 attributes.

Table 14 shows that the Stress value of MDS analysis of each dimension has each dimension has a value smaller than 2.5%, meaning that the smaller the Stress value, the better the MDS analysis output. The coefficient of determination (R2) value in each dimension shows the results of monte carlo analysis conducted 25 times repetition at the 95% confidence level, it appears that the ordination model that has been done is a good model because the errors that occur in the ordination determination process are very small. These results show that the analysis of the sustainability of coffee cultivation in Bener Meriah Regency needs to pay attention to 5 sensitive attributes, namely (1) utilization of coffee skin waste, (2) waste disposal, (3) comparison of income with district minimum wage, (4) land area (5) participation in education and (6) the role of extension workers.

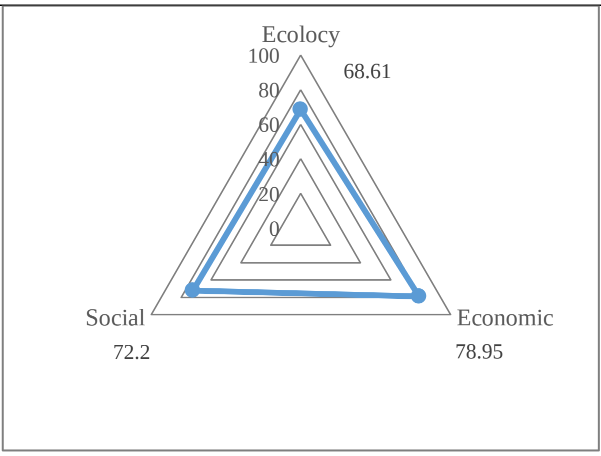

Figure 12. Sustainability analysis flyer diagram
(source: Inkolema primary data, 2024)

CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn: Inkolema is designed based on integrated coffee cultivation activities with honey bee cultivation carried out in an integrated and environmentally sound manner, thus providing mutualism symbiotic benefits to increase coffee and honey production and increase farmers' income.

Coffee productivity before and after Inkolema is significantly different, where the average coffee productivity before Inkolema increased by 2,87%, thus providing mutualism benefits for coffee plants in the function of pollination and pest control, as well as for bees as bee pollen as a source of food source.

Farmers' income before and after Integration is also significantly different, where the average income of farmers from coffee sources increased by 4,44%. so that Inkolema is an alternative choice for farmers to increase family income.

Coffee farming that applies Inkolema in Bener Meriah Regency obtained an average sustainability index value from the ecological dimension, economic dimension and social dimension of 73,25%, meaning that it is quite sustainable, but there are several attributes that need to be improved in the form of utilization of coffee skin waste, waste disposal, income comparison with district minimum wage, land area, education participation and the role of extension workers.

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