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Integrated Farming of Crops and Livestock: Effects on Cashew Farming Income in Sumenep Regency

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ABSTRACT

The integration of crops and livestock is a common practice in agriculture, particularly within the cashew farming sector. This approach supports the efficient use of limited land resources and promotes sustainable agricultural development. Nevertheless, its economic implications for farmers warrant closer investigation. This study was conducted to examine the relationship between integrated farming practices and farm income in Sumenep District, East Java Province. The analysis employed the 4F framework (food, feed, fuel, and fertilizer) as the basis for integrated farming practice. The study used a quantitative approach. A total of 40 farmers were collected for the study and analysed using frequency distribution, income analysis, and the Chi-Square test). Most farmers applied the 3F system, with two variations: food–feed–fertilizer and food–fertilizer–fuel. An average income was Rp 24,369,217 per hectare, however, the majority of farmers reported income levels below Rp 5 million. The Chi-Square analysis revealed a statistically significant association between the implementation of integrated farming (through the 4F framework) and the income of cashew farmers. Further intervention is needed to strengthen integrated farming practices in order to improve farmers' income.
Keywords**:** Integrated farming, 4F (food, feed, fuel, dan fertilizer), cashew-livestock, income

INTRODUCTION

Food security and farmer welfare are critical issues for Indonesia. Achieving synergistic development that ensures both food security and farmer welfare in the agricultural sector remains difficult. According to Swastika et al (2024), Indonesia faces significant challenges in meeting food demand with a population of approximately 270 million. One major challenge is that most Indonesian farmers cultivate small plots of land (0.1–0.5 ha), with land use that is often suboptimal (Kadir, 2020). In addition to this, agricultural land decreased from 8.4 million hectares in 1990 to 7.18 million hectares in 2022 (Ivanka et al., 2024). This decline has created pressing challenges for food security, community welfare, employment opportunities, natural resource sustainability, global market competitiveness, and climate change, all of which must be anticipated (Swastika et al., 2024).

One of strategies to strengthen food security under limited land conditions is the adoption of integrated farming systems. Integrating plantation crops and livestock represents a promising model for agricultural development. Crop–livestock integration is a highly efficient agricultural practice and has long been embedded in Indonesian farming culture. Nyoman (2020) noted that crop–livestock integration is particularly suitable for rural agricultural development. Previous studies have demonstrated the benefits of

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crop–livestock integration. Feronika et al. (2020) showed that Palm–cattle integration utilized palm fronds, leaves, and weeds as cattle feed, while cattle manure enhanced soil fertility for oil palm cultivation. Nyoman (2020) also found that integrating coffee with goats improved soil fertility through goat manure, thereby increasing coffee yields and farmer income. Next, Syafruddin (2022) reported that cocoa–goat integration reduced feed and fertilizer costs.

These previous studies underscored the potential of integrated systems to improve productivity and income. This practice should not only leads to the mutually beneficial relationship between crops and livestock within integrated systems, but also the land use is optimized and waste from one component is utilized by the other in order to get economic benefit (Parulian et al., 2019). However, such integration should be implemented sustainably with the support of science (Kadir, 2020). Sumekar et al. (2023) further introduced the 4F concept (food, feed, fuel, fertilizer), which enables farmers to transform agricultural waste into valuable resources, thereby enhancing efficiency and profitability. By embedding the 4F framework into farming systems, farmers can achieve not only higher economic returns but also ecological sustainability through waste recycling, resource efficiency, and long-term productivity.

Cashew (*Anacardium occidentale L.*) is one of the strategic commodities in Indonesia with strong potential for integrated farming system. Hidayati et al. (2021) noted that cashew trees can serve both food and feed purposes within integrated systems. Cashew–livestock integration offers opportunities for investment while simultaneously alleviating poverty among farmers. Data from the Central Bureau of Statistics (BPS, 2021) show that cashew nut exports reached 62,472.785 tons, valued at USD 118 million. East Java Province is one of Indonesia's major cashew-producing regions (Nurdiansah et al., 2022). It also has significant livestock potential, particularly poultry and beef cattle, with the highest production levels recorded in East Java (Widianingrum & Septio, 2023). In this province, Madura Island has most potentials for cashew sector and cattle development Especially Sumenep Regency, cashew plantations cover 11,301 hectares, producing 334,200 tons—the highest yield in the region (Syaifullah et al., 2021).

Given above, the potential integration of cashew plantations with livestock in Sumenep Regency warrants investigation to assess its impact on farmer income. The objective of this study is to examine the relationship between integrated farming and farmer income in Sumenep Regency. The integrated farming need to use the 4F framework to provide valuable insights for policymakers and institutions in designing agricultural strategies, particularly in relation to cashew and livestock development.

RESEARCH METHOD

Study area and samples

The study was conducted in Jelbudan Village, Dasuk Subdistrict, Sumenep Regency in September up to December 2024. This Regency is recognised as the center of cashew production in East Java Province and received 'cashew belt' program from the government for cashew intensification-extensification (Kementrian Pertanian, 2022). This strategic designation underscores the importance of Sumenep as a key hub for cashew development, making the findings of this study highly relevant for regional agricultural policy and future sustainability initiatives.

This study employed a quantitative approach. Respondents were selected purposively, with the criteria that they practice cashew farming and raised

livestock. A total of 40 cashew farmers were included in the sample. This sample size was guided by Sugiyono (2016), who states that a minimum of 30 respondents is appropriate for studies of this nature. Previous research supports this benchmark: Syafruddin (2022) examined cocoa–goat integration and its impact on farmer income using 40 respondents; Mama et al. (2023) employed 30 respondents to analyze income from integrated sugarcane–beef cattle farming; Wutwensa et al. (2022) used 30 respondents to assess coconut–beef cattle integration. These precedents demonstrate that the chosen sample size is consistent with established research practices in integrated farming studies.

Analysis

A series of quantitative analysis was conducted. First, descriptive statistics were applied to examine the general characteristics of respondents (e.g., demographics, age, number of cashew trees, etc.). This analysis utilized frequency distribution measures such as percentage, mean, and median. It was also used to identify farmers' activities related to the 4F framework (food, feed, fuel, and fertilizer), which were categorized into four levels, adapted from previous studies (Sumekar et al., 2023). The application of the 4F framework was classified as follows: (1 = application of one F; 2 = application of two Fs; 3 = application of three Fs; 4 = application of all four Fs).

Next, an income analysis was conducted to determine the level of farmers' earnings. The income analysis of integrated cashew–livestock farming can be formulated as follows (Amal et al., 2022):

1. Income

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

Notes: π= Cashew farming Income (Rp/year); TR = Total Revenue from cashew farming (Rp/year); And TC = Total Cost of cashew farming (Rp/year)

2. Total Cost

$$TC = TFC + TVC \quad (2)$$

Notes: TC= Total Cost of cashew farming (Rp/year); TFC= Total fixed Cost of cashew farming (Rp/year); TVC= Total variable Cost of cashew farming (Rp/year)

3. Total Revenue

$$TR = P \times Q \quad (3)$$

Notes: TR= Total Revenue from cashew farming (Rp/year); P= Price of cashew nuts (Rp/Kg); Q= Production (Kg)

The final analysis was conducted using the Chi-Square test, which aims to examine whether two variables are related. In this study, the test was applied to determine the relationship between the application of the 4F framework and cashew farmers' income. The dependent variable was farmers' income, which was divided into three categories: below 5 million, between 5 million and 10 million, and above 10 million rupiah (Table 1). This classification follows earlier studies: Kaharuddin et al. (2019) identified income levels below and above 5 million rupiah, Alfian et al. (2020) reported an average income of 5 million rupiah; Molebila et al. (2022) observed income levels above 10 million rupiah. This study applied a 95% confidence level or p-value (0.05). The testing criteria were as follows: if the p-value ≤ 0.05, there is a significant relationship between the implementation of the 4F framework and farmers' income; whereas if the p-value > 0.05, no significant relationship exists (Latif et al., 2022).

Table 1.
Income categories

No	Income	Category
1	< Rp. 5.000.000	1
2	Rp. 5.000.000 – Rp. 10.000.000	2
3	> Rp. 10.000.000	3

RESULTS AND DISCUSSION

Characteristics of Respondents

The characteristics of respondents in this study (Table 2) include gender, age, education, farming experience, membership in farmer groups, farming objectives, land ownership status, farming method, and land size. The majority (60%) of respondents are women. One reason for the high number of female respondents in this study is that women are more often present at home or on the farm. However, statistical data (BPS, 2023) mentioned that the female population in Jelbudan Village of Sumenpe Regency (1,804 individuals) is larger than the male population (1,567 individuals). Meanwhile, this finding contrasts with the study of Saghu et al. (2021), which reported that cashew farming was predominantly carried out by men.

Cashew farmers in Sumenep are largely within the productive age group (95%), ranging from 15 to 64 years. According to some studies (Gela et al., 2021; Sumekar et al., 2023), especially the age range of 15–55 years is considered productive, as farmers at this stage generally possess strong physical capacity and maturity in decision-making. Meanwhile the age range over 55 years old up to 64 is considered late productive. Next, the education level of cashew farmers remains relatively low, with nearly half (48%) having only completed primary school. As noted by Gela et al. (2021), farmers are often dominated by minimal education levels. Yet, Amal et al. (2022) emphasized that education is a key factor in helping farmers improve their farming practices, as it enables them to respond more effectively to changes in agriculture. Despite their limited formal education, most cashew farmers have extensive farming experience, with 80% reporting more than 10 years of involvement. This long experience is attributed to cashew farming being practiced from childhood and passed down across generations. This aligns with the findings of Syathori & Verona (2020), who noted that farmers often have long-term experience exceeding 10 years. Similarly, Wutwensa et al. (2022) argued that extended farming experience contributes to better cost management practices.

Another notable characteristic is farmer group membership. The majority of cashew farmers (93%) are not members of farmer groups, which warrants attention. Hidayati et al. (2023) highlighted that farmers who are not part of farmer groups miss opportunities to develop their farming practices. The limited number of farmers joining farmer groups also prevents collective integration efforts, particularly in supporting post-harvest processing. However, the study found that most farmers (70%) cultivate cashew as a supplementary source of income. It is because cashew is a perennial crop often intercropped with seasonal commodities. Cashew farming is generally practiced in intercropping systems, where farmers focus more on cultivating their main seasonal commodities such as maize, peanuts, and others. According to Khoirunisa & Santhyami (2023), cashew is typically grown in intercropping systems, where seasonal crops serve as the main source of income while cashew provides additional income. Farmers also raise

livestock such as chickens, goats, and cattle.

Next, in terms of land ownership, the majority of farmers (85%) inherited their farmland, and all respondents cultivate cashew on their own land. Landholding size among farmers is generally small. A single plot of land is equivalent to 0.0625 ha, and most farmers own fewer than five plots, amounting to less than approximately 0.3 ha.

Tabel 2.
Characteristics of Cashew Farmers in Jelbudan Village, Dasuk Subdistrict, Sumenep Regency

No	Categories	Frequency	Percentage%
1	**Gender**		
	a. Male	16	40
	b. Female	24	60
2	**Age (Year)**		
	a. Productive age (15-64)	38	95
	b. Non-Productive age (>64)	2	5
3	**Education**		
	a. University/College	1	3
	b. Senior High School	4	10
	c. Junior High School	7	18
	d. Elementary School	19	48
	e. Not finished school/no education	9	23
4	**Experience**		
	a. < 5 years	0	0
	b. 5-10 years	8	20
	c. > 10 years	32	80
5	**Farmer group membership**		
	a. Yes	3	8
	b. No	37	93
6	**Purpose**		
	a. Main Income	12	30
	b. Additional Income	28	70
7	**Land status**		
	a. Owned	40	100
	b. Rent	0	0
9	**Farming method**		
	a. Mixed farming	28	70
	b. Mono farming	12	30
10	**Area**		
	a. < 5 Plots	32	80
	b. 5-10 Plots	8	20
	c. > 10 Plots	0	0

Sumber: Data Primer Diolah, 2024

Cashew farming is thus passed down from generation to generation. Murnilayati et al. (2020) noted that farmers who own land generally achieve higher income compared to those who rent land.

Implementation of Integrated Farming Model

Farmers have already adopted integrated farming practices. Based on Table 4, cashew farming generally applies integrated farming in various forms, rather than relying solely on food as a single benefit. Cashew trees produce fruit, nuts, and shells. Cashew nut is the main product, primarily used for food. The fruit is used as animal feed, consumed directly, or sold in markets. Marketable fruit refers to ripe cashew apples ready for consumption, categorized as food. When cashew nuts are shelled, the cashew shells can be sold and also serve as fuel for local lime factories. In addition, waste from cashew farming and livestock is utilized. Cashew farmers utilize natural resources such as livestock manure as a source of nutrients for cashew trees. The application of livestock manure also improves soil structure and texture, thereby accelerating root development. Ngawit et al. (2024)found that the use of livestock waste as fertilizer positively affects cashew growth, including the number of leaves, branches, and the weight of cashew apples. The absence of unused waste from crops and livestock indicates that cashew farmers have long practiced farming (>10 years), with considerable efforts devoted to managing both cashew and livestock farming. Their maturity in thinking and acting has become a supporting factor in effectively utilizing agricultural waste.

Table 3.
Implementation of integrated farming (4F) in cashew farming

Implementation category	Frequency	Percentage %
4F	9	23
3F	22	55
2F	9	23
1F	0	0

The results of integrated farming practices among cashew farmers in Jelbudan Village show that the highest proportion (55%) of farmers applied 3F. This finding is consistent with the study of Sumekar et al. (2023), which reported that more farmers implemented 3F than 4F. Similarly, Nyoman, (2020) found that in integrated coffee–goat farming systems, the majority of farmers also applied 3F (food, feed, and fertilizer). The application of 3F among farmers shows two type of variations: food–feed–fertilizer and food–fertilizer–fuel. Meanwhile, the implementation of 4F and 2F was found in 23% of farmers. The 2F application consisted of food and fertilizer. Few farmers have adopted 4F because not all of them own cashew shelling equipment, which is necessary to get the cashew shell to be used for fuel. In addition, farmers prefer selling cashew nuts in raw form rather than shelled.

Income Analysis

The income generated by cashew farmers presented in Table 4 shows that farmers in Sumenep Regency earned an average income of Rp 24,369,217 per hectare.

This income is considered relatively high (above Rp 20 million per hectare). the average cashew production per farmer was 1,217 kg/ha. Farmers sell cashew nuts in dried form (sun-dried for 3–4 days) at an average price of Rp 22,563. this price is considered high and is intended for export. As reported by Hidayati et al (2021a), more than 70% of Indonesia's cashew production is exported to Vietnam and India, including from Madura Island. The substantial average income is largely due to cashew farming being passed down across generations. In addition, land ownership significantly reduces production costs. Lower costs are also attributed to the integration of cashew farming with livestock, which helps minimize expenses such as fertilizer. Farmers rarely carry out cashew tree replanting, as regeneration often occurs naturally (with seeds germinating on their own).

Table 4.
Income Analysis

No	Item	Total
A	**Fixed cost**	
	Hoe (Rp)	Rp 23.480
	Sickle (Rp)	Rp178.936
	Axe (Rp)	Rp 29.267
	Total Fixed Cost	Rp 231.682
B	**Biaya Variabel**	
	Labourer7:	Rp2.854.233
	Total Variable Cost	Rp2.854.233
C	**Total Cost (Fixed + Variable Cost)**	Rp3.085.916
D	**Revenue**	
	Price (dry in-shell nuts) (Rp)	Rp 22.563
	Production (Kg)	1217
	Total Revenue (Price x Production)	Rp 27.455.133
E	**Income (Revenue-Total Cost)**	Rp24.369.217

Source: Primary data, processed, 2024

The fixed costs incurred by cashew farmers amounted to Rp 231,682, which is relatively small. Land costs are not included because all farmers use their own land and do not pay taxes, as taxes are fully covered by the village administration. Meanwhile, farmers only use simple tools such as sickles (Rp 178,936), hoes (Rp 23,480), and axes (Rp 29,267). These tools are rarely used, as maintenance activities are relatively simple, such as pruning, cutting grass, and trimming branches, which are not performed daily. Meanwhile, the variable costs in this study refer to labor expenses. Labor costs support cashew production activities, including replanting, weeding, fertilizing, and harvesting. The total production cost incurred was Rp 3,085,916 per hectare, or Rp 192,870.

Relationship Between 4F Application and Income

The Chi-Square test results on the relationship between the 4F framework and cashew farmers' income in Jelbudan Village, Dasuk Subdistrict, Sumenep Regency is presented in Table 5.

Table 5.
The Relationship Between 4F Application and Farm Income

Income (Rp)	Implementation of Integrated Farming						*P-Value*
	2Fs		3Fs		4Fs		
	N	%	N	%	N	%	
< 5 millions	7	17.5%	13	32.5%	9	22.5%	
5– 10 millions	0	0.0%	7	17.5%	0	0.0%	0.050
>10 millions	2	5.0%	2	5.0%	0	0.0%	

Source: Primary data processed 2024

Farmers with incomes below Rp 5,000,000 were most likely to apply 3F (13 farmers). The p-value obtained was 0.05 (≤ 0.05), thus H1 was accepted. This indicates a significant relationship between the application of integrated farming and farmers' income in Jelbudan Village. Integrated farming practices help reduce production costs. On average, farmers applying 3F produced manure, animal feed, and food. Cashew farmers also had more than 10 years of experience, enabling them to implement mutually beneficial practices across their farming activities. These findings are consistent with another study (Wutwensa et al., 2022), who reported that integrating coconut farming with beef cattle reduced costs by utilizing crop and livestock waste for feed and fertilizer. This study therefore contributes novel empirical evidence by showing that cashew–livestock integration in Madura not only reduces costs but also strengthens farmers' resilience through long-term experience and resource efficiency.

These further highlight that farmers' demographic characteristics—such as their predominance in the productive age group, extensive farming experience (often exceeding 10 years), and inherited land ownership—contribute significantly to their resilience and ability to sustain farming practices across generations. Despite limited formal education and low participation in farmer groups, cashew farmers have achieved relatively high average incomes, supported by natural resource utilization and intercropping systems. Thus, integrated farming not only strengthens farmers' economic outcomes but also supports ecological balance through waste recycling. Expanding farmer group participation and improving access to post-harvest technologies could further enhance the benefits of integrated farming, ensuring greater resilience and competitiveness for cashew farmers in Sumenep Regency and beyond.

CONCLUSION

This study demonstrates that cashew farmers in Jelbudan Village, Sumenep Regency have long practiced integrated farming systems that combine cashew cultivation with livestock management. The application of integrated farming through the 4F framework (food, feed, fuel, and fertilizer) has proven to be an effective strategy for reducing production costs, utilizing agricultural and livestock waste, and enhancing farm sustainability. Most farmers applied 3F, particularly food–feed–fertilizer, which reflects both resource availability and practical constraints such as limited access to shelling equipment. The Chi-Square analysis confirmed a significant relationship between the application of integrated farming (4F) and farmers' income, reinforcing the theoretical and empirical evidence that integration enhances efficiency and profitability. This study contributes novel insights by contextualizing integrated farming within cashew–livestock systems in Madura, showing that long-term experience,

resource efficiency, and waste utilization are key drivers of sustainability and income improvement. Further research is needed to explore the integration of cashew farming and livestock in Indonesia, as this study has not fully captured practices across the entire country. Expanding the coverage to more areas would provide a clearer picture of integration patterns. Strengthening farmer group participation, improving access to post-harvest technologies, and promoting the 4F framework (food, feed, fuel, fertilizer) are also recommended to enhance efficiency, reduce costs, and support sustainable farming systems.

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