Farmers' perception of the integrated farming system of arrowroot and livestock in supporting a zero-waste agriculture system

Fanny Widadie*, *Endang Siti* Rahayu, *Heru* Irianto, *Sugiharti Mulya* Handayani, *Setyowati, and Mei Tri* Sundari

Agribusiness Department, Faculty of Agriculture, Universitas Sebelas Maret

Abstract. The integrated farming system plays an important role in supporting zero-waste agriculture. This study aims to describe the implementation of the integrated farming system of arrowroot and livestock adopted by arrowroot farmers, analyze the farmers' perception of this integrated farming system, and analyze the relationship between farmers' perception and their socio-economic conditions. The research was conducted on 91 members of women's farming groups in Pengasih District, Kulonprogo Regency, and in Prambanan District, Sleman Regency, Yogyakarta Special Region Province. These groups practice an integrated farming system combining arrowroot cultivation and livestock. The results show that the integrated farming system of arrowroot and livestock supports sustainable agriculture, particularly zero-waste, by reducing agricultural and livestock waste. Farmers have a positive perception of the integrated system, especially regarding production efficiency and environmental benefits. Farmers' perceptions are positively correlated with household involvement in farming, educational level, and active participation in farmer groups, and negatively correlated with farmers' risk levels.

1 Introduction

Sustainable agriculture has become increasingly important as global demand rises for environmentally friendly and resource-efficient farming practices. One approach gaining attention to achieve these goals is the Integrated Farming System, which combines various agricultural activities, such as crop and livestock farming, into one system to maximize resource use and minimize waste [1]. This approach is considered a potential solution to support zero-waste agriculture, where by-products from one process are used as inputs for another [2].

The integrated farming system between arrowroot (*Maranta arundinacea*) cultivation and livestock farming is an example of this approach. Arrowroot, a local food crop with high potential, is integrated with livestock farming in a mutually beneficial system. Livestock waste, such as animal manure, can be used as organic fertilizer for arrowroot crops, while arrowroot harvest residues can be used as animal feed. By integrating these two systems,

* Corresponding author: fannywidadie@staff.uns.ac.id

resource efficiency and waste reduction are achieved, supporting the concept of environmentally friendly sustainable agriculture [3]

Previous studies have shown that integrated farming systems offer various benefits, both economically and environmentally. For example, research by [4] indicates that integrated farming systems can increase land productivity by utilizing the synergies between crops and livestock. Additionally, these systems reduce reliance on external inputs like chemical fertilizers, potentially lowering operational costs for farmers while reducing negative environmental impacts [5]. Further research by [6] suggests that integrated farming systems can enhance food security in rural areas by diversifying production and increasing farmers' incomes.

However, the success of implementing integrated farming systems depends not only on their technical potential but also on how farmers perceive and accept them. Farmers' perceptions are crucial in determining how widely these systems can be adopted. Farmers' attitudes and views on integrated farming systems are influenced by various factors, including their socio-economic conditions, level of participation in farmer groups, and risk perceptions [7].

This study aims to describe the implementation of the integrated farming system between arrowroot and livestock, analyze farmers' perceptions of the system, and analyze the relationship between these perceptions and farmers' socio-economic characteristics. By understanding farmers' perceptions and the factors influencing them, this study hopes to provide valuable insights for developing policies and programs that support the implementation of zero-waste farming systems in Indonesia.

2 Research Methods

The research was conducted in the Yogyakarta Special Region Province, specifically with the Sari Makmur women's farming group in Sumberharjo Village, Prambanan District, Sleman Regency, and the Lestari Women's Farming Group in Sendangsari Village, Pengasih District, Kulonprogo Regency. These women's groups practice the integrated farming system of arrowroot cultivation and livestock farming. The study's respondents consisted of all 91 members of the two women's farming groups.

Data were collected through surveys, observations, and direct interviews with farmers using structured questionnaires. The questionnaires gathered information on the implementation of the integrated farming system of arrowroot and livestock, as well as farmers' perceptions of this farming practice. The questionnaire was designed to collect data on farmers' characteristics, including socio-economic conditions, risks, and perceptions of the integrated farming system.

Descriptive analysis was used to describe the implementation of the integrated farming system between arrowroot and livestock. This section illustrates how livestock and arrowroot waste are integrated to implement a zero-waste farming system. Spearman rank correlation analysis was used to analyze the relationship between farmers' perceptions of the integrated farming system and socio-economic variables, including risks. Since the data were ordinal, the Spearman rank correlation was the appropriate method [8]. The Spearman rank correlation formula is as follows:

$$r_s = 1 - \frac{6\,\Sigma d_i^2}{n(n^2-1)} \quad (1)$$

Where:
d_i = the difference in rank between two variables for the *i*-th observation
n = the number of data pairs
r_s = Spearman rank correlation coefficient

A r_s value close to 1 or -1 indicates a strong correlation, while a value close to 0 indicates a weak or no correlation.

Farmers' perceptions of the integrated farming system were assessed based on their perceptions of the benefits of implementing the arrowroot and livestock farming system. Respondents (farmers) were asked to rate their agreement with statements about the impact of the integrated farming system using a 1-5 Likert scale, where 1 means strongly disagree, 2 means disagree, 3 means neutral, 4 means agree, and 5 means strongly agree. The perception variable was measured by evaluating the impact of the integrated system on production efficiency, the environment, and economic improvement.

The socio-economic characteristics of the farmers included age, education level, household size, active participation in farmer groups, experience, production levels, and risk levels. The risk level used in this study refers to farmers' perceptions of risks encountered in farming activities, including climate change, pests, plant diseases, price fluctuations, and limited resource inputs.

3 Results and Discussion

3.1 Respondent Characteristics

Based on Table 1 of respondent characteristics, the 91 arrowroot farmers exhibit a diverse range of factors such as age, land area, education level, farming experience, household size, production, and risk level. The average age of respondents is 58.19 years, indicating that most respondents fall into the middle-aged to elderly group, which can influence their approach to farming practices. Respondents have an average land area of 299.78 m², with significant variation from 10 m² to 1,500 m², reflecting differences in land size, which can impact production levels. This variation is due to arrowroot being cultivated in intercropping systems with other plants such as vegetables, cassava, and legumes.

Table 1. Respondent Characteristics

No.	Variable	Average	Std. Deviation	Min	Max
1.	Age (years)	58.19	13.43	25	87
2.	Land area (m^2)	299.78	241.06	10	1,500
3.	Education (years)	7.29	3.36	0	15
4.	Farming experience (years)	20.87	14.49	2	60
5.	Household size (people)	2.68	1.29	1	10
6.	Production (kg)	160.41	325.84	5	3,000
7.	Participation in farming groups (dummy)	0.813	0.391	0	1
8.	Risk (likert scale)	2.56	0.520	1.333	4.16

The average education level of respondents is 7.29 years, indicating that most have only basic to secondary education. In terms of experience, respondents have an average of 20.87 years of farming experience, suggesting that most possess extensive practical knowledge in this field. The average household size is 2.68 people, indicating relatively small households, which may affect the availability of labor within the household for farming activities. The average production is 160.41 kg, with a large standard deviation, indicating wide variation in production outcomes. This could be due to differences in resource access, land conditions, or farming techniques used. Activeness of farmer group members Lastly, the average risk score of 2.56 indicates that respondents face varying levels of risk in their

farming activities, which may be related to external factors such as climate, pests, plant diseases, prices, and resource input limitations.

3.2 Implementation of Integrated Farming between Arrowroot and Livestock

The implementation of the Integrated Farming System between arrowroot (*Maranta arundinacea*) and livestock involves a mutually supportive integration between two activities, namely arrowroot cultivation and livestock farming. This process begins with the planting of arrowroot on land managed using organic fertilizers produced from livestock waste, such as processed manure turned into compost. The use of organic fertilizers not only improves soil quality and increases crop yields but also reduces dependence on chemical fertilizers. After harvest, arrowroot plant residues such as leaves, stems, and starch are used as feed for livestock, such as cattle or goats, which are part of the integrated livestock system. The livestock waste, including manure, is collected and processed back into organic fertilizer that will be used to support the next farming cycle. Figure 1 Flow of the Integrated Farming System between Arrowroot and Livestock.

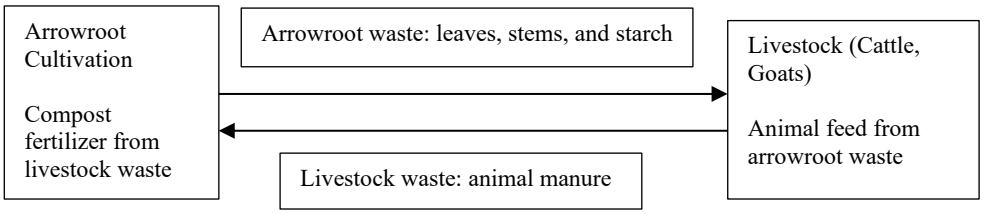

Fig 1. Flow of the Integrated Farming System between Arrowroot and Livestock

This system supports zero-waste, where every by-product from one part of the process can be reused as a resource for another part. Therefore, no part of the system is wasted. In this context, plant waste is used as livestock feed, and livestock waste is used as fertilizer for crops. This aligns with the principles of sustainable agriculture, which emphasize efficient resource use and minimizing negative environmental impacts through a closed-loop resource cycle [9], [10].

The zero-waste concept not only reduces the waste produced by both livestock farming and agriculture but also lowers production costs by reusing organic materials available on the farm [11], [12]. With this integration, farmers can optimize the use of their land and resources, while also creating diversified income streams.

3.3 Farmers' Perception of Integrated Farming

The tendency to adopt technology is strongly influenced by perception. If farmers believe that adopting the integrated farming system will increase profits and efficiency, they will be more likely to embrace the technology openly. Conversely, if farmers are concerned that the technology is difficult to implement and does not provide tangible benefits, their perception of the technology may be negative, leading to rejection of the innovation. Farmers' perceptions of the integrated farming system between arrowroot and livestock were assessed through questions exploring their views on the system's effects on production efficiency, environmental improvement, and economic benefits. Overall, the average farmer perception score of 3.79 indicates that farmers have a highly positive perception of the integrated farming system.

Table 2. Distribution of Farmers' Perceptions of Integrated Farming System Implementation

No	Dimension	Indicator	SS (5)	S (4)	N (3)	TS (2)	STS (1)	Perception level
1	Production Efficiency	Increased productivity	49	39	3	-	-	4.50
		Reduced pesticide use	18	49	12	11	1	3.79
		Reduced chemical fertilizer use	28	52	7	2	2	4.12
		Reduced external dependence	23	52	14	2	-	4.05
2	Environmental Improvement	Increased environmental sustainability	27	51	10	3	-	4.12
3	Economic improvement	Increased farmer income	22	53	6	7	3	3.92
		Reduced risk of crop failure	13	48	11	18	1	3.59
		Increased product diversity	8	34	34	11	4	3.34
Average perception			3.79					

3.1.1 Production Efficiency

The perception of the integrated farming system's impact on increasing production efficiency is measured by four indicators. The first indicator is increased productivity. The study results show a perception score of 4.50, indicating that the integrated farming system has a positive impact on increasing arrowroot productivity. Farmers strongly agree that the integrated farming system implemented has effectively enhanced the productivity of arrowroot. These findings align with previous research stating that the integration of crop and livestock farming can boost productivity in both sectors simultaneously [13], [14].

Secondly, the integrated farming system is perceived positively in reducing pesticide use, with a perception score of 3.79. This suggests that the system is believed to help reduce pesticide use. This suggests that the system is believed to help reduce pesticide use. This finding is consistent with prior studies, indicating that Integrated Farming Systems (IFS) can minimize pesticide use by improving soil health and fertility [15].

Thirdly, the perception that IFS reduces chemical fertilizer use is supported by a score of 4.12. This shows that farmers strongly agree or believe that IFS implementation can lower chemical fertilizer use. The use of chemical fertilizers in arrowroot farming is reduced due to the availability of compost from livestock waste, thus enhancing efficiency [16].

Fourthly, the perception score for reducing external dependency is 4.05. This means that the integrated farming system has an impact on reducing dependence on external production inputs. Farmers no longer rely on purchasing production inputs such as fertilizers, pesticides, and animal feed from the market, as these needs are already fulfilled or obtained through the implementation of the integrated farming system.

Overall, these perception scores indicate that the integrated farming system is perceived very positively by farmers. It is seen as capable of increasing production efficiency by boosting agricultural productivity and reducing reliance on external inputs like chemical fertilizers and pesticides.

3.1.2 Environmental Improvement

Farmers' perception of the integrated farming system's impact on environmental sustainability is measured by its influence on sustainability. The perception score of 4.12 indicates a positive view from farmers regarding the environmental benefits of the integrated farming system. Integrated farming practices can enhance environmental sustainability by increasing profitability, recycling nutrients, improving soil quality, boosting biodiversity, and reducing greenhouse gas emissions[17].

3.1.3 Economic improvement

Farmers also hold a positive view of the economic benefits provided by the integrated farming system. This improvement is seen through several indicators. Firstly, the integrated farming system is perceived to increase economic income, with a perception score of 3.91. This suggests that the system can enhance farmers' income. These results align with previous studies, which show that farmers practicing integrated farming tend to have higher incomes than those who do not [5], [18]

Secondly, the perception of the system's impact on reducing crop failure risk scored 3.59, indicating a positive effect. Implementing the integrated farming system helps mitigate risks by providing additional income from both arrowroot cultivation and livestock farming. Production risks can be reduced through the use of organic materials, which improve soil fertility [19].

Thirdly, the perception score for increasing product diversity is 3.34, suggesting that the system has a positive impact on product diversification. Farmers are not solely dependent on a single commodity, such as arrowroot, but can also benefit from livestock products like cattle and goats.

3.2 The Relationship between Perception and Farmer Characteristics

Table 3 shows the relationship between farmers' perceptions and their characteristics, analyzed using Spearman's rank correlation. The results indicate that household size, participation in farmer groups, and farmers' risk levels are associated with their perceptions of the integrated farming system.

The correlation analysis shows that household size is positively associated with perception, with a significance value of 0.05 and a weak correlation coefficient of 0.198. This shows that the more members a farming household has, the more likely they are to have a positive perception of the integrated farming system, making it easier to adopt the system. This is likely because the integrated farming system offers benefits to the entire family, both economically and socially. This finding is consistent with previous research, which shows that farmers' ability to implement the System of Rice Intensification (SRI) is influenced by family support [20].

Participation in farmer groups is strongly correlated with perception, with a significance value of 0.04 and a fairly strong correlation coefficient of 0.68. This indicates that farmers who are more active in group activities tend to have a more positive perception of the integrated farming system compared to those who are not active. Being active in farmer groups provides opportunities to gain new knowledge and information related to the integrated farming system [21].

Risk perception has a negative correlation with farmers' perceptions of the integrated farming system, with a moderately strong negative coefficient of -0.321. This suggests that the higher the risk perceived by farmers in their farming activities, the more negative their

perception of the integrated farming system. As perceived risks increase, farmers' acceptance of the system tends to decline. Therefore, reducing risks and ensuring clear benefits from the integrated farming system are crucial for increasing adoption among farmers [2]. Risk is still seen as a barrier to adopting new innovations, particularly integrated farming systems.

Table 3. Relationship between Farmer Characteristics and Perception of the Integrated Farming System

Analysis	**Farmer Characteristic**		**Perception**
Spearman's rho	Land area	Correlation Coefficient	-0.17
		Sig. (2-tailed)	0.105
		N	91
	Age	Correlation Coefficient	-0.07
		Sig. (2-tailed)	0.945
		N	91
	Experience	Correlation Coefficient	0.166
		Sig. (2-tailed)	0.115
		N	91
	Active in Farmer Group	Correlation Coefficient	0.689
		Sig. (2-tailed)	0.04**
		N	91
	Production	Correlation Coefficient	0.014
		Sig. (2-tailed)	1.105
		N	91
	Income	Correlation Coefficient	0.017
		Sig. (2-tailed)	0.869
		N	91
	Education	Correlation Coefficient	0.025
		Sig. (2-tailed)	0.811
		N	91
	Household Size	Correlation Coefficient	0.198
		Sig. (2-tailed)	0.05**
		N	91
	Risk Rate	Correlation Coefficient	-0.321
		Sig. (2-tailed)	0.001***
		N	91

4 Conclusion

This research reveals that the integrated farming system between arrowroot and livestock plays an important role in supporting zero-waste farming in Sleman and Kulonprogo, Yogyakarta. The integrated farming system reduces waste from arrowroot, such as stems, leaves, and starch, by using them as livestock feed, while livestock waste is used as compost for crops. Thus, the integration between arrowroot and livestock farming supports the creation of a zero-waste agricultural system.

Farmers have a positive perception of the integrated farming system, which they believe can improve production efficiency, environmental sustainability, and economic benefits. There is a positive relationship between farmers' perceptions of the integrated farming system and household size and participation in farmer groups. On the other hand, risk levels negatively correlate with farmers' perceptions of the system.

Therefore, the integrated farming system can be seen as an effective approach for supporting sustainable agriculture, reducing negative environmental impacts, and increasing economic efficiency for farmers. However, acceptance and adoption of this system can be further optimized with efforts to enhance farmers' understanding and awareness of the long-term benefits of zero-waste farming, along with institutional support from farmer groups and agricultural extension services.

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