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Horizontal Diversification with Cayenne Pepper and Tomato and Its Farm Income Implications in Minahasa Regency.

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Abstract. Cayenne pepper and tomato are important horticultural crops for smallholder farmers in North Sulawesi, Indonesia, yet their role within horizontally diversified farming systems is not well documented. This study analyses horizontal crop diversification as a strategy for strengthening household economies in Taraitak Satu Village, North Langowan District, Minahasa Regency. An exploratory case-study design was used, combining descriptive quantitative and qualitative approaches. Primary data were collected through structured interviews with ten purposively selected farmers who simultaneously cultivated cayenne pepper (Capsicum frutescens L.) and tomato (Solanum lycopersicum L.) on the same land during one production season. Information on land area, input use, production costs, yields, prices, revenues and capital sources was used to construct farm budgets for the diversified system. The results show that most farmers operate on less than 0.5 ha, yet the combined cayenne–tomato system generates relatively high net farm income. Total production cost for the ten farmers amounted to IDR 120,428,163, while total revenue reached IDR 905,842,000, resulting in a total net income of IDR 785,413,837. Individual net incomes ranged from IDR 21,965,000 to IDR 195,007,000 per season, with an average of about IDR 78.5 million per farmer. Some farmers relied on formal bank credit to finance input purchases and labour, reflecting the link between diversification and access to capital. The findings suggest that horizontal diversification with cayenne pepper and tomato can provide substantial income under favourable conditions, although the small sample size and single-season data mean that results should be interpreted as indicative rather than generalisable.

Keywords: horizontal diversification; cayenne pepper; tomato; farm income; smallholder farmers.

INTRODUCTION

Agriculture plays a central role in supporting rural livelihoods and economic development in Indonesia[1]. A resilient agricultural sector is considered essential for maintaining national food security, particularly in the face of volatile global conditions, climate variability and the ongoing conversion of agricultural land to non-agricultural uses[2]. Recent concerns about declining productivity and shrinking areas of productive farmland have raised questions about the ability of smallholder farmers to sustain their production and income in the long term[3], [4]. When farm productivity falls, farmers may face difficulties in securing working capital for subsequent planting seasons, which in turn can threaten local food availability[5].

Agricultural diversification has long been promoted as one of the main strategies to address these challenges[6]. Diversification refers to efforts by farmers to broaden the range of agricultural activities or crops they undertake, thereby reducing dependence on a single commodity and spreading production and market risks[7]. Farmers may diversify by combining different farm enterprises, such as crop and livestock activities, or by cultivating several crops on the same land. In the Indonesian context, diversification has been encouraged as a way to stabilise production, improve farm incomes and support rural food security[8], [9].

From a farm management perspective, diversification can be distinguished into horizontal and vertical diversification[10]. Horizontal farm diversification refers to the cultivation of multiple crops or agricultural enterprises within the same production unit and time frame[11]. It is primarily intended to reduce the risk of production failure and price fluctuations, while creating multiple

streams of farm income. Vertical diversification, in contrast, involves adding off-farm or post-harvest activities that increase the value of primary products, such as processing or marketing initiatives[12]. Multiple cropping systems, in which the same plot of land is used to grow two or more crops in a year, are a common form of horizontal diversification among smallholder farmers in tropical regions[13].

In North Sulawesi, particularly in Taritak Satu Village, North Langowan District, Minahasa Regency, farmers have adopted horizontal diversification by cultivating horticultural crops, especially cayenne pepper (Capsicum frutescens L.) and tomato (Solanum lycopersicum L.), on the same land. These crops are important components of local diets and are widely traded in regional markets. They also offer relatively high value but are characterised by substantial price variability, which makes risk management and capital access crucial for smallholder farmers[14], [15].

Previous studies on agricultural diversification in Indonesia have examined its role in increasing farm income, reducing risk and supporting rural economic development[7], [16]. However, empirical evidence on how horizontal diversification in small-scale horticultural systems affects farm-level income and capital patterns in specific local contexts remains limited. In particular, there is a lack of detailed case studies that document cost structures, revenue, net farm income and sources of capital for farmers who combine cayenne pepper and tomato within a single farming system[17].

Against this background, the present study aims to analyse horizontal farm diversification as a strategy for strengthening the economy of smallholder households in Taritak Satu Village. The specific objectives are: (i) to describe the characteristics of farmers who apply horizontal crop diversification with cayenne pepper and tomato; (ii) to estimate production costs, revenues and net farm income from the diversified farming system; and (iii) to identify capital patterns and the role of formal credit in supporting these activities. The study is designed as an exploratory case study with a small number of farmers and is therefore intended to provide in-depth insights into the functioning of horizontal diversification at the local level rather than to generate statistically generalisable results.

MATERIALS AND METHODS

Study area

The study was conducted in Taritak Satu Village, North Langowan District, Minahasa Regency, North Sulawesi Province, Indonesia. The village was purposively selected because it is one of the production centres for food and horticultural crops in the regency and because a number of farmers already practise horizontal diversification by cultivating cayenne pepper (*Capsicum frutescens* L.) and tomato (*Solanum lycopersicum* L.) on the same land. The research covered one production season from March to September 2025.

Research design and sampling

The study employed a descriptive case-study design with a combination of qualitative and quantitative techniques. The target population consisted of farmers in Taritak Satu who grew both cayenne pepper and tomato during the study season. A purposive sampling technique was applied, using the criterion that respondents had to cultivate these two crops within a horizontally diversified farming system. Ten farmers who met this criterion were selected as respondents and treated as a small, exploratory sample rather than a statistically representative population.

Data collection

Primary data were collected through structured interviews using a questionnaire

administered to the ten farmers. The questionnaire captured information on:

1. Farmer and household characteristics (age, education, family size, farming experience);
2. Land area and cropping pattern;
3. Input use and production costs for cayenne pepper and tomato, including seeds, fertilisers, pest and disease control, hired labour and depreciation of tools;
4. Production, selling prices, revenues and net farm income for each crop;
5. Sources and patterns of farm capital, including the use of bank credit.

Additional qualitative information on motivations for diversification and the use of credit was obtained through open-ended questions during the interviews. Secondary data on the general agricultural situation in Minahasa Regency were collected from local government offices and published statistics. The main variables used in the analysis are summarised in Table 1..

Table 1. Main variables and measures used in the study

Variable	Symbol	Unit	Description
Land area	A	hectare	Land cultivated with the cayenne pepper–tomato diversified farming system
Production of cayenne	Qc	kilogram per season	Total harvested cayenne pepper per farmer per season
Production of tomato	Qt	kilogram per season	Total harvested tomato per farmer per season
Price of cayenne	Pc	Indonesian Rupiah/kg	Farmgate selling price of cayenne pepper
Price of tomato	Pt	Indonesian Rupiah/kg	Farmgate selling price of tomato
Total revenue	TR	Indonesian Rupiah	Revenue from cayenne pepper and tomato combined
Total production cost	TC	Indonesian Rupiah	Sum of variable and fixed costs for both crops
Net farm income	π	Indonesian Rupiah	Net income from the diversified farming system (TR minus TC)
Access to formal credit	–	binary / descriptive	Use of loans from banking institutions for farm capital
Other socio-economic traits	–	descriptive	Age, education, household size, farming experience

Table 1 provides an overview of the core quantitative and qualitative variables used to characterise the diversified farming system and to assess its economic performance and capital patterns.

Data analysis

The study applied descriptive statistics to summarise farmer characteristics, land use, costs, revenues and income from the horizontally diversified farming system, as well as the patterns of capital use[18]. For each farmer, total revenue from the diversified system was calculated as the sum of revenues from cayenne pepper and tomato:

$$TR_i = Q_{ci} \times P_{ci} + Q_{ti} \times P_{ti}$$

where $TR_i$is the total revenue of the i-th farmer, $Q_{ci}$and $Q_{ti}$are the quantities of cayenne pepper and tomato produced, and $P_{ci}$and $P_{ti}$are their respective farmgate prices.

Total production cost for each farmer consisted of variable costs (seeds, fertilisers, pest and disease control, hired labour) and fixed costs (depreciation of

tools). Net farm income from the diversified farming system was then computed as:

$$\pi_i = TR_i - TC_i$$

where $\pi_i$is the net income and $TC_i$is the total production cost of the i-th farmer.

For the sample of ten farmers, totals, means, minima and maxima of revenue, cost and net income were calculated. Given the small sample size and purposive sampling design, the analysis is exploratory and does not attempt statistical inference to a wider population. Patterns of capital use, including the role of bank credit, were analysed qualitatively based on farmers' responses and interpreted in relation to their income levels and farm characteristics.

RESULTS AND DISCUSSION

Farmer and land characteristics

The ten sample farmers in Taritak Satu Village are smallholders who combine cayenne pepper and tomato within a horizontally diversified farming system. Land is a key production factor, and the distribution of land area among respondents is shown in Table 2.

Table 2. Land area of cayenne pepper–tomato farmers in Taritak Satu Village

No.	Land area (ha)	Number of farmers	Percentage (%)
1	≤ 0.5	6	60
2	0.6–1.0	4	40
	Total	10	100

Table 2 shows that most respondents (60 percent) cultivate up to 0.5 hectares, while the remaining 40 percent operate between 0.6 and 1.0 hectare. This confirms that the diversified cayenne–tomato system is implemented under small-scale conditions, although a subset of farmers has begun to expand their cultivated area within this horizontal diversification pattern.

Production costs of the diversified farming system

Production costs include variable and fixed costs incurred during one cropping season for both cayenne pepper and tomato. Variable costs consist of seeds, fertilisers, pest and disease control and hired labour, while fixed costs are represented by depreciation of tools. The cost structure for the ten farmers combined is summarised in Table 3.

Table 3. Production costs of cayenne pepper–tomato farming in one season.

Cost item	Amount (IDR)
Seeds	12,245,000
Fertilisers	31,775,500
Pest and disease control	16,763,000
Hired labour	57,291,000
Depreciation of tools	2,353,663
Total production cost (10 farmers)	**120,428,163**
Average production cost per farmer	**12,042,816**

Table 3 indicates that labour is the largest single cost component, followed by fertilisers, reflecting the labour-intensive nature of horticultural production and the importance of nutrient management for both crops. Seed costs are relatively modest compared with labour and fertiliser, while depreciation of tools accounts for a small share of total cost.

Revenue from cayenne pepper

Farm revenue depends on production volume and farmgate prices. For cayenne pepper, production and revenue per farmer in one season are presented in Table 4.

Table 4 shows substantial variation in cayenne pepper revenue across farmers, reflecting differences in both production and prices received. During the study period, farmgate prices ranged from IDR 55,000 to 60,000 per kilogram, while individual production ranged from 280 to 830 kilograms per season. Farmers with larger land areas and higher yields naturally achieved higher gross revenues.

Revenue from tomato

Tomato is the second major crop in the diversified system. As with cayenne pepper, revenue depends on output and market prices. Table 5 summarises tomato production and revenue per farmer.

Table 4. Revenue from cayenne pepper in one cropping season

No.	Production (kg)	Price (IDR/kg)	Revenue (IDR)
1	280	55,000	15,400,000
2	410	55,000	22,550,000
3	635	58,000	36,830,000
4	470	55,000	25,850,000
5	526	60,000	31,560,000
6	830	60,000	49,800,000
7	427	58,000	24,766,000
8	545	60,000	32,700,000
9	395	55,000	21,725,000
10	615	60,000	36,900,000
	Total	5,133	298,081,000
	Average	513.3	29,808,100

Table 5. Revenue from tomato in one cropping season

No.	Production (kg)	Price (IDR/kg)	Revenue (IDR)
1	860	14,000	12,040,000
2	1,375	19,000	26,125,000
3	2,482	15,000	37,230,000
4	980	19,000	18,620,000
5	6,185	14,000	86,590,000
6	8,750	19,000	166,250,000
7	1,005	15,000	15,075,000
8	2,305	19,000	43,795,000
9	1,864	14,000	26,096,000
10	9,260	19,000	175,940,000
	Total	35,066	607,761,000
	Average	3,506	60,776,100

Table 5 indicates that tomato revenues are, on average, higher than those from cayenne pepper, mainly because several farmers cultivate tomato on relatively larger areas and benefit from favourable prices during the study period. Prices varied between IDR 14,000 and 19,000 per kilogram, and total tomato production reached more than 35 tonnes for the ten farmers combined.

Net farm income from horizontal diversification

Net farm income from the horizontally diversified system was calculated by combining revenues from cayenne pepper and tomato and subtracting total production costs for each farmer. The corrected income figures are presented in Table 6.

Table 6 shows that net farm income from the diversified cayenne–tomato

system varies widely across farmers, reflecting differences in land area, productivity and cost structure. The lowest net income among respondents is IDR 21,965,000 per season, while the highest reaches IDR 195,007,000. The total net income for the ten farmers combined is IDR 785,413,837, with an average of about IDR 78.5 million per farmer per season. These figures confirm that, in this particular case study, horizontal diversification with cayenne pepper and tomato can generate relatively high net returns for smallholder households, although results are heterogeneous and strongly influenced by scale and management.

Table 6. Net farm income from diversified cayenne pepper–tomato farming

No.	Total revenue (IDR)	Total cost (IDR)	Net farm income (IDR)
1	27,440,000	5,475,000	21,965,000
2	48,675,000	6,840,000	41,835,000
3	74,060,000	13,065,163	60,994,837
4	44,470,000	7,012,000	37,458,000
5	118,150,000	16,762,000	101,388,000
6	216,050,000	21,043,000	195,007,000
7	39,841,000	7,920,000	31,921,000
8	76,495,000	14,370,000	62,125,000
9	47,821,000	8,046,000	39,775,000
10	212,840,000	19,895,000	192,945,000
	Total	**905,842,000**	**120,428,163**
	Average	**90,584,200**	**12,042,816**

It is important to note that the earlier Indonesian version of the paper treated the revenue from cayenne pepper alone as if it were net income from mixed cropping. The corrected calculations in Table 6 clearly distinguish between total revenue, total cost and net income, providing a more accurate picture of the economic performance of the diversified system.

Capital patterns in the diversified farming system

Farm capital is another key element of economic strengthening. In Taritak Satu, several farmers reported using bank credit as a source of capital for their diversified farming activities. Farmers who accessed formal credit were typically 40–55 years old, had household sizes of four to six members, cultivated between 500 and 1,000 square metres, earned more than IDR 15 million per season from farming, had 10–15 years of farming experience and had completed junior secondary education.

Farmers reported that they chose bank credit despite relatively complex procedures because they perceived interest rates as more affordable and considered banks to offer better protection and clearer rights and obligations compared with informal lenders. Motivations for taking loans included the need to finance input purchases and labour costs at the beginning of the season. From the perspective of horizontal diversification, access to formal credit can support the expansion or stabilisation of diversified farming systems, but it also introduces repayment obligations that depend on the success of both cayenne and tomato crops.

CONCLUSION

This study examined horizontal farm diversification through the combined cultivation of cayenne pepper and tomato among smallholder farmers in Taritak Satu Village, North Langowan District, Minahasa Regency, North Sulawesi. The results show that the diversified system is implemented on relatively small landholdings, with most farmers cultivating up to 0.5 ha and only a few expanding to between 0.6 and 1.0 ha. Within these scale

constraints, farmers manage two high-value horticultural crops in a single farming system.

The cost structure analysis indicates that labour and fertilisers are the dominant components of production cost, confirming the labour-intensive and input-dependent nature of diversified horticultural farming. For the ten farmers combined, total production cost in one season amounted to IDR 120,428,163, or about IDR 12,042,816 per farmer. On the revenue side, both cayenne pepper and tomato contributed substantially to farm earnings, with total revenues of IDR 298,081,000 and IDR 607,761,000 respectively. When combined and set against total costs, the diversified cayenne–tomato system generated a total net farm income of IDR 785,413,837 for the ten farmers, with individual net incomes ranging from IDR 21,965,000 to IDR 195,007,000 per season and an average of approximately IDR 78.5 million. These figures suggest that, in this particular case study, horizontal diversification with cayenne pepper and tomato can provide relatively high net returns to smallholder households, although outcomes vary considerably according to land area, management and market conditions.

The analysis of capital patterns shows that some farmers rely on formal bank credit to finance their diversified farming activities. Farmers who access credit tend to have medium-scale landholdings within the village context, higher income levels and longer farming experience. They perceive bank credit as offering more transparent conditions and more reasonable interest rates than informal lenders, even though procedures are more complex. This indicates that horizontal diversification is linked not only to production decisions but also to access to formal financial services, which can support or constrain farmers' ability to maintain and expand diversified systems.

Given the small sample size, the focus on a single village and the absence of a comparison group of monocrop farmers, the findings should be interpreted as exploratory rather than definitive evidence that horizontal diversification increases income. Nevertheless, the study provides detailed empirical insight into the cost, revenue, income and capital patterns of a specific horizontally diversified horticultural system. Future research could build on this work by comparing diversified and non-diversified farmers, analysing risk and income variability over multiple seasons and exploring the role of diversification in enhancing household resilience under changing market and climatic conditions.

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