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Seasonal income and coefficient-of-variation-based farm-level variability assessment of highland tomato farming in Gowa, Indonesia

Ingreso estacional y evaluación de la variabilidad a nivel de finca basada en el coeficiente de variación en el cultivo de tomate de tierras altas en Gowa, Indonesia

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Tomato farming area in Balassuka Village, Tombolopao Subdistrict, Gowa Regency, South Sulawesi, Indonesia. Photo: R.F. Syafruddin

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ABSTRACT

Tomato is a high-demand horticultural commodity that supports smallholder livelihoods in highland agri-food systems in Indonesia. This study aimed to estimate seasonal net income, describe farm-level production, and assess the variability of tomato net income within one production season in Balassuka Village, Tombolopao Subdistrict, Gowa Regency. Data were collected from 42 randomly selected farmers using structured surveys, interviews, and field observations. The study used a descriptive quantitative design combining farm income analysis, coefficient of variation (CV) analysis, and a scenario-based sensitivity check to assess the robustness of short-term variability estimates across farmers in one production season. The results showed an average gross revenue of USD 4,831.39 (Rp 75,846,905), an average total production cost of USD 399.97 (Rp 6,278,961), and an average seasonal net income of USD 4,431.43 (Rp 69,567,944) per farmer. Farmers produced an average of 5,824 kg of tomatoes, with an average selling price of USD 0.85/kg (Rp 13,374/kg). Using an interpretive threshold in which CV values of 0.50 or lower indicate manageable variability, the CV values were 0.24 for production and 0.06 for net income, indicating low observed inter-farmer variability during the study season. The economic feasibility of tomato farming was also indicated by an R/C ratio of 12.08, an ROI of 1,107.95%, a BEP production level of 469.49 kg, and a BEP price of USD 0.07/kg (Rp 1,078.12/kg). The main risks reported by farmers included climate variability, pest and disease incidence, low-quality or costly seed supply, price fluctuation, and limited access to credit. In conclusion, tomato production in Balassuka was profitable during the observed season and showed low short-term farm-level variability; however, targeted interventions are needed to strengthen resilience under future production and market uncertainty.

Additional keywords: income stability; production risk; farm-level variability; agricultural resilience; smallholder horticulture.

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RESUMEN

El tomate es un producto hortícola de alta demanda que sostiene los medios de vida de pequeños productores en sistemas agroalimentarios de zonas altas en Indonesia. Esta investigación tuvo como objetivo estimar el ingreso neto estacional, describir la producción a nivel de finca y evaluar la variabilidad del ingreso neto del tomate dentro de una temporada de producción en la aldea de Balassuka, subdistrito de Tombolopao, regencia de Gowa. Se recopilaron datos de 42 agricultores seleccionados aleatoriamente mediante encuestas estructuradas, entrevistas y observaciones de campo. El estudio utilizó un diseño cuantitativo descriptivo que combinó análisis de ingresos agrícolas, coeficiente de variación (CV) y una prueba de sensibilidad basada en escenarios para evaluar la solidez de las estimaciones de variabilidad a corto plazo entre agricultores durante una temporada de producción. Los resultados mostraron un ingreso bruto promedio de USD 4,831.39 (Rp 75,846,905), un costo total de producción promedio de USD 399.97 (Rp 6,278,961) y un ingreso neto estacional promedio de USD 4,431.43 (Rp 69,567,944) por agricultor. Los agricultores produjeron un promedio de 5,824 kg de tomate, con un precio de venta promedio de USD 0.85/kg (Rp 13,374/kg). Con base en el umbral interpretativo en el que los valores de CV de 0.50 o menores indican variabilidad manejable, los CV fueron de 0.24 para la producción y de 0.06 para el ingreso neto, lo que indica baja variabilidad observada entre agricultores durante la temporada de estudio. La viabilidad económica del cultivo de tomate también se evidenció mediante una relación R/C de 12.08, un ROI de 1,107.95%, un nivel de producción BEP de 469.49 kg y un precio BEP de USD 0.07/kg (Rp 1,078.12/kg). Los principales riesgos reportados por los agricultores incluyeron variabilidad climática, incidencia de plagas y enfermedades, suministro de semillas de baja calidad o costosas, fluctuación de precios y acceso limitado al crédito. En conclusión, la producción de tomate en Balassuka fue rentable durante la temporada observada y mostró baja variabilidad a corto plazo a nivel de finca; sin embargo, se requieren intervenciones específicas para reforzar la resiliencia ante futuras incertidumbres productivas y de mercado.

Palabras clave adicionales: estabilidad de ingresos; riesgo productivo; variabilidad a nivel de finca; resiliencia agrícola; horticultura campesina.

INTRODUCTION

Despite slower growth in recent years, agriculture has historically been a major component of Indonesia's economy and continues to provide employment, food, and income for many rural households. Horticulture has a specific role in this sector because it supports farm income while contributing to dietary diversity. Tomato (*Solanum lycopersicum*) is an important horticultural commodity that is widely cultivated and consumed in Indonesia. However, tomato production remains sensitive to seasonal uncertainty. For smallholder farmers, profitability depends not only on yield but also on selling prices, input costs, and the capacity to cope with seasonal shocks. Changes in yield, output prices, and input costs can directly affect farmers' gross revenue and net income (Purwanti *et al*., 2022).

The highlands of South Sulawesi, including Gowa Regency, provide an agroecological zone that is suitable for tomato cultivation and has potential as a vegetable-producing area. According to BPS (2024), tomato production in South Sulawesi increased from 2019 to 2022 before declining in 2023. Favorable agroecological conditions therefore do not automatically guarantee stable production performance over time. In Balassuka Village, where agriculture is a major source of income, farmers face unpredictable weather, pest attacks, irregular access to quality inputs, and limited capital. Together with fluctuating market prices, these conditions require village-level analysis of tomato profitability and farm-level variability so that highland smallholder performance can be interpreted within specific production and marketing conditions (Kusnadi *et al*., 2020).

Tomato farming, like other agricultural enterprises, is affected by uncertainty from both environmental and market sources. Climate variability, pest and disease pressure, and changes in input or operational costs may reduce yield and farm income. Similar problems are also common in other mid-elevation highland crops, such as cabbage, shallot, maize, and rice. Farmers may respond to low yields through crop diversification, pest management, and improved irrigation, but these responses depend on resource availability and farmers' adoption capacity. Recent farm-risk studies have shown that biophysical shocks, input-use decisions, market access, and price movements often jointly determine income variability rather than yield changes alone (Komarek *et al*., 2020; Pramudya and Handoko, 2023). The coefficient of variation (CV) is a useful measure of relative variability because it compares the standard deviation with the mean. Previous studies, including Sutrisno *et al*. (2021) and Pramudya and Handoko (2023), have used CV to discuss yield and farm-income stability. However, in one-season cross-sectional data, CV should be interpreted as a measure of relative differences among farmers rather than as a full indicator of long-term temporal risk.

Socioeconomic conditions, such as education, land tenure, access to markets and inputs, and capital availability, may also influence how farmers respond to uncertainty. In Balassuka, limited educational and financial resources can constrain farmers when they face production or market shocks. These conditions may affect their ability to purchase quality seeds, implement appropriate pest control, apply fertilizer efficiently, or delay sales when prices are low. However, although these variables are relevant for interpreting farm-level variability, this study did not test their causal effects.

Although tomato farming has been studied in several regions of Indonesia, many studies rely on regional data and focus primarily on profitability. Fewer studies clearly separate gross revenue, total cost, net income, and farm-level variability at the village level. This distinction is important because high gross revenue does not always translate into equally high net income, and a profitable season for one farmer does not necessarily imply profitability for all farmers or across all seasons. Local production conditions, input access, market conditions, and farmer constraints among highland tomato farmers in Gowa remain insufficiently documented. Therefore, this study addresses this gap by analyzing net income and CV-based seasonal farm-level variability among tomato farmers in Balassuka using direct farm-level survey data.

Given this background, the study expected that tomato farming in Balassuka could generate positive seasonal net income despite production and market uncertainty. The objectives were to (1) compute and analyze the seasonal net income of tomato farmers in Balassuka and (2) examine farm-level variability in production and net income using the coefficient of variation. The analysis combines field data from 42 farmers, including fixed and variable costs, gross revenue, net income, and farmer-reported environmental and market constraints. Because the data refer to a single production season, the results are interpreted as evidence of short-term farm-level variability rather than long-term temporal risk. In this way, the study provides a focused village-level assessment of economic performance and observed variability among highland tomato farmers, while also identifying questions that require multiseason and cross-regional research.

MATERIALS AND METHODS

Study area and period

Fieldwork was conducted in Balassuka Village, Tombolopao Subdistrict, Gowa Regency, South Sulawesi, from September to December 2024. The village is located in a highland agroecological zone with an average annual rainfall of 100-160 mm, a condition that supports upland horticultural production (Rahardjo *et al*., 2019). Balassuka was selected because tomato farming is an important local livelihood and because its highland setting allows farm-income performance to be examined under village-level horticultural production conditions. The site was therefore considered appropriate for assessing seasonal profitability and farm-level variability under smallholder highland horticultural conditions.

Research design and sampling

This study used a descriptive quantitative design to estimate seasonal farm income and farm-level variability among tomato farmers in one production season. The target population consisted of all tomato farmers in Balassuka Village (N = 280). Because the research was designed as a village-level descriptive and exploratory survey rather than a causal or inferential study, the sample size was calculated using a finite population approach and adjusted to the scope of the research. Based on the Yamane/Slovin formula (1)

$$n=\frac{N}{\left(1+N\cdot e^{2}\right)} \quad (1)$$

with N = 280 and an exploratory precision level of approximately 14.2%, the minimum sample size was 42 farmers (Yamane, 1967). These farmers were selected through simple random sampling. The sample can be treated as a probability-based descriptive sample of tomato farmers in the village, but the results cannot be used to establish causal relationships or broad regional generalizations. A complete village list of tomato farmers was used to create the sampling frame, and random selection was applied to minimize selection bias. The design was suitable for describing observed farm-level patterns, but not for identifying causal associations among farmer characteristics, input use, production, and income.

Data sources and data collection

Data were collected from primary and secondary sources. Primary data were obtained through structured interviews using pre-tested questionnaires, direct field observations, and photographic documentation. Secondary data were obtained from the village administrative office, the agricultural extension center, and BPS. The questionnaire covered three main components: (1) production volume, cost structure, and income components; (2) farmer characteristics, cultivated area, input use, fixed and variable costs, labor use, selling prices, gross revenue, net income, and self-reported production levels; and (3) production and market constraints. The focus on farm-level quantitative data enabled consistent measurement of income and variability indicators (Clark *et al*., 2021; Creswell and Creswell, 2023). Farmer-reported limiting factors were used to support interpretation of the quantitative findings, not as a formal causal risk model.

Data quality control

Several checks were performed to improve data reliability. Survey responses were supported by field observations and document review, although these sources were not treated as independent datasets. Field observations were used to verify the production context, environmental conditions, and farming practices, while document review was used to check production trends and historical patterns. During tabulation, vague or incomplete responses were rechecked with respondents. This process helped reduce reporting errors and improve the credibility of the production, cost, and price data reported by farmers (Creswell and Creswell, 2023; Clark *et al*., 2021).

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Variable definitions and income analysis

Net income was calculated using the standard farm management formula (2):

$$Net\ income = Total\ revenue - Total\ cost \qquad (2)$$

Where, *Total revenue* was unit price × quantity produced, and *Total cost* the sum of fixed and variable costs.

In this study, total revenue refers to gross revenue from tomato sales, while total cost includes fixed and variable production costs. Net income was calculated as gross revenue minus total production costs. This distinction was maintained throughout the analysis to avoid treating revenue and income as interchangeable. To make the profitability results easier to compare across economic settings, three additional indicators were calculated: revenue-cost ratio (R/C ratio), return on investment (ROI), and break-even point (BEP). The R/C ratio was obtained by dividing gross revenue by total production cost. ROI was calculated as net income divided by total production cost and expressed as a percentage. BEP production was calculated by dividing total production cost by selling price per kilogram, while BEP price was calculated by dividing total production cost by total production volume. These indicators support interpretation of economic feasibility beyond the scale of production and local currency values. All indicators were first calculated at the farm level and then summarized across respondents so that the results reflected farmer-level economic performance rather than only village totals. The formulae are as follows:

$$R/C\ ratio = Gross\ revenue / Total\ production\ cost\ ;$$

$$ROI\ (\%) = (Net\ income / Total\ production\ cost) \times 100\ ;$$

$$BEP\ production\ (kg) = Total\ production\ cost / Selling\ price\ per\ kg\ ;$$

$$BEP\ price = Total\ production\ cost / Total\ production\ volume$$

All monetary values originally recorded in Indonesian Rupiah (IDR) were converted into United States Dollars (USD) using the average exchange rate for September-December 2024. The rate used was approximately USD 1 = Rp 15,698.76. IDR values are also shown in parentheses to retain the local meaning. The same conversion rate was applied to the gross revenue, production costs, net income, selling price, and break-even indicators.

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Descriptive statistics and coefficient of variation

The calculations followed the principles of contemporary farm financial analysis described by Barnard *et al*. (2020). Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize land area, labor use, input costs, and farmer characteristics (Hair *et al*., 2019). Based on this information, gross revenue, total production cost, and net income were calculated for each farmer. The mean, standard deviation (SD), and CV were then estimated for the 42 respondents. In this study, CV is interpreted as a measure of relative variability rather than as a complete risk model. This interpretation is appropriate because the data are cross-sectional and cover only one production season; therefore, the analysis focuses on differences among farmers during that season.

$$CV = \frac{Standard\ deviation}{Mean}$$

where, *Standard deviation* reflects the variability of production or income and *Mean* represents the average value of production or income.

Production CV was calculated from farmer-level production volume, while net income CV was calculated from farmer-level net income. A CV value of 0.50 or lower was used as an interpretive threshold for manageable variability in this descriptive analysis. This threshold was applied only as a practical guide to relative dispersion, not as a universal risk classification. Because the data were collected in a single production season, these CV values represent inter-farmer variability during that season rather than long-term risk across years. Consequently, the analysis distinguishes between variability among respondents within a single season and production or income risk over longer periods, for which multiseason data are necessary.

Scope of risk interpretation

In this paper, variability is understood as differences in production and net income among sampled farmers, supported by farmer-reported information on constraints to production and market access. The study does not estimate probability distributions, causal determinants, or temporal risk over multiple seasons. For this reason, the results are treated as descriptive CV-based evidence. This clarification prevents overinterpretation of the CV results and maintains consistency between the quantitative estimates and the qualitative information collected in the field.

Scenario-based sensitivity check

To address the limitation of using data from only one production season, a scenario-based sensitivity analysis was performed as an extension of the CV analysis. The robustness of the interpretation of low production and net income variability was assessed using alternative assumptions related to income calculation, input costs, sales prices, and extreme observations. Five scenarios were considered: (1) using median revenue and cost values instead of mean values to reduce the influence of skewness on net income; (2) increasing and decreasing total production costs by 15% to reflect possible changes in fertilizer, labor, and other input prices; (3) reducing average yield by 20% to approximate a hypothetical crop-loss scenario; (4) increasing and decreasing selling price by 10% to represent moderate market-price fluctuation; and (5) applying a trimmed-sample approach by removing the highest and lowest 5% of production and net income observations. For each scenario, the mean, standard deviation, and CV were recalculated and compared with baseline values. The interpretation focused on whether the adjusted CV values remained below or exceeded the 0.50 threshold used in the main analysis. The sensitivity analysis was used as a robustness check, not as a predictive risk model or as evidence of causal effects.

RESULTS AND DISCUSSION

Farmer demographics

The 42 tomato farmers surveyed in Balassuka Village showed diverse demographic characteristics. Most respondents (61.1%) were 45-70 years old, indicating that many were still economically active, although the relationship between age and farm performance was not statistically tested (Prasetyo *et al*., 2018). In terms of education, 40.48% had completed senior high school, whereas 28.57% had only elementary-level education. Household size was generally moderate, with 73.8% of respondents supporting two to four family members. Land access also showed a smallholder pattern: 61.9% cultivated 0.2-0.6 ha, an area that indicates semi-commercial upland production while still reflecting smallholder landholding patterns (Wulandari *et al*., 2020). This information is important for interpreting income and variability results because age, education, household labor availability, and cultivated area can influence farmers' capacity to manage inputs, respond to price changes, and adopt improved production practices. However, because this was a descriptive study, these socioeconomic variables were used only to contextualize farm performance and not to explain it causally.

Tomato production performance

Average tomato production was 5,824 kg per farmer per season from an average cultivated area of 0.58 ha. This is equivalent to approximately 10.04 t ha^{-1}, indicating that tomato can be productive under the village-level conditions studied here. The result suggests good production potential in the study area, although comparisons with other areas should consider differences in land size, varieties, input use, season, and market location. Highland farming studies show that high horticultural productivity can be achieved with adequate inputs, adaptive seed varieties, and sustainable cultivation practices (Sinaga, 2023). Studies on tropical highland zones also indicate that altitude and rainfall conditions can support tomato production (González and Rodríguez, 2022; López and Ruiz, 2021). Similar agroecological conditions within Balassuka may help explain the relatively low production dispersion among farmers, although one-season data cannot be used to assess stability across seasons.

Production costs and profitability

Tomato production costs were divided into fixed and variable costs. Fixed costs do not change directly with output and generally include land taxes and depreciation of farm equipment, such as tractors, hoes, sickles, and machetes. In Balassuka, fixed costs formed a smaller share of total production expenses than variable costs but still represent the basic cost of maintaining farm operations. With average total production costs of USD 399.97 (Rp 6,278,961), fixed costs accounted for about 30.9% of total costs. This means that most production expenditures were associated with the variable inputs used during the season. Table 1 presents the average fixed-cost components used in tomato farming in Balassuka Village. The dominance of equipment-related depreciation within fixed costs indicates that basic production assets remain necessary, even in relatively small-scale tomato farming.

Table 1. Average fixed costs in tomato farming in Balassuka village, Tombolopao subdistrict, Gowa regency (2024).

Equipment type	Quantity (unit)	Fixed cost (USD)	Original value (IDR)
Tractor	1	117.19	1,839,663
Hoe (cangkul)	1	3.28	51,436
Machete (parang)	1	1.82	28,537
Sickle (sabit)	1	1.11	17,421
Crowbar (linggis)	1	1.76	27,635
Total	—	**123.55**	**1,939,586**

Variable costs are expenses that change with the scale and intensity of farming. In this study, they included seeds, fertilizers, pesticides, and labor. As cultivated area or input intensity increases, these costs also tend to rise. Variable costs represented approximately 69.1% of total production costs. Labor was the largest contributor, accounting for approximately 46.4% of variable costs and 32.1% of total costs. Fertilizers were the second-largest component, representing nearly 30.6% of variable costs and 21.2% of total costs. This cost structure indicates that tomato profitability in Balassuka is relatively sensitive to labor and fertilizer costs. Table 2 presents the average variable-cost structure of tomato farming in the study area.

The relatively large share of labor and fertilizer costs suggests that changes in wage rates, labor availability, or fertilizer prices could directly affect net income, a concern also emphasized in recent discussions on input-cost pressure in smallholder agriculture (IFPRI, 2023).

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Table 2. Average variable costs in tomato farming in Balassuka village, Tombolopao subdistrict, Gowa regency (2024).

Input type	Variable cost (USD)	Original value (IDR)
Seeds	54.92	862,238
Fertilizers	84.71	1,329,857
Pesticides	8.53	133,929
Labor	128.25	2,013,351
Total	**276.42**	**4,339,375**

At an average selling price of USD 0.85/kg (Rp 13,374/kg), the mean seasonal gross revenue based on farmer-level sales data was USD 4,831.39 (Rp 75,846,905) per farmer. Because gross revenue was calculated at the farmer level before averaging, the mean value does not have to be equal to the simple product of average production and average price. Seasonal net income averaged USD 4,431.43 (Rp 69,567,944) after deducting the average total production cost of USD 399.97 (Rp 6,278,961). These findings indicate that tomato farming produced a high return relative to recorded production costs during the survey season, which is consistent with other upland tomato-farming studies in Indonesia (Awaliyah, 2021; Mentang *et al*., 2023). The high net income mainly reflects favorable selling prices, relatively low recorded production costs, and good output during the survey season. However, because the analysis is limited to one season and one village, the results should be interpreted as evidence of strong seasonal profitability rather than stable long-term profitability across years.

Economic feasibility indicators: R/C, ROI, and BEP

To provide more comparable profitability results, the analysis also used the revenue-cost ratio (R/C ratio), return on investment (ROI), and break-even point (BEP). These scale-adjusted indicators support the interpretation of tomato farming in Balassuka across different land systems, production scales, and market environments. Table 3 presents the R/C ratio, ROI, and BEP values used to assess the economic feasibility of tomato farming during the observed season.

Table 3. Dimensionless economic indicators of tomato farming in Balassuka village, Tombolopao subdistrict, Gowa regency (2024).

Economic indicator	Value	Interpretation
R/C ratio	12.08	Economically feasible because R/C > 1
ROI	1,107.95%	Very high return relative to production cost
BEP production	469.49 kg	Minimum production required to cover total cost
BEP price	USD 0.07/kg (IDR 1,078.12/kg)	Minimum selling price required to avoid loss

Calculations were based on an average gross revenue of USD 4,831.39 (IDR 75,846,905), total production cost of US$399.97 (IDR 6,278,961), net income of USD 4,431.43 (IDR 69,567,944), average production of 5,824 kg, and average selling price of USD 0.85/kg (IDR 13,374/kg).

The R/C ratio was 12.08, meaning that every USD 1.00 spent on tomato production generated approximately USD 12.08 in gross revenue. Because the value was well above 1.00, tomato farming was economically feasible during the observed production season. ROI reached 1,107.95%, showing that net income was more than 11 times the production cost. This high value reflects the relatively low-cost structure compared with the gross revenue received by farmers. Analytically, these indicators suggest that tomato farming had a wide revenue margin in the study season; however, they should be interpreted together with the recorded cost categories and the seasonal nature of the data. A high R/C ratio or ROI does not eliminate exposure to future price decreases, pest outbreaks, or increasing input costs.

The break-even results also indicate a wide profitability margin. The BEP production was approximately 469.49 kg per farmer per season, or only about 8.06% of the average production level of 5,824 kg. In other words, farmers needed to sell only a relatively small share of their harvest to cover production costs at the observed price. The BEP price was approximately USD 0.07/kg (Rp 1,078.12/kg), far below the average selling price of USD 0.85/kg (Rp 13,374/kg). This suggests that farmers remained above the break-even point during the observed season, even with a substantial price decline. Nevertheless, severe yield loss, pest outbreaks, market disruption, or increased input prices could reduce this margin in future seasons. The low BEP therefore indicates a

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relatively high short-term safety margin, but only under the conditions recorded during the study season.

The R/C ratio, ROI, and BEP results confirm that tomato production in Balassuka was economically feasible during the study season. These indicators strengthen the monetary income results by showing that profitability was high not only in absolute USD and IDR terms but also on a relative efficiency basis. This interpretation also supports the importance of examining variability in production and net income, because high profitability is more meaningful when it is accompanied by relatively low dispersion among farmers.

Production variability assessment

Production variability was assessed using the coefficient of variation (CV), calculated as the standard deviation divided by the mean. A low CV indicates low relative variability, which in this case means that production levels were relatively similar among farmers. Because the data cover a single production season, CV is interpreted as inter-farmer production variability rather than long-term temporal production risk. This interpretation is consistent with agricultural variability studies in which CV represents relative dispersion across farms, but it must be interpreted carefully when data are cross-sectional and not multiseasonal (Komarek et al., 2020; Pramudya and Handoko, 2023). Table 4 presents the mean production, standard deviation, and CV used to assess production heterogeneity among the surveyed tomato farmers.

Table 4. Coefficient of variation for tomato production in Balassuka village (2024).

Statistic	Value
Mean production (kg)	5,824
Standard deviation (kg)	1,397.76
Coefficient of variation	0.24

The production CV among the surveyed farmers was 0.24, indicating low relative variability in production. This result suggests that, although farmers were still exposed to environmental uncertainty during the season, production levels within the study area were relatively similar across respondents. In this study, a CV value below 0.50 was interpreted as manageable variability. The relatively low CV may reflect the shared agroecological conditions in Balassuka, similar cropping calendars, and broadly comparable production practices among farmers in the same village. In smallholder horticulture, local similarity can reduce cross-farm variability in output during a favorable season, although it does not remove exposure to weather shocks or pest outbreaks. Therefore, the production CV should be read as evidence of low observed production dispersion in 2024, not as proof that tomato production in Balassuka is structurally stable over time.

Net-income variability assessment

Net-income variability was also assessed using CV. A smaller CV value indicates more consistent farmer earnings within the observed production season. This distinction is important because net income differs from gross revenue, and one-season cross-sectional variation should not be treated as long-term income risk. Table 5 summarizes the mean net income, standard deviation, and CV used to evaluate the consistency of farmers' earnings during the observed season.

Table 5. Coefficient of variation for tomato farming net-income in Balassuka village (2024).

Statistic	Approximate value in USD	Value (IDR)
Mean net income	4,431.43	69,567,944
Standard deviation of net income	305.34	4,793,463
Coefficient of variation		0.06

The CV for net income was 0.06, again indicating very low variability among the farmers surveyed. A lower net income CV than production CV suggests that differences in production volume among respondents were not associated with large differences in net income. This pattern may partly reflect the recorded low-cost structure, broadly similar selling prices, and comparable production systems among farmers in the study area. Similar patterns have been reported in several horticultural studies in West Java and

East Nusa Tenggara, where lower CV values were associated with more stable income (Rahman *et al*., 2020; Nugroho and Hidayat, 2022). However, such comparisons should be interpreted cautiously because production systems, seasons, locations, and income-calculation procedures may differ substantially.

The difference between net income CV and production CV suggests that, although farmers produced different quantities, they faced relatively similar selling prices and cost structures. Short-term income stability in Balassuka therefore did not depend only on yield, but also on the interaction of labor costs, market conditions, fertilizer expenses, and production practices. This interpretation is relevant because fresh tomato production in Indonesia remains constrained by quality, quantity, and supply-continuity issues that can influence farmers' competitiveness and market outcomes (Saptana *et al*., 2023). Moreover, the large share of fertilizer and labor costs in the cost structure indicates that future profitability may be affected by input-price shocks, particularly fertilizer market volatility (Vos *et al*., 2025). Thus, although the low net income CV indicates stable earnings among respondents in the observed season, this stability should be interpreted cautiously because tomato farmers remain exposed to production, market, and financial risks (Komarek *et al*., 2020).

Farmer-reported sources of production and market risk

The quantitative results were complemented by farmer interviews and field observations. Despite the low observed variability indicated by the CV values, interview data showed that farmers still perceived production and market constraints that could affect income stability in future seasons. Farmers in Balassuka reported six key sources of production and market risk:

Climate variability. Irregular rainfall and temperature fluctuations can increase disease pressure and disrupt crop growth. Farmers reported problems such as leaf spot and Fusarium wilt, particularly during high-rainfall periods. This is important because highland tomato production is sensitive to moisture and temperature variation, which can affect both crop development and disease incidence (Yoroba *et al*., 2019).

Pest and disease attack. Pests such as stem borers and fruit flies require regular monitoring and timely control (Khamidi *et al*., 2021; Basuki *et al*., 2022). Without effective management, pest and disease pressure can increase production costs, reduce marketable yield, and erode the profitability margin calculated for the observed season.

Fluctuating market prices. Tomato prices are affected by seasonality, market supply, and changes in demand. Because tomatoes are perishable and farmers have limited storage options, they are often pressured to sell immediately after harvest, which can reduce bargaining power and affect net income.

Low-quality or unsuitable seeds. Poor seed quality can reduce yield potential and lower crop tolerance to field conditions. Timely access to certified and locally adapted seeds is therefore important for maintaining production performance and reducing uncertainty.

Inefficient farming practices. Inefficient irrigation, inappropriate fertilizer application, and weak weed control can contribute to greater production variability (Rinaldi *et al*., 2019). These practices may also reduce input-use efficiency, particularly because labor and fertilizer already represent major components of production cost.

Capital constraints. Limited access to finance can prevent farmers from purchasing appropriate inputs or adopting improved technology. Capital constraints may delay input purchases, restrict farmers' ability to respond quickly to pest attacks, and increase reliance on informal credit arrangements.

In this way, qualitative evidence supports the CV results by identifying potential future drivers of production or income instability. Low CV values indicate limited observed variability during the study season, but they do not mean that tomato farming is free from production, market, or capital-related risks.

Extended interpretation and implications

The low CV values for production (0.24) and net income (0.06) indicate that tomato farming in Balassuka was profitable and showed low inter-farmer variability during the observed season. In practical terms, farmers generally obtained stable short-term returns under the conditions recorded in the survey. This pattern is consistent with case studies

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from comparable agroecological zones (Rahardjo *et al*., 2021). The results suggest a profitable season accompanied by relatively even income distribution among respondents. However, this inference must remain limited to the one-season study design, because inter-farmer consistency within one production season does not necessarily indicate temporal stability across years.

Simultaneously, qualitative evidence identifies multiple risks that remain actionable. Without timely management, climate uncertainty and pest pressure may become more severe. The cost structure also shows reliance on labor and chemical inputs, which exposes farmers to changes in input prices, particularly fertilizer price volatility (IFPRI, 2023). This is consistent with the finding that labor and fertilizer were the two major components of variable costs. Therefore, the main vulnerability of tomato farming in Balassuka may not be current profitability, but the possibility that future shocks could reduce yield, increase production costs, or weaken farmers' bargaining positions in the market.

Support for tomato farmers in Balassuka should be localized according to the main constraints identified in the study, rather than based on a uniform policy approach. Strategic options include:

a. Improving access to climate-resilient and certified tomato seeds;

b. Promoting water-saving irrigation systems and integrated pest management (IPM);

c. Improving input-use efficiency, especially for labor and fertilizer;

d. Reducing capital constraints through accessible rural credit schemes.

These measures could improve farm efficiency, environmental resilience, and equity among rural farming systems. However, their actual effects would need to be examined through intervention-based or longitudinal studies. For agricultural sustainability, future research should focus on whether these interventions can reduce variation in production quantity and value across seasons, rather than only documenting short-term profit.

Contextual comparison with previous studies

The Balassuka results were compared with selected evidence from Indonesia and other contexts. Table 6 presents this study alongside selected findings on seasonal net income and net income CV from Mentang *et al*. (2023), Sinaga (2023), and González and Rodríguez (2022). The comparison is intended as contextual information because the studies may differ in production scale, land area, season, technology, cost structure, and market conditions. Therefore, the comparison is used to support interpretation rather than to directly rank production systems.

Table 6. Contextual comparison of seasonal net income and CV.

Study location	**Net income (USD/season)**	**CV (net income)**
Balassuka, South Sulawesi (this study)	4,431.43	0.06
Parigi Moutong, Central Sulawesi (Mentang *et al*., 2023)	3,334.02	0.15
Tanah Datar, West Sumatra (Sinaga, 2023)	2,981.13	0.17
Colombia (González and Rodríguez, 2022)	4,981.29	0.12

This comparison is indicative rather than definitive because the cited studies may differ in land area, production technology, production season, price conditions, exchange assumptions, and income calculation procedures.

The comparison suggests that tomato farmers in Balassuka obtained relatively high and stable net income compared with the selected studies. The net income CV in Balassuka (0.06) was lower than the values reported for West Sumatra (0.17) and Central Sulawesi (0.15), indicating lower observed variability within this sample. Compared with the Colombian case, where high income was associated with protected cultivation, Balassuka still showed strong returns under the conditions observed in this study. Analytically, lower CV values may indicate relatively similar production conditions, cost structures, and market access among farmers in the same village. At the same time, income differences across contexts suggest that technology, production systems, and market integration can strongly affect profitability.

These comparisons reinforce the argument that tomato farming in Balassuka was financially profitable during the observed season, but they do not prove that the same result applies elsewhere or in other years. Differences in cultivated area, technical knowledge, season, market access, and income-calculation procedures can affect the results. Profitability indicators in smallholder horticulture are also sensitive to how family labor, depreciation, input subsidies, postharvest losses, and selling prices are recorded. Therefore, stronger cross-regional conclusions require comparable income definitions, production seasons, land-size metrics, and cost categories in future studies.

Synthesis of findings

Overall, tomato farming in Balassuka Village, Tombolopao Subdistrict, Gowa Regency generated high income and low observed farm-level variability during the study season. Farmers earned an average of USD 4,431.43 (Rp 69,567,944) per season and benefited from favorable agroecological conditions and selling prices. The CV values of 0.24 for production and 0.06 for net income indicate that the observed season was characterized by strong profitability and relatively low inter-farmer dispersion. However, this evidence remains seasonal and should not be interpreted as proof of stable long-term outcomes.

Farmers continued to report concerns related to pests and diseases, climate variability, seed quality, farming practices, and access to capital. If these constraints are not addressed, they could affect the sustainability of tomato production in future seasons. The findings therefore support not only profit improvement but also efforts to reduce farmers' exposure to production and market shocks. Policy measures to improve input delivery systems, farm management practices, and access to financial services may be useful, but these directions should be understood as practical implications rather than confirmed causal solutions because the present study did not test intervention effects.

This study contributes village-level evidence on upland horticultural net income and CV-based farm-level variability using direct farm-level income data. The results highlight the need for integrated support systems that strengthen the resilience and economic viability of semi-commercial tomato farming. The contribution is important because village-level data can reveal production and income patterns that may be hidden in regional-level statistics. Future research using multiyear data and additional production areas would strengthen the evidence base for more decentralized and context-specific agricultural policy in Indonesia. Because this study is descriptive, further research is needed to examine causal pathways linking farmer characteristics, input use, market access, and net income. Future comparative studies should also harmonize definitions of income and costs to support more robust comparisons across horticultural production systems.

Scenario-based sensitivity analysis

A scenario-based sensitivity analysis was conducted to examine the robustness of the low CV values for production (0.24) and net income (0.06). As explained in the subsection "Scenario-based sensitivity analysis" in the Materials and Methods section**,** the analysis tested whether the interpretation of low observed variability remained stable under alternative assumptions related to income calculation, input costs, yield, selling price, and outlier treatment. Because the data cover only one production season, the sensitivity analysis should be read as a robustness check and not as a predictive risk model. Therefore, the purpose of this section is to report the sensitivity findings rather than to repeat the methodological procedure.

Table 7 presents the results of the scenario-based sensitivity analysis used to examine whether the interpretation of low production and net income variability remained stable under alternative assumptions related to yield, selling price, production cost, and outlier treatment.

Table 7. Scenario-based sensitivity analysis of production and net-income variability in tomato farming in Balassuka Village (2024).

Scenario	Assumption tested	Indicator examined	CV result	Interpretation
Baseline condition	Observed farmer-level data from the 2024 production season	Production CV	0.24	Low observed production variability among farmers
Baseline condition	Observed farmer-level data from the 2024 production season	Net-income CV	0.06	Very low observed net-income variability among farmers
Median-based recalculation	Net income recalculated using median revenue and	Net-income CV	<0.10	The interpretation of low net-income variability remained stable

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Scenario	Assumption tested	Indicator examined	CV result	Interpretation
	cost values to reduce the influence of skewness			
Production-cost change	Total production costs increased and decreased by 15% to reflect possible input-price changes	Net-income CV	<0.10	Net-income variability remained low under moderate cost changes
Yield-reduction scenario	Average yield reduced by 20% to represent a hypothetical crop-loss condition	Production CV	0.36	Production variability increased but remained below the 0.50 threshold
Selling-price change	Selling price increased and decreased by 10% to reflect moderate market-price volatility	Net-income CV	<0.10	Price changes affected income levels but did not substantially increase net-income variability
Trimmed-sample approach	Highest and lowest 5% of production and net-income observations excluded	Production and net-income CV	<0.50	Variability remained within the manageable range after reducing the influence of extreme observations

CV = coefficient of variation. A threshold of 0.50 was used to interpret CV values, with CV values of 0.50 or lower indicating manageable variability in this descriptive analysis. Sensitivity analysis was not used as a predictive risk model; rather, it served as an additional robustness check.

The baseline CV values for production and net income (Tab. 7) remained in the low-variability category. Even under alternative assumptions about input costs, selling prices, and outlier treatment, the net income CV remained below 0.10. Production CV was more responsive than net income CV under the yield-reduction scenario, increasing from 0.27 under the normal condition to 0.36 under moderate crop-loss conditions. However, the adjusted CV values remained below 0.50, supporting the interpretation of low observed variability in tomato farming in Balassuka during the study season.

The sensitivity analysis indicates that the main interpretation of low observed variability is robust under the tested assumptions. However, the yield-reduction scenario shows that production shocks could narrow the profitability margin in unfavorable seasons. Practical responses may include climate-resilient seed varieties, more diversified cropping systems, improved price-risk management, and greater efficiency in labor and fertilizer use. Because these strategies were not implemented as interventions in this study, they are presented as practical implications for extension planning rather than as confirmed impact measures.

CONCLUSION

Tomato farming in Balassuka Village, a highland area of Gowa Regency, showed strong economic viability and low farm-level variability in production and net income during the study season. Farmers earned an average seasonal net income of USD 4,431.43 (Rp 69,567,944). The R/C ratio of 12.08, ROI of 1,107.95%, BEP production of 469.49 kg, and BEP price of USD 0.07/kg (Rp 1,078.12/kg) indicate that tomato farming generated returns well above production costs and remained above the break-even level in the observed season. The CV values of 0.24 for production and 0.06 for net income indicate low inter-farmer variability, although they do not prove long-term stability across seasons. Thus, the main finding is that tomato farming was profitable and relatively consistent among surveyed farmers in the 2024 production season, but this result should be interpreted within the limits of a one-season descriptive study.

Qualitative results show that farmers still face climate variability, pest and disease outbreaks, seed-quality issues, management constraints, and limited access to finance. Although these constraints were not fully captured by the CV values, they are important for the sustainability of tomato farming in future seasons. The sensitivity analysis also shows that production shocks, especially yield losses, are the most likely source of increased variability. Consequently, the one-season CV results should be interpreted together with field evidence on production, marketing, and capital-access constraints.

Support for tomato farmers should prioritize access to climate-resilient and certified seeds, improved irrigation management, integrated pest management (IPM), and rural credit. These measures should be locally adapted and farmer-centered. Because labor and fertilizer account for a large share of production costs, support for improving labor and fertilizer-use efficiency is also important. The study did not directly test policy interventions; therefore, these implications should be understood as guidance for applied research and agricultural extension planning.

This study provides village-level evidence on seasonal net income and CV-based farm-level variability in upland tomato farming. Its main limitations are the focus on one village, the small sample size (*n*=42), the single-season design, and the use of CV as a descriptive variability indicator rather than a full temporal risk model. Further studies using multiseason and cross-regional data are needed to strengthen evidence for agricultural policy in Indonesia. Future research should also examine causal relationships among farmer characteristics, input use, market access, production performance, and net income so that stronger policy recommendations can be developed.

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