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A model for enhancing value addition in chili farming to support food security and SDGs in Indonesia

Fafurida[1+]
Wijang Sakitri[2]
Fauzul Adzim[3]
Annis Nurfitriana Nihayah[4]
Meilani Intan Pertiwi[5]

[1,2,3,4,5]*Faculty of Economics and Business, Universitas Negeri Semarang, Indonesia.*
[1]*Email:* fafurida@mail.unnes.ac.id
[2]*Email:* wijangsakitri@mail.unnes.ac.id
[3]*Email:* fauzuladzim@mail.unnes.ac.id
[4]*Email:* annisnurfitriana@mail.unnes.ac.id
[5]*Email:* intanmeilani05@mail.unnes.ac.id


(+ Corresponding author)

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ABSTRACT

This study aims to develop a model that enhances the value of chili farming, with the objectives of improving food security and contributing to the achievement of the Sustainable Development Goals (SDGs) in Central Java. The research employs a mixed-method approach, integrating quantitative data from surveys and Hayami value-added analysis with qualitative insights from interviews, observations, and group discussions. Data analysis involves Hayami analysis to quantify value addition during chili processing into powder, interregional input-output (IRIO) analysis to assess the economic impact of chili farming on related sectors, and Importance Performance Analysis (IPA) to identify strategic priorities for value enhancement. The findings indicate that processing chili into powder increases its value by 34%, with a profit margin of 25%, thereby increasing farmers' income and generating employment opportunities. The IRIO analysis reveals that the chili processing industry in Central Java is highly interconnected with other industries, particularly in DKI Jakarta and East Java. The IPA results suggest that improving access to high-quality raw materials, facilitating easier loan access, providing better training for workers, and developing effective marketing strategies are essential for sector development. The study confirms that an integrated approach, emphasizing cross-sector collaboration, institutional strengthening, production efficiency, and market-oriented processing, is necessary to build an effective model for increasing chili's added value. The implications of this model extend beyond competitiveness, supporting poverty alleviation, food security, and sustainable industrialization aligned with the SDGs framework.

Contribution/Originality: This study combines value-added analysis, IRIO modeling, and Importance-Performance Analysis (IPA) to develop a comprehensive model for enhancing chili value addition linked to the Sustainable Development Goals (SDGs). The approach integrates technical, institutional, market, and policy aspects that have not been thoroughly addressed in previous studies in Indonesia.

1. INTRODUCTION

Indonesia, as an agricultural country, has a high dependence on the agricultural sector in maintaining economic, social, and national food security stability. One of the horticultural commodities that has strategic value is chili (Hadiyati & Suryani, 2018; Setiawan & Rahayu, 2021). Chili is not only an important part of the consumption patterns of the Indonesian people, who are famous for their spicy taste, but also has a significant contribution to food inflation, especially when there is price volatility (Aini & Zulfikar, 2020; Alemayehu & Gecho, 2016; Nayal et al., 2023; Rustiani, Effendy, & Sudradjat, 2019; Saengtipbovorn, Tongsiri, & Phimphanthavong, 2016). Chili is usually considered a sensitive food item that directly affects the well-being of families and the overall health of the economy. However, the process of growing and selling chili in Indonesia still has many serious problems. Productivity is not improving much, there isn't much new technology used after the crops are harvested, and farmers mainly sell their fresh produce. Because of this, the extra value that chili brings is not being used to its full potential (Nayal, Raut, Lopes de Sousa Jabbour, Narkhede, & Gedam, 2025; Prasetyo & Harahap, 2021). When the amount of chili produced does not match the demand, it leads to significant changes in prices, especially during times when there is a large harvest or when crops fail due to bad weather or pests (Chu, Peretto, & Wang, 2022; Martinez, Sanchez, & Delgado, 2020; Phongphit & Wongwanich, 2018; Setiawan & Sutrisno, 2020). This problem not only puts chili farming businesses at risk but can also lead to a shortage of supply, which can harm food security (Reringga & Mursalin, 2019; Setyowati & Raharjo, 2020; Sharma, Kamble, Gunasekaran, Kumar, & Kumar, 2020). In reality, most chilies are sold fresh, which makes them more likely to go bad or be wasted. These issues of food loss and waste are significant problems in the global food system and are closely tied to using resources efficiently and protecting the environment. Meanwhile, post-harvest processing and diversification of chili-based products such as packaged chili sauce, chili powder, or pickles are still not common practices among farmers or farmer cooperatives (Martinez, Garcia, & Ramirez, 2022; Putra & Zahri, 2019; Putra, Nugroho, & Widjaja, 2020; Rachman, Putri, & Hakim, 2019; Rachman & Widjaja, 2022). In fact, the development of a local processing industry based on village agro-industry has the potential to provide a multiplier effect: extending the shelf life of products, creating jobs, increasing local competitiveness, and strengthening the position of farmers in the agribusiness value chain.

These issues signal the urgency of developing a comprehensive model for increasing the added value of chili farming, adaptive to local conditions, and capable of driving the transformation of a food system based on sustainability. This model must include aspects of production, post-harvest, marketing, institutions, and digitalization, in order to produce solutions that not only strengthen national food security but also encourage farmer empowerment, economic efficiency, and the achievement of SDGs targets in a more targeted manner.

Several earlier studies have discussed ways to increase the value of various agricultural products, such as chilies, by focusing on aspects such as post-harvest processing, the development of different product types, and improvements in the supply chain (Lailiyah, Saputra, & Kurniawan, 2021; Ramdani & Tamam, 2018; Rana, Tricase, & De Cesare, 2021; Rejekiningrum & Ritung, 2020). Some studies highlight the importance of using better technology for processing and packaging chilies to make them last longer, while others examine marketing strategies and ways to improve access to markets to help farmers earn more money (Herman & Wahyuni, 2020; Lee, Park, & Kim, 2020; Muchdie, 2017; Mulyono, Hilman, Sastro, & Setiani, 2019; Ndlovu, Shumba, & Vakira, 2018). However, there is still a lack of research that connects improving the value of chili farming with efforts to enhance food security and achieve the Sustainable Development Goals (SDGs) (Ibanah, Muhlison, & Arum, 2022; Kamble, Gunasekaran, & Gawankar, 2020; Noviyanti, Ismawati, & Rosiana, 2022; Nuryanti & Swastika, 2018; Ormanovic et al., 2017; Ozturk, Durdyev, Aras, Ismail, & Banaitienė, 2020). The new part of this research is the creation of a complete model that not only looks at the technical side of chili processing but also includes social, economic, and environmental factors in line with the SDGs. This model is meant to bring together efforts to increase the value of chilies, improve food security, and meet SDGs goals like reducing poverty, encouraging fair economic growth, and making better use of resources. This study aims to offer fresh ideas to both the research and practical work in sustainable development within the agricultural field. The need for this research is that the model for improving value can make the supply chain more efficient and sustainable, which helps to strengthen the country's food security. In the context of achieving the SDGs, increasing the value added of chili farming is not only relevant to the goal of food security but also related to other goals, such as poverty alleviation (SDG 1), zero hunger (SDG 2), inclusive economic growth (SDG 8), and responsible consumption and production (SDG 12). By optimizing the added value of chili farming, it is expected to create new jobs, increase farmers' income, and reduce dependence on chili imports. Based on the background of the problem, the purpose of this study is to develop a strategic model for increasing the value added of chili farming in strengthening food security as an effort to accelerate the achievement of SDGs.

2. METHODS

This study employs a mixed methods approach, combining both quantitative and qualitative methods to provide a comprehensive and in-depth understanding of the dynamics of the chili farming system, particularly in the context of increasing added value and its contribution to food security and the acceleration of Sustainable Development Goals (SDGs). This approach was selected due to the complexity of the problem, which encompasses not only economic and technical aspects but also social, institutional, and policy factors. The research design adopted is sequential explanatory, where quantitative data collection and analysis are conducted first to establish an overview and identify statistical patterns, followed by qualitative data collection and analysis to deepen the understanding of the quantitative results and explore the local context and narratives behind the data.

The data used in this study consist of primary data and secondary data. Primary data were obtained directly from the field through several data collection techniques, namely surveys, in-depth interviews, observations, and focus group discussions (FGD). The survey was conducted by distributing questionnaires to chili farmers, traders, chili processing MSMEs, and consumers, who were selected through purposive sampling techniques and stratified random sampling based on the region and segmentation of the chili value chain. In-depth interviews were conducted with strategic parties such as representatives from the agricultural service, farmer cooperatives, agro-industry entrepreneurs, and other stakeholders who are directly involved in the production, processing, distribution, and marketing of chili. The FGD involved various important actors such as academics, local governments, farmer associations, and logistics actors, who together discussed challenges and solutions in efforts to increase the added value of chili farming. In addition, field observations were conducted to gain a direct understanding of cultivation practices, post-harvest, and the processing and distribution process of chili.

Table 1. Hayami value-added calculation method.

Output, input, and price	Notation
Output/Total production (Kg/Production)	A
Raw material input of paddy (Kg/Production)	B
Labor Input (HOK/Production)	C
Conversion factor	A/B=M
Labor coefficient	C/B=N
Output price (Rp/Kg)	D
Labor wages (Rp/Kg)	E
Revenue and profit	
Price of raw material input for paddy (Rp/Kg)	F
Other input contribution (Rp/Kg)	G
Product value (Rp)	M*D=K
Added value (Rp)	KFG=I
Value added ratio (%)	(I/O) %=H%
Labor income (Rp/Kg)	P=N*E
Employee rewards (%)	(P/I) %=Q
Profit (Rp/Kg)	IP=R
Profit level	(R/I) %=S%
Remuneration for production factors	
Margin (Rp/Kg)	KF=T
Labor income (%)	(P/T) %=U%
Other input contribution (%)	(G/T) %=V%
Processing profit (%)	(R/T) %=W%

Meanwhile, secondary data is obtained from various official and relevant sources, such as statistical publications from the Central Statistics Agency (BPS), reports from the Ministry of Agriculture, Ministry of Trade, related agencies at the provincial and district levels, as well as academic literature and documents from international organizations such as FAO. This data is used to support and complement information from primary data, as well as to provide a macro context to the issues being studied.

The research location is focused on Central Java Province, which is one of the main centers of chili production in Indonesia and has quite complex distribution dynamics and post-harvest processing. The research subjects include all important elements in the chili farming value chain, from farmers, collectors, processing business actors, cooperatives, related agencies, to market actors and end consumers. To ensure the validity and reliability of the data, a triangulation technique of methods and sources is used, where data obtained from surveys, interviews, observations, and FGDs are compared and verified with each other to obtain consistent and reliable results.

There are three methods of analysis in this study, namely the first is the analysis of the calculation of added value with the Hayami method to determine the amount of added value generated from chili downstreaming. The calculation model for added value with the Hayami method is presented in Table 1.

The second analysis method involves examining the impact of increasing the added value of chili on various derived products, particularly those related to the IRIO model. The database utilized for this analysis is the 2016 IRIO Table published by the Central Statistics Agency. The following is the formula used in the impact *analysis*.

1. Impact on output

Change in output in region P sector i.

$$\Delta X_i^P = \sum_{j=1}^{n} k_{ij}^{PP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{PQ}\, \Delta Y_j^Q$$

Change in output in region Q sector i.

$$\Delta X_i^Q = \sum_{j=1}^{n} k_{ij}^{QP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{QQ}\, \Delta Y_j^Q$$

2. Impact on revenue

Changes in income in region P sector i.

$$\Delta W_i^P = w_i^P \left(\sum_{j=1}^{n} k_{ij}^{PP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{PQ}\, \Delta Y_j^Q \right)$$

Change in income in region Q sector i.

$$\Delta W_i^Q = w_i^Q \left(\sum_{j=1}^{n} k_{ij}^{QP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{QQ}\, \Delta Y_j^Q \right)$$

3. Impact on workforce:

Changes in workforce in area P sector i.

$$\Delta T_i^P = t_i^P \left(\sum_{j=1}^{n} k_{ij}^{PP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{PQ}\, \Delta Y_j^Q \right)$$

Changes in workforce in region Q sector i.

$$\Delta T_i^Q = t_i^Q \left(\sum_{j=1}^{n} k_{ij}^{QP}\, \Delta Y_j^P + \sum_{j=1}^{n} k_{ij}^{QQ}\, \Delta Y_j^Q \right)$$

The third method for developing a strategy to add value to chili farming in Central Java is called Importance-Performance Analysis, or IPA. This tool helps assess the importance of specific features in the marketing process and identifies which areas require the most improvement (Ormanovic et al., 2017). IPA examines both the perceived importance of certain features and their current performance. The results are displayed on a graph divided into four sections (Martilla & James, 1977; Ong & Pambudi, 2014):

1. Quadrant I (Top Priority): Attributes that are considered important by respondents, but their performance is still low. Attributes in this quadrant are a priority for improving their performance.
2. Quadrant II (Maintain Performance): Attributes that are considered important by respondents and whose performance is also high. Attributes in this quadrant need to be maintained.
3. Quadrant III (Low Priority): Attributes that are considered less important by respondents, and their performance is also low. Attributes in this quadrant can be ignored for the time being.
4. Quadrant IV (Excessive): Attributes that are considered not very important by respondents, but their performance is high. Attributes in this quadrant can be allocated resources to other attributes that are priorities.

In the context of strengthening the palm sugar marketing network, attributes that can be evaluated using IPA include aspects such as the availability of raw materials, processing technology, infrastructure, market access, government support, and others (Nurmala & Nurmalina, 2015).

The procedures or steps taken in IPA analysis (Anggraini, Bachtiar, & Shalihati, 2020) include:

1. Weighting of importance level *and* performance *level*

IPA analysis uses a 4-rank Likert scale, each of which is assigned a score or weight as shown in the following table:

Table 2. Importance level weighting.

Criteria	Scale	Description
SP	4	If the performance of the condition indicator is very important in influencing the marketing performance of palm sugar in Purworejo Regency.
P	3	If the performance of the condition indicator is important in influencing the marketing performance of palm sugar in Purworejo Regency.
TP	2	If the performance of the condition indicator is not important in influencing the marketing performance of palm sugar in Purworejo Regency.
STP	1	If the performance of the condition indicator is very unimportant in influencing the marketing performance of palm sugar in Purworejo Regency.

Table 2 presents the importance level weighting used to assess how strongly each condition indicator influences the marketing performance of palm sugar in Purworejo Regency. The scale ranges from 1 to 4, where a score of 4 (SP) signifies that the indicator is very important, a score of 3 (P) denotes important, a score of 2 (TP) indicates not important, and a score of 1 (STP) reflects that the indicator is very unimportant. This classification helps prioritize the key factors that affect marketing performance based on their perceived significance.

Table 3. Performance level weighting.

Criteria	Scale	Description
SB	4	If the performance of the condition indicator is very good in influencing the marketing performance of palm sugar in Purworejo Regency.
B	3	If the performance of the condition indicator is good in influencing the marketing performance of palm sugar in Purworejo Regency.
TB	2	If the performance of the condition indicator is not good in influencing the marketing performance of palm sugar in Purworejo Regency.
STB	1	If the performance of the condition indicator is very poor in influencing the marketing performance of palm sugar in Purworejo Regency.

Table 3 presents the performance level weighting, which is used to evaluate the effectiveness of each condition indicator in influencing the marketing performance of palm sugar in Purworejo Regency. The scale ranges from 1 to 4, where a score of 4 (SB) represents very good performance, 3 (B) indicates good performance, 2 (TB) signifies not good, and 1 (STB) denotes very poor performance. This rating helps identify which indicators are performing well and which require improvement in supporting palm sugar marketing strategies.

2. Calculating the value of conformity between the level of importance and the level of performance

The level of conformity is calculated with the aim of determining the priority order that should receive primary attention. The formulas used are:

$$Tki = \frac{xi}{yi} \times 100\%$$

Information:

Tki = level of conformity.

xi = performance assessment score.

yi = importance assessment score.

3. Calculate the average of each attribute

The average for each attribute perceived by respondents is calculated using the following formula:

$$\overline{XI} = \frac{\sum XI}{n}; \overline{YI} = \frac{\sum YI}{n}$$

Information:

$\overline{XI}$= average score of product performance level.

$\overline{YI}$= average score of level of importance towards the product.

n = number of respondents.

4. Cartesian diagram

The Cartesian diagram limits are created to determine where the level of importance and performance lies; the limits can be calculated using the following formula:

$$\overline{\overline{X}} = \frac{\sum \overline{XI}}{k}; \overline{\overline{Y}} = \frac{\sum \overline{YI}}{k}$$

Information:

$\overline{\overline{X}}$= average product performance level score of all factors or attributes.

$\overline{\overline{Y}}$= average level of importance of all attributes that influence consumer satisfaction.

k = the number of attributes that can influence consumer satisfaction.

3. RESULTS AND DISCUSSION

3.1. Analysis of Added Value of Chili Processing

Value-added analysis is a method used to measure changes in the value of a product from the initial stage of production to the final product ready for sale. In the context of chili downstreaming, value-added analysis can be applied from the chili cultivation process by farmers to its processing into processed products.

Table 4 presents the results of the analysis of the added value of processing red chili into processed products in the form of chili powder. Based on these data, it is known that to produce 10 kilograms of chili powder, 15 kilograms of red chili are needed as the main raw material, involving two man-days (HOK) in one production cycle. This shows that the process of processing red chili into powder has a conversion factor of 0.67, which means that from every 1 kg of red chili, only 0.67 kg of chili powder is produced. The labor coefficient of 0.13 indicates that every 1 kg of product requires around 0.13 man-days, reflecting the level of labor intensity in the production process.

In terms of price, the final product of chili powder is priced at IDR 50,000 per kilogram. Assuming the labor wage per HOK is IDR 50,000, the total labor cost for two HOKs reaches IDR 100,000. The price of the main raw material, namely red chili, is IDR 15,000 per kilogram, so the total cost of raw materials for 15 kg is IDR 225,000. On the other hand, there are additional costs from other inputs of IDR 7,000 per kilogram, or IDR 70,000 for 10 kg of product. Based on the cost components and production results, the value of the product produced is IDR 333,333, while the added value is recorded at IDR 113,333. This value is obtained by subtracting the total of all main and additional input costs from the product value.

Table 4. Analysis of added value of processed chili powder products.

Output, input, and price	Chili powder
Output/Total production (Kg/Production)	10
Red chili raw material input (Kg/Production)	15
Labor Input (HOK/Production)	2
Conversion factor	0.67
Labor coefficient (HOK)	0.13
Output price (Rp/Kg)	50,000
Labor wages (Rp/HOK)	50,000
Revenue and profit	
Red chili raw material input price (Rp/Kg)	15,000
Other input contribution (Rp/Kg)	7,000
Product value (Rp)	33.333
Added value (Rp)	11,333
Value added ratio (%)	34%
Labor income (Rp/Kg)	6,667
Employee rewards (%)	58.82%
Profit (Rp/Kg)	4,667
Profit level	41.18%
Remuneration for production factors	
Margin (Rp/Kg)	18,333
Labor Income (%)	36%
Other input contribution (%)	38%
Processing profit (%)	25%

The ratio of the resulting added value reached 34%, indicating that about one-third of the total product value is the result of the processing process carried out. Of this value, labor income per kilogram of product is IDR 6,667, while labor compensation to added value reaches 58.82%. This shows that the contribution of labor to the production process is quite significant. The net profit per kilogram of product is IDR 4,667, which reflects a profit level of 41.18% of the added value. Thus, the business of processing chili into powder is quite profitable.

Furthermore, analysis of production factor remuneration shows that the margin obtained is Rp18,333 per kilogram. The distribution of this margin is divided into 36% for labor income, 38% for other input contributions, and 25% as profit from the processing process. This shows that in addition to labor, other input costs also have a large contribution to the resulting margin. The percentage of processing profit of 25% of the total margin confirms that this agro-industry activity not only provides economic added value but is also financially feasible to be developed on a larger scale.

The results of this analysis indicate that the process of processing red chili into chili powder provides a positive contribution to the creation of added value, efficient use of production factors, and relatively balanced income distribution among production actors. These findings support the development of household-scale agro-industry or MSMEs in the agricultural sector, especially in efforts to improve the welfare of farmers and micro-entrepreneurs through processing products based on local agricultural products.

3.2. Analysis of the Impact of Chili Downstreaming

In Central Java Province, the highest forward linkage value for chili farming is the chili processing industry sector in DKI Jakarta, with a linkage value of 3.8718. This linkage value indicates that if there is an increase in final demand in the chili farming sector in West Java Province of Rp1,000,000, then the increase in output allocated to the chili processing industry sector in DKI Jakarta is Rp3,871,800. Other sectors with the highest forward linkages to the chili farming sector in Central Java Province include the chili farming sector in Central Java, chili farming in DKI Jakarta, the chili processing industry in Central Java, and the chili farming sector in Papua.

Table 5 shows the backward linkage value of the sub-sector of Annual Horticultural Crops, Crops, and Others in the province of Java Island. Through segregation of chili plants, it is known that the highest backward linkage value of the chili plant farming sector in DKI Jakarta is the chili farming sector in East Java with a linkage value of 4.1491. This linkage value indicates that if there is an increase in final demand in the chili farming sector of DKI Jakarta Province of Rp1,000,000, then the increase in input needed from the chili sector in East Java is Rp4,149,100. Other sectors with the highest backward linkages to the chili farming sector in DKI Jakarta are the chili farming sector in DKI Jakarta, chili farming in Aceh, chili farming in Central Java, and the chili farming sector in West Java.

In Central Java Province, the highest backward linkage value for chili farming is the chili farming sector itself in the same province, with a linkage value of 1.0356. This linkage value indicates that if there is an increase in final demand in the chili farming sector in Central Java of Rp1,000,000, then the increase in input needed from the sector itself is Rp1,035,600. Other sectors with the highest backward linkages to the chili farming sector in Central Java include the chemical, pharmaceutical, and traditional medicine industry sectors, wholesale and retail trade (excluding cars and motorcycles), agricultural services and hunting, and the livestock sector in Central Java.

Table 5. Total Linkages to the Future of the Agricultural Sector of Annual Horticultural Crops, Plants, and Others on Java Island.

Chili Farming		Sectors with the Highest Forward Linkages				
No	**Province**	**1**	**2**	**3**	**4**	**5**
1	Jakarta	1.0005	0.0018263	0.0000002	0.00000004	0.00000002
		Chili (Jakarta)	Chili processing industry (Jakarta)	Food and drink provision (Jakarta)	Provision of accommodation (Jakarta)	Water supply, waste management, waste and recycling (Jakarta)
2	West Java	5.8992	1.0230	0.3764	0.03754	0.0155
		Chili Processing Industry (Jakarta)	Chili (West Java)	Chili (Jakarta)	Chili Processing Industry (West Java)	Chili (Banten)
3	Central Java	3.8718	1.0356	0.7580	0.0385	0.0276
		Chili processing industry (Jakarta)	Chili (Central Java)	Chili (Jakarta)	Chili processing industry (Central Java)	Chili (Papua)
4	DI Yogyakarta	1.0015	0.0967	0.0753	0.0095	0.0050
		Chili (DI Yogyakarta)	Chili processing industry (Jakarta)	Chili Processing Industry (DI Yogyakarta)	Food and drink provision (DI Yogyakarta)	Chili (Jakarta)
5	East Java	14.2322	4.1492	1.0204	0.0496	0.0097
		Chili processing industry (Jakarta)	Chili (Jakarta)	Chili (East Java)	Chili (Papua)	Chili processing industry (East Java)
6	Banten	1.0044	0.0717	0.0169	0.0037	0.0008
		Chili (Banten)	Chili processing industry (Jakarta)	Chili (Jakarta)	Chili processing industry (Banten)	Food and drink provision (Banten)

Table 6 presents the total backward linkages of the agricultural sector, specifically in chili farming, across six provinces on Java Island. The table identifies the five sectors with the highest backward linkages in each province, indicating the degree to which chili farming activities rely on inputs from other sectors. For example, in Jakarta, chili farming is strongly linked to chili production in East Java and Jakarta itself, as well as to sectors such as trade and pharmaceuticals. In provinces like West Java and Central Java, significant backward linkages are observed with the wholesale and retail trade sector, agriculture and hunting services, and the pharmaceutical industry. The values listed alongside each sector represent the backward linkage coefficient, illustrating the relative strength of intersectoral dependence. This information is crucial for understanding which sectors contribute the most to chili farming and where policy interventions could enhance supply chain efficiency and regional agricultural development.

Table 6. Total Backward Linkages of the Agricultural Sector of Annual Horticultural Crops, Crops, and Others in Java Island.

Chili Farming		Sectors with the Highest Backward Linkages				
No	Province	1	2	3	4	5
1	Jakarta	41,491	10,005	0.8515	0.758	0.3764
		Chili (East Java)	Chili (Jakarta)	Chili (Aceh)	Chili (Central Java)	Chili (West Java)
2	West Java	10,230	0.0243	0.024	0.0216	0.0101
		Chili (West Java)	Agriculture and Hunting Services (West Java)	Wholesale and Retail Trade. Not Motor Vehicles and Motorcycles (West Java)	Chemical, Pharmaceutical and Traditional Medicine Industry (West Java)	Metal Goods, Computers, Electronic Goods, Optics, and Electrical Equipment Industry (West Java)
3	Central Java	10,356	0.037	0.0255	0.0157	0.0112
		Chili (Central Java)	Chemical, Pharmaceutical and Traditional Medicine Industry (Central Java)	Wholesale and Retail Trade, Not Cars and Motorcycles (Central Java)	Agriculture and Hunting Services (Central Java)	Farm (Central Java)
4	In Yogyakarta	1.0015	0.0443	0.0191	0.0137	0.0087
		Chili (DI Yogyakarta)	Other Financial Services (DI Yogyakarta)	Chemical, Pharmaceutical and Traditional Medicine Industry (DKI Jakarta)	Chemical, Pharmaceutical and Traditional Medicine Industry (West Java)	Wholesale and Retail Trade, not Cars and Motorcycles (DI Yogyakarta)
5	East Java	1.0204	0.0834	0.0263	0.014	0.0102
		Chili (East Java)	Chemical, Pharmaceutical and Traditional Medicine Industry (East Java)	Wholesale and Retail Trade, not Motorbikes and Motorcycles (East Java)	Financial Intermediary Services Other Than Central Bank (East Java)	Agriculture and Hunting Services (East Java)
6	Banten	10,044	0.0155	0.0141	0.0137	0.0044
		Chili (Banten)	Chili (West Java)	Farm (Banten)	Wholesale and Retail Trade, not Motorbikes and Motorcycles (Banten)	Chili (Central Java)

3.3. Results of Analysis of the Strategy Model for Increasing the Added Value of Chili Farming in Strengthening Food Security as an Effort to Accelerate the Achievement of SDGs

In determining the increase in value added of chili farming in strengthening food security in Central Java, this study uses Important Performance Analysis (IPA). The results of the IPA related to the level of performance and importance of several aspects in increasing the value added of chili farming to strengthen food security in Central Java are presented in Figures 1 and 2.

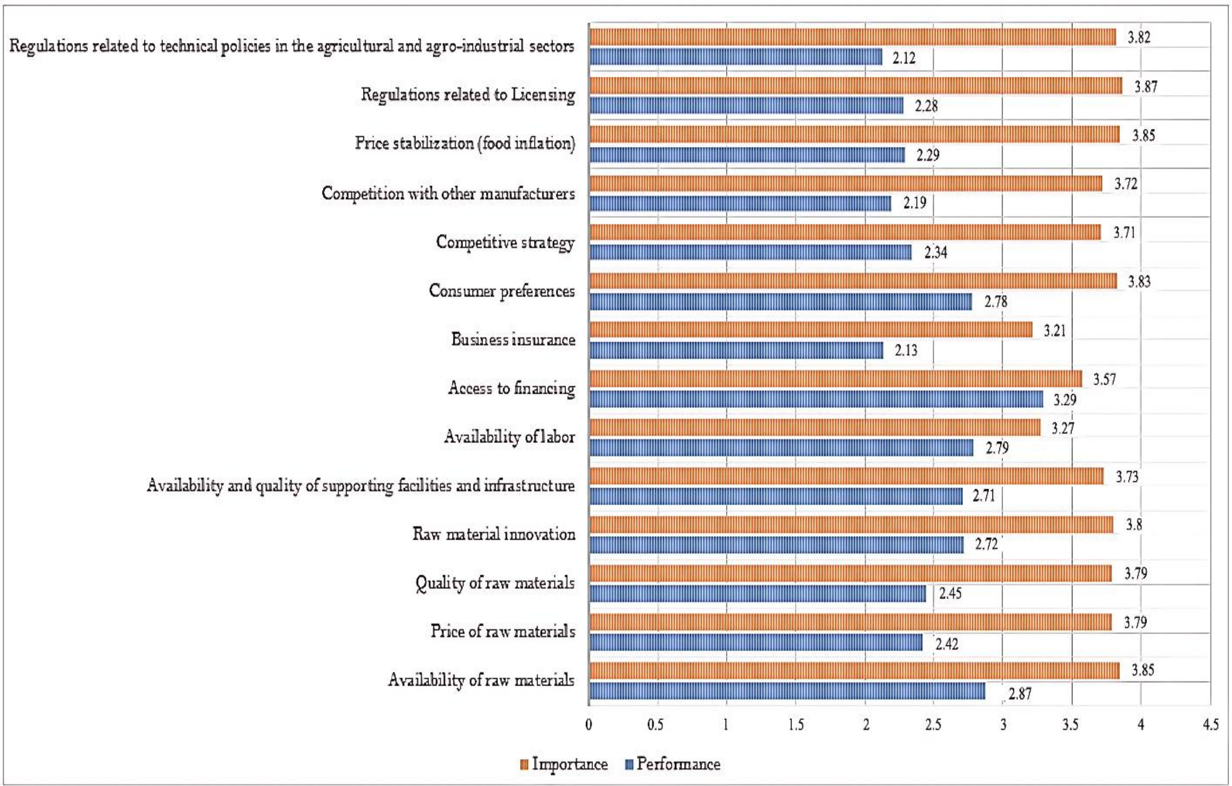

Figure 1. Analysis of performance level and level of importance of aspects in the strategy for increasing the added value of chili farming in strengthening food security in central Java in quadrant 1.

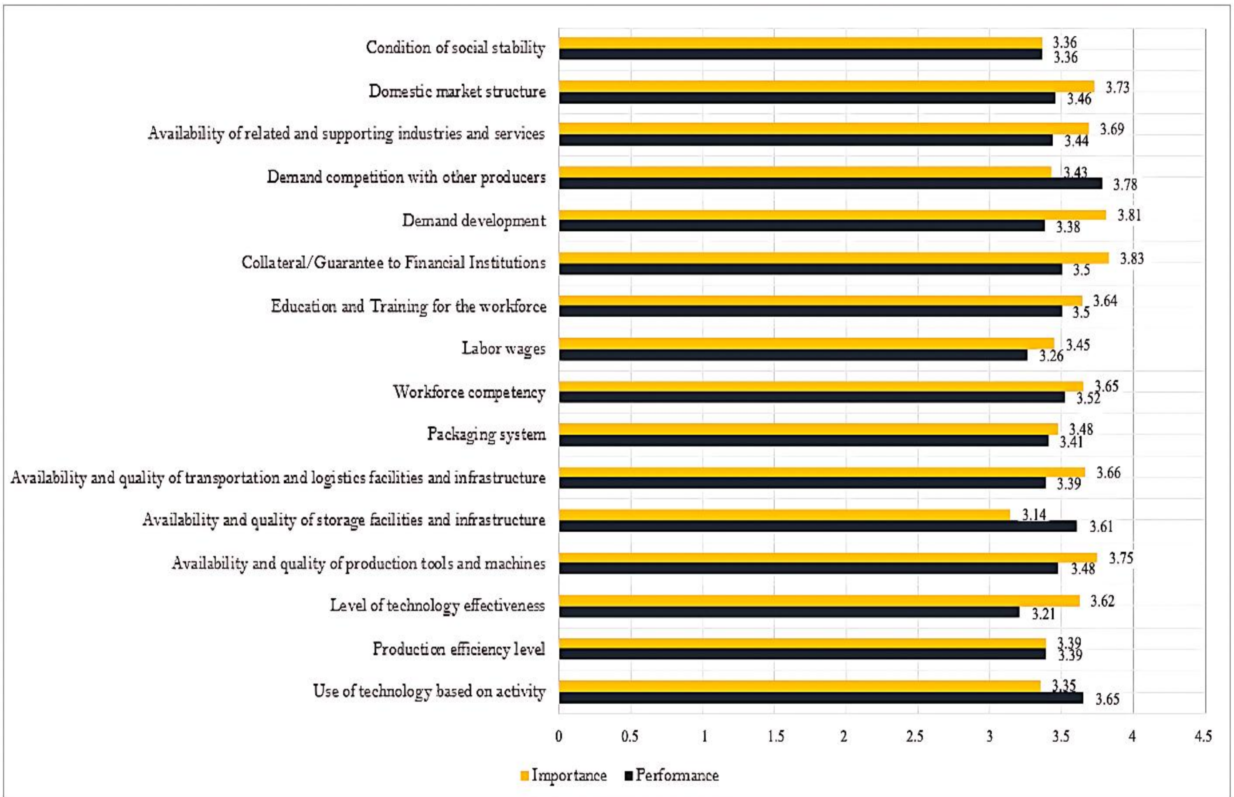

Figure 2. Analysis of performance level and level of importance of aspects in the strategy for increasing the added value of chili farming in strengthening food security in central Java in quadrant 2.

The results of the IPA calculations in Figure 1 and 2 produce the following Cartesian diagram:

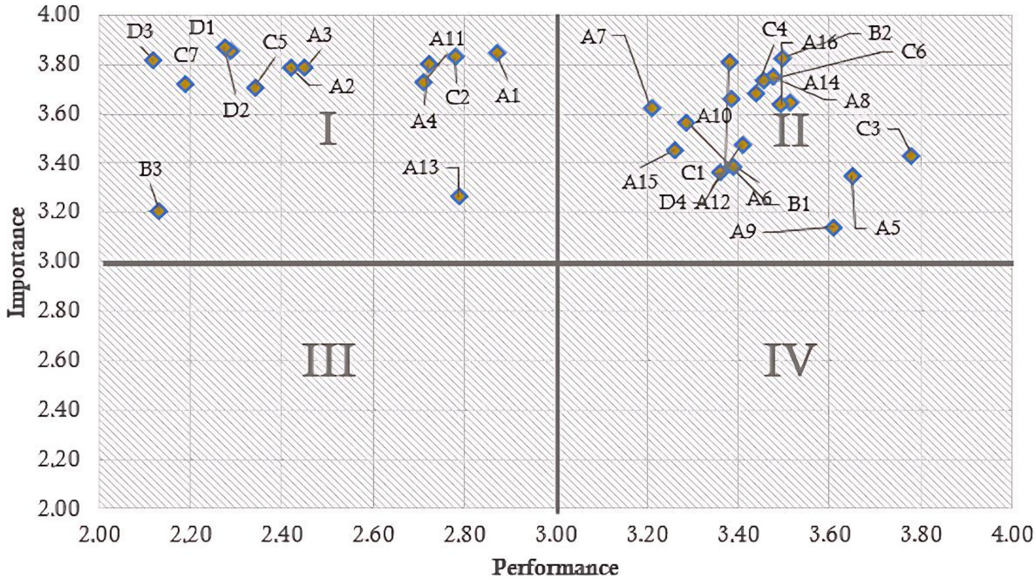

Figure 3. Cartesian diagram of IPA analysis.

Figures 1, 2 and 3 are the results of the analysis using the Importance Performance Analysis (IPA) approach to identify strategic priorities in increasing added value in the chili farming sector as part of efforts to strengthen food security in Central Java Province. The results of this analysis group various indicators into four quadrants that represent the difference between the level of importance and performance of each aspect. Quadrant I contains aspects that are very important but have low performance, indicating the need for immediate intervention. Quadrant II includes aspects that are important and have performed well, so they need to be maintained. Quadrant III is an aspect that has low importance and performance, while Quadrant IV shows aspects with high performance but low importance, indicating potential for inefficient resource allocation.

In Quadrant I, a number of strategic indicators show a high level of importance, but their performance is still below expectations. These indicators include the availability and quality of supporting facilities and infrastructure for quality (A11), education and training for workers (A16), competition for demand with other producers (C3), and competitive strategy (C5). The position of these indicators in Quadrant I shows that increasing human resource capacity and quality infrastructure are the most urgent aspects to be improved in an effort to increase the competitiveness and efficiency of the chili product downstream process. In addition, strategies to face market competition, both from the supply and demand sides, need to be designed in a more focused manner so that business actors in this sector can survive and thrive amidst competitive market dynamics.

Meanwhile, indicators in Quadrant II are aspects that have performed well and have a high level of importance. These indicators include the use of technology based on activities (A5), production efficiency level (A6), technology effectiveness level (A7), availability and quality of production tools and machines (A8), and availability of labor (A13), business insurance (B3), availability of supporting industries and services (C4), and regulations related to agriculture and agro-industry (D3). The results show that chili farming in Central Java has performed well in adopting new technologies and making production processes more efficient. These areas should be maintained and improved to ensure continued growth in productivity and the value of chili products. Skilled labor is crucial for the production process, so it is important to ensure workers are well-trained and that there is a steady supply of labor.

Based on the full analysis, the model for increasing the value of chili farming to improve food security and help achieve the SDGs is shown in Figure 4.

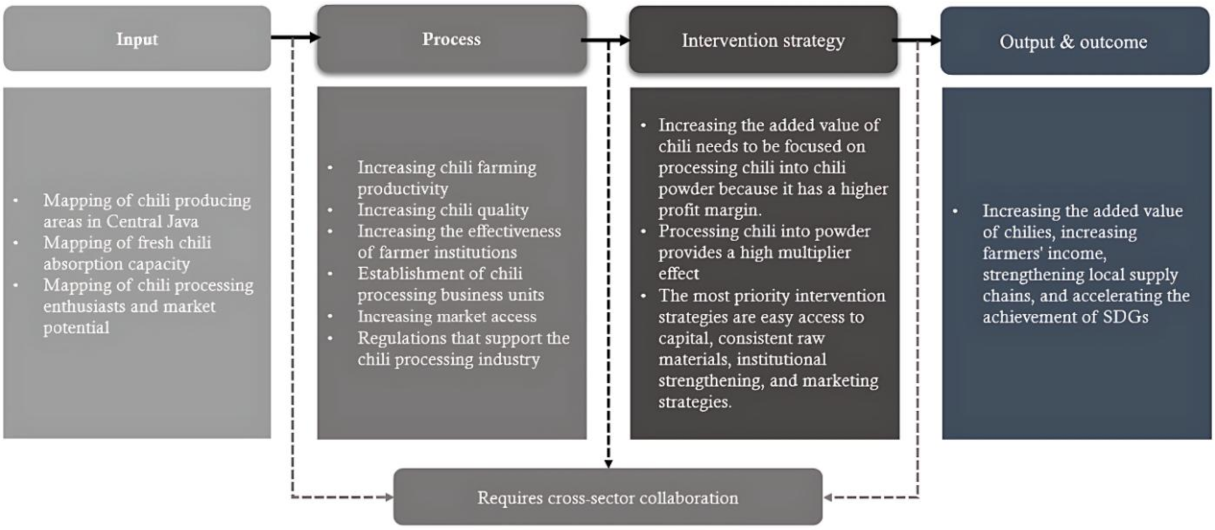

Figure 4. Model for increasing the value added of chili farming to strengthen food security and accelerate the achievement of the Sustainable Development Goals (SDGs).

The figure illustrates a model that explains how increasing the value of chili farming can contribute to improving food security and achieving the Sustainable Development Goals (SDGs). This model consists of three components: input, process, and intervention strategies, all aimed at attaining sustainable outcomes aligned with the SDGs. In the input stage, the model emphasizes the importance of utilizing data to formulate effective policies. Three key activities are identified: (1) locating chili cultivation areas in Central Java, (2) assessing the capacity of local and regional markets to absorb fresh chili, and (3) identifying potential buyers and businesses for chili processing collaborations. This information supports the development of plans tailored to local needs and market opportunities. The process stage involves efforts to enhance the entire supply chain, from cultivation to sales. This includes increasing productivity through improved farming techniques, enhancing chili quality, and fostering better cooperation among farmers. Additionally, it involves establishing chili processing businesses, facilitating easier market access for farmers, and implementing regulations that promote the growth of the chili processing industry. Effective regulations are crucial for creating a more sustainable and conducive business environment. In the intervention strategy stage, the model focuses on making chili more valuable through processing, especially into chili powder. This product has higher value and makes more profit than selling fresh chili. Processing chili also helps increase income for farmers and local workers. The main strategies here include obtaining more business funding for farmers, ensuring there is enough raw material, supporting local groups, and marketing chili products in ways that match consumer preferences.

The output and outcome of this model are expected to encourage increased added value of chili products, increased farmer income, strengthened local supply chains, and accelerated achievement of SDGs indicators, especially those related to poverty alleviation (SDG 1), food security (SDG 2), decent work and economic growth (SDG 8), and inclusive and sustainable industrialization (SDG 9). This entire process emphasizes the importance of cross-sector collaboration, both between farmers, business actors, government, financial institutions, and research and education institutions to create an efficient, inclusive, and sustainable chili agro-industry system.

3.4. Discussion

The results of the study show that processing chili into processed products such as chili powder provides a significant contribution to increasing added value in the horticultural agricultural sector. With a value-added ratio reaching 34% and a profit level of 41.18%, this downstream activity not only increases the efficiency of resource use but also is able to distribute income more evenly among workers, capital owners, and input providers. This finding strengthens the *value chain theory* by Porter (1985), which emphasizes that value creation through downstream activities, such as product processing and marketing, can be an important source of competitive advantage. Post-harvest innovation, such as processing chili into powder, is a form of product diversification that is also in line with the concept of community-based agro-industry (Sahid, Syukur, Maharijaya, & Nurcholis, 2022; Salimah & Herliansyah, 2019; Sandy & Irawan, 2018), which states that increasing added value at the farmer level will be more effective if supported by a local processing system that is adaptive to market needs.

Furthermore, this finding strengthens the research results by Santoso (2021) which shows that added value in the agricultural sector can be significantly increased through the adoption of processing technology and vertical market integration. The study by Septiani and Sari (2021) also states that an efficient agro-industry system must be built by paying attention to *inter-industry linkages*, as shown in the IRIO analysis of this study, which identified that the chili processing industry has strong future linkages with regions such as DKI Jakarta and East Java. This indicates the importance of an inter-regional market development strategy as a driving force for the regional economy based on superior local commodities. From the strategic operational perspective, the results of the Importance-Performance Analysis (IPA) identified several weak points that require immediate improvement, including the availability of quality raw materials, adequate access to financing, strengthening workforce capacity through training, and adaptive marketing strategies. This aligns with the findings of Alene (2020), who emphasized that the success of local agro-industry development depends on four main pillars: input quality, production efficiency, managerial ability, and distribution strategy. In contrast, aspects such as the use of technology, production efficiency, and the availability of production tools show relatively good performance and reflect the success of some business actors in adopting a *technological upgrading approach*, as explained in the theory of agricultural innovation by Mariyono (2017).

The conceptual model developed in this study represents a holistic approach that integrates spatial data-based inputs, production capacity and institutional enhancement processes, and market-based intervention strategies. This model not only reflects the systemic approach as developed in the *Sustainable Food Systems framework* by Food and Agriculture Organization of the United Nations (FAO) (2014) but also implements the principles of Elkington (1998) which emphasizes a balance between economic, social, and environmental aspects. In the context of the SDGs, this model directly supports the achievement of SDG 1 (poverty eradication), SDG 2 (food security), SDG 8 (inclusive economic growth), and SDG 9 (sustainable industrialization and innovation), as emphasized by (Mordor Intelligence, 2024) in an integrative approach to global development. The policy implications of these findings emphasize that achieving success in the value-added enhancement model cannot be achieved partially, but requires cross-sector collaboration between the government, academics, business actors, financial institutions, and farmer communities.

4. CONCLUSION

This study concludes that that processing chili into powdered products is the most efficient and profitable downstream option, with a value-added ratio of 34% and a profit level of 41.18%. In addition, the IRIO results confirm that the chili processing sector has a high multiplier effect on other economic sectors. Through the IPA analysis, it was found that aspects that need to be prioritized for intervention include the availability of quality raw materials, increasing access to financing, training workers, and strengthening marketing strategies. Therefore, an effective value-added increase model must be built collaboratively across sectors and integrated within the framework of a sustainable agro-industrial ecosystem. This model is expected to encourage the transformation of the chili farming system from being based on fresh commodities to a system that prioritizes processing, innovation, and empowering farmers in a sustainable manner. Based on the findings and conclusions of the study, it is recommended that local governments, especially in Central Java Province, together with related institutions such as the agricultural service, cooperatives, and financial institutions, formulate strategic policies that encourage the development of locally-based chili agro-industry. One of the priority steps is to strengthen farmers' accessibility to flexible and affordable business financing, considering that limited capital is a major obstacle in the product down streaming process. In addition, structured interventions are needed in the form of providing supporting quality facilities and infrastructure, such as processing, packaging, and storage facilities that comply with food safety standards. Continuous training and technical assistance programs for farmers and MSMEs must also be an integral part of the strategy to increase added value, with an emphasis on innovation in processing technology and business management.

Needs to be synergy between the academic sector, business actors, and the government in forming an agro-industrial ecosystem that is market-oriented and responsive to changes in consumer demand. It is also recommended that strengthening farmer institutions, such as cooperatives or farmer groups, be facilitated to strengthen bargaining positions in the value chain. Meanwhile, the development of a digital information system based on spatial data for mapping chili production, distribution, and market demand is also worth considering to support efficient governance and transparency of the supply chain.

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Institutional Review Board Statement: The Ethical Committee of the Universitas Negeri Semarang, Indonesia has granted approval for this study on 25 March 2025 (Ref. No. B/4830/UN37/KP.09.02/2025).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
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