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ECONOMIC PERFORMANCE AND PRODUCTION EFFICIENCY OF RED CHILI FARMING WITHIN AN AGROPOLITAN AGRICULTURAL SYSTEM

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ABSTRACT

Sustainable agricultural development requires farm-level efficiency to be analyzed within integrated regional systems. Despite the economic importance of red chili farming, empirical evidence linking production efficiency and economic performance within agropolitan agricultural systems remains limited. This study applied a quantitative explanatory approach to assess the economic performance and production efficiency of red chili farming within an agropolitan system. Farm income analysis was used to evaluate economic viability, while a Cobb–Douglas production function estimated input elasticities and returns to scale based on primary survey data from red chili farmers. The results indicate that red chili farming is economically viable, generating a net farm income of IDR 4,597,870.97 per production cycle on 2,080 m² of land, with revenue–cost ratios of 2.59 (cash costs) and 1.59 (total costs). Average productivity reached 0.44 kg per plant, reflecting moderate performance constrained by inefficient input allocation. The production function analysis reveals increasing returns to scale, with a total elasticity of 1.28533. The study demonstrates that efficiency and favorable scale dynamics underpin the economic sustainability of red chili farming within agropolitan systems. These findings highlight the role of efficiency-oriented interventions and system-level coordination in supporting integrated and sustainable horticultural development.

Keywords:
agropolitan, budidaya cabai merah, kinerja ekonomi, sistem pertanian.

ABSTRACT

Pembangunan pertanian berkelanjutan membutuhkan analisis efisiensi tingkat pertanian dalam sistem regional terintegrasi. Meskipun budidaya cabai merah memiliki kepentingan ekonomi yang besar, bukti empiris yang menghubungkan efisiensi produksi dan kinerja ekonomi dalam sistem pertanian agropolitan masih terbatas. Studi ini menerapkan pendekatan penjelasan kuantitatif untuk menilai kinerja ekonomi dan efisiensi produksi budidaya cabai merah dalam sistem agropolitan. Analisis pendapatan pertanian digunakan untuk mengevaluasi kelayakan ekonomi, sementara fungsi produksi Cobb-Douglas memperkirakan elastisitas input dan pengembalian skala berdasarkan data survei primer dari petani cabai merah. Hasil menunjukkan bahwa budidaya cabai merah layak secara ekonomi, menghasilkan pendapatan bersih pertanian sebesar Rp 4.597.870,97 per siklus produksi pada lahan seluas 2.080 m², dengan rasio pendapatan-biaya sebesar 2,59 (biaya tunai) dan 1,59 (biaya total). Produktivitas rata-rata mencapai 0,44 kg per tanaman, mencerminkan kinerja moderat yang dibatasi oleh alokasi input yang tidak efisien. Analisis fungsi produksi menunjukkan peningkatan pengembalian skala, dengan elastisitas total sebesar 1,28533. Studi ini menunjukkan bahwa efisiensi dan dinamika skala yang menguntungkan mendukung keberlanjutan ekonomi budidaya cabai merah dalam sistem agropolitan. Temuan ini menyoroti peran intervensi yang berorientasi pada efisiensi dan koordinasi tingkat sistem dalam mendukung pembangunan hortikultura terpadu dan berkelanjutan.

INTRODUCTION

Agriculture remains a strategic sector in supporting food security (Aldilla et al., 2024; Vermeulen et al., 2012), employment generation, and regional economic development (Loizou et al., 2019), particularly in developing countries (Suherman et al., 2024). In recent decades, global agricultural development has shifted from a sole emphasis on increasing production toward sustainable agricultural development (Kassam & Friedrich, 2012; Pretty, 2018), which balances economic performance, environmental preservation, and social well-being of farming communities (Adefila et al., 2024; Mezentseva et al., 2024). Accordingly, the main challenges facing contemporary agriculture extend beyond output growth to include efficient use of production inputs, income stability for farmers, and the long-term sustainability of agricultural systems (Kleinman et al., 2018; Pretty & Bharucha, 2014).

For high-value horticultural commodities such as red chili (Capsicum annuum L.), sustainability issues are particularly critical. Red chili production is generally characterized by relatively high input intensity, especially in fertilizer and labor use, and is highly vulnerable to price volatility and market risks (Daryanto & Daryanto, 2016; Hilman & Sayekti, 2015). Inefficient input utilization not only reduces farmers' income but may also increase environmental pressure and undermine the sustainability of horticultural production systems (Argento et al., 2024; Pretty et al., 2018). Therefore, production efficiency and economic performance are fundamental prerequisites for achieving sustainable horticultural farming systems.

The economic performance and production efficiency of horticultural farming are commonly examined at the farm level using partial approaches, focusing primarily on input–output relationships or short-term financial profitability (Fenollosa et al., 2014; Taoumi & Lahrech, 2023). While such approaches provide valuable insights into technical and allocative efficiency, many studies do not explicitly situate farm-level efficiency within a broader sustainable agricultural systems framework, particularly one that accounts for spatial linkages, institutional arrangements, and integration between production activities, infrastructure, and market access.

As the sustainable agriculture paradigm evolves, integrated and system-based agricultural approaches have received increasing attention in both policy and academic discourse. One such approach is the agropolitan concept, which promotes agriculture-based regional development by integrating production, processing, marketing, and supporting services within a spatially connected system (Aldilla et al., 2924; Irianto & Nurany, 2024). From a sustainability perspective, agropolitan systems are expected to enhance economic efficiency, strengthen upstream–downstream linkages, reduce transaction costs, and foster inclusive and socially sustainable agricultural development (Ahmad & Saleh, 2019; Akkoyunlu, 2015; Surya et al., 2021).

Despite the growing recognition of agropolitan development as a strategy for sustainable rural and agricultural development, empirical studies that directly link farm-level economic performance and production efficiency with the agropolitan agricultural system remain limited, particularly for high-value horticultural commodities. Existing studies have predominantly focused on regional planning, infrastructure provision, or development policies (Saleh et al., 2017; Sobirin et al., 2023), while micro-level analyses of farming performance are often detached from the regional systems within which farms operate (Filippini et al., 2021; Huttunen, 2019).

In Indonesia, studies on red chili farming have largely emphasized income analysis, cost structures, and conventional production factors (Achmad et al., 2022; Miranda et al., 2023; Saidah et al., 2024). Although these studies provide important insights into financial feasibility, they have not sufficiently integrated production efficiency and scale analysis within an agropolitan agricultural system as a framework for sustainable agriculture. Consequently, the role of agropolitan systems in improving efficiency, enhancing farmers' income, and supporting the sustainability of horticultural farming remains insufficiently understood.

Based on this context, a clear research gap exists in the literature, namely the lack of studies that integrate farm-level economic performance and production efficiency analysis within an agropolitan agricultural system from a sustainable agriculture perspective. Research that connects micro-level indicators—such as income, input use, and returns to scale—with the broader regional agricultural system is essential to understand how integrated farming systems can enhance both competitiveness and sustainability.

Therefore, this study aims to: (1) analyze the economic performance of red chili farming within an agropolitan agricultural system; (2) identify production factors influencing output levels and input-use efficiency as a basis for economic sustainability; and (3) evaluate returns to scale as an indicator of the economic viability and sustainability of red chili farming within the agropolitan framework. The findings are expected to contribute to the advancement of integrated and sustainable agriculture research and to support evidence-based agricultural development policies.

RESEARCH METHODS

Study Area and Research Design

This study was conducted within an agropolitan agricultural system, where farming activities are integrated with regional infrastructure, input provision, and market access. The agropolitan context is treated not merely as a geographical setting, but as a functional agricultural system that influences farm-level production decisions, economic performance, and sustainability outcomes.

A quantitative explanatory research design was employed to analyze the economic performance and production efficiency of red chili farming at the farm level, while explicitly situating these outcomes within the agropolitan system. This design enables the identification of relationships between production inputs, output levels, and economic indicators, which are essential for assessing sustainability from an efficiency-based perspective.

Data Collection and Sampling

Primary data were collected through structured field surveys of red chili farmers operating within the agropolitan area. The survey captured detailed information on farm characteristics, input use, production levels, labor allocation, and cost structures for a single production cycle. Secondary data related to regional agricultural development, agropolitan planning, and supporting infrastructure were used to contextualize farm-level analysis within the broader system.

Farmers were selected using a purposive sampling approach to ensure that all respondents were actively engaged in red chili farming within the agropolitan system during the study period.

This approach ensured data relevance while maintaining consistency with the objectives of efficiency and economic performance analysis.

Analytical Framework

To align with the integrated and sustainable agriculture perspective, the methodology combines farm-level economic analysis with production efficiency assessment, which together provide a comprehensive evaluation of sustainability in economic terms.

Income and Economic Performance Analysis

Economic performance was evaluated using farm income analysis, which distinguishes between cash income and total income. Total revenue was calculated based on actual output and prevailing market prices, while production costs were classified into variable and fixed costs. Key economic indicators included net farm income and revenue–cost ratios, which serve as proxies for economic viability and short-term sustainability of red chili farming. This income-based approach allows for an assessment of whether farming activities within the agropolitan system generate sufficient economic returns to sustain farmers' livelihoods and maintain production continuity.

Production Function and Efficiency Analysis

Production efficiency was analyzed using a Cobb–Douglas production function, which estimates the relationship between output and key production inputs, including labor, seed, chemical fertilizers, and organic inputs. This functional form was selected due to its widespread application in agricultural efficiency studies and its suitability for estimating input elasticities. The estimated coefficients were used to evaluate the contribution of each input to output and to assess the degree of efficiency in input utilization. From a sustainability perspective, efficient input use is interpreted as a mechanism for reducing unnecessary input intensity while maintaining or increasing output levels.

Returns to Scale Assessment

Returns to scale were assessed by summing the estimated input elasticities derived from the production function. This indicator provides insight into the scale properties of red chili farming within the agropolitan system. An increasing return to scale suggests that proportional increases in input use lead to more-than-proportional increases in output, indicating potential for farm expansion and improved economic sustainability. Conversely, decreasing returns to scale would signal structural or system-level constraints that may limit long-term viability.

Sustainability Perspective

In this study, sustainability is operationalized primarily through economic efficiency and viability, recognizing that stable income and efficient resource use are foundational dimensions of sustainable agriculture. By integrating income analysis, production efficiency, and scale assessment, the methodology captures how farm-level decisions interact with the agropolitan system to influence sustainability outcomes. Rather than directly measuring environmental or social indicators, this study emphasizes efficiency-based sustainability, which is particularly relevant for smallholder-dominated agropolitan systems where economic resilience is a prerequisite for broader sustainability transitions.

RESULTS

Economic Performance of Red Chili Farming within the Agropolitan System

The empirical results indicate that red chili farming within the agropolitan agricultural system demonstrates strong economic performance at the farm level. As presented in Table 1, farmers obtain a net farm income of IDR 4,597,870.97 per production cycle for a cultivated area of 2,080 m², while family labor income reaches IDR 7,278,902.09 for the same land size. These values confirm that red chili farming generates sufficient returns not only to cover cash expenditures but also to adequately compensate family labor inputs. Furthermore, the revenue–cost (R/C) ratio based on cash costs reaches 2.59, while the R/C ratio calculated using total production costs is 1.59 (Table 1). R/C ratios greater than unity indicate that red chili farming is financially viable and economically profitable. This finding suggests that the agropolitan agricultural system—by facilitating access to markets, input suppliers, and supporting infrastructure—creates favorable conditions for farm-level economic sustainability.

Table 1. Economic performance of red chili farming within the agropolitan agricultural system.

Indicator	Value	Unit / Description
Cultivated area	2,080	m²
Net farm income	4,597,870.97	IDR per production cycle
Family labor income	7,278,902.09	IDR per production cycle
R/C ratio (cash cost)	2.59	Dimensionless
R/C ratio (total cost)	1.59	Dimensionless

Production Costs and Input Structure

The structure of production costs, summarized in Table 2, shows that red chili farming is dominated by variable costs. Labor constitutes the largest share of total production expenses, followed by seeds and chemical fertilizers. This cost composition reflects the labor-intensive nature of horticultural production and highlights the strategic role of labor availability within the agropolitan system, where proximity to rural labor markets supports continuous farming activities. The relatively high share of fertilizer-related costs indicates a strong dependence on external inputs (Table 2). While such input use contributes to output generation, it also underscores the importance of efficient input management. Inefficient allocation of fertilizers may increase production costs and reduce overall economic efficiency, posing challenges to long-term sustainability.

Table 2. Production cost structure of red chili farming in the agropolitan system.

Cost Component	Relative Contribution	Description
Labor	Highest share	Reflects labor-intensive horticultural production
Seeds	Moderate	Improved seed varieties used
Chemical fertilizers	Moderate–high	Dominated by nitrogen-based fertilizers
Organic manure	Low–moderate	Supplementary soil fertility input
Fixed costs	Low	Tools and depreciation

Productivity and Input Use Efficiency

Empirical evidence presented in Table 3 shows that the average productivity of red chili farming is 0.44 kg per plant, which can be categorized as moderate to low when compared with recommended productivity levels. This productivity gap suggests that production constraints are more closely related to inefficiencies in input use rather than limitations in land or labor availability.

Table 3 further indicates that fertilizer application patterns are imbalanced, with a predominance of nitrogen-based fertilizers, while recommended nutrient management emphasizes a higher proportion of phosphorus. This suboptimal nutrient composition contributes to lower productivity and reflects inefficiencies in production practices. Within the agropolitan system, these inefficiencies point to potential weaknesses in extension services, technical assistance, or coordination between farmers and input suppliers.

Table 3. Productivity and input use efficiency of red chili farming.

Indicator	Value	Unit
Average productivity	0.44	kg per plant
Fertilizer application pattern	Imbalanced	Nitrogen-dominated
Nutrient composition suitability	Suboptimal	Below recommended standards

Production Function Estimation and Returns to Scale

The estimated Cobb–Douglas production function results are summarized in Table 4. The analysis reveals that labor, seed use, urea fertilizer, SP-36, KCl, and organic manure significantly influence red chili output. The sum of input elasticities reaches 1.28533, indicating the presence of increasing returns to scale.

This finding implies that a proportional increase of 100% in all production inputs would increase output by approximately 128.53% (Table 4). The existence of increasing returns to scale suggests that red chili farming within the agropolitan system has not yet reached its optimal production scale. This outcome reflects the enabling environment of the agropolitan system, which reduces production and transaction constraints that commonly limit smallholder expansion. A synthesized overview of farm income, production efficiency, and scale properties within the agropolitan system is presented in Figure 1.

Table 4. Estimated production function and returns to scale of red chili farming.

Indicator	Value	Interpretation
Sum of input elasticities	1.28533	Increasing returns to scale
Returns to scale type	Increasing	Output increases > proportional to inputs
Scale implication	Expansion potential	Economically scalable farming system

DISCUSSION

Economic Performance and the Role of the Agropolitan System

The income levels and R/C ratios reported in Table 1 provide robust empirical evidence that red chili farming is economically viable within the agropolitan agricultural system. Net income exceeding IDR 4.5 million per 2,080 m² and R/C ratios well above unity indicate that farmers benefit

from system-level integration, particularly through improved market access and reduced transaction costs.

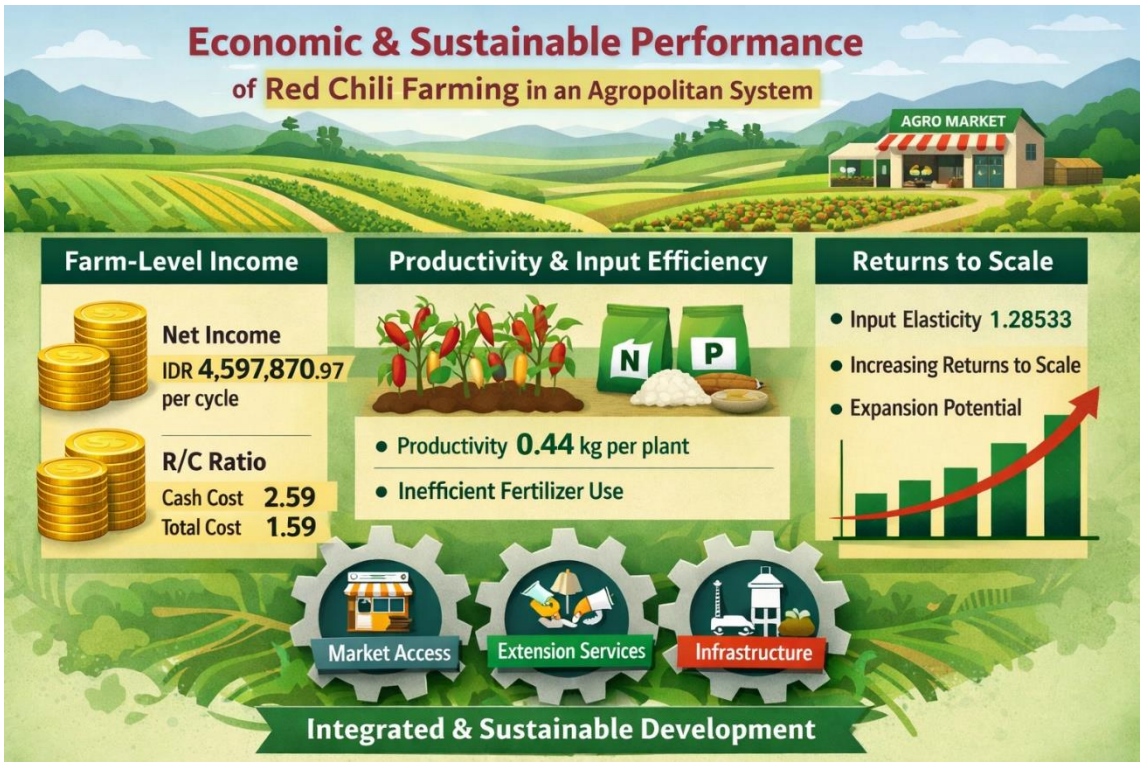

Figure 1. Economic performance, production efficiency, and returns to scale of red chili farming within an agropolitan agricultural system.

These findings support the view that agropolitan systems function not merely as spatial development concepts but as economic platforms that enhance farm profitability and resilience. The agropolitan system functions not only as a spatial development concept but also as an economic platform that enhances farm profitability, resilience, and long-term agricultural sustainability (Abramson, 2020; Sobirin et al., 2023; Surya et al., 2021). Compared with non-integrated farming systems, agropolitan-based farming offers structural advantages that help farmers cope with price volatility and high input intensity.

Production Efficiency as a Foundation for Sustainability

The productivity level of 0.44 kg per plant reported in Table 3 highlights a key sustainability challenge. Although red chili farming is profitable, inefficiencies in input allocation—especially fertilizer imbalance—constrain productivity gains and increase production costs. From a sustainability perspective, such inefficiencies undermine both economic and environmental performance. Improving fertilizer efficiency represents a strategic entry point for enhancing sustainability (Tjilen et al., 2024). Within the agropolitan system, better coordination among extension services, input suppliers, and farmers could reduce inefficiencies, lower costs, and minimize environmental risks while maintaining output levels (Anggraeni et al., 2022; Lestari et al, 2024; Suherman et al., 2024).

Returns to Scale and Sustainable Agricultural Development

The finding of increasing returns to scale (elasticity = 1.28533) in Table 4 has important implications for sustainable agricultural development. It indicates that red chili farming remains economically scalable and that expansion could enhance efficiency and income levels if managed appropriately. However, scale expansion must be guided by system-level coordination to prevent excessive intensification of inputs that could compromise sustainability (Gaitán-Cremaschi et al., 2020; Sari et al., 2024; Suherman et al., 2024). The agropolitan framework provides a mechanism to align farm expansion with sustainability objectives through integrated infrastructure, institutional support, and market development (Sobirin et al., 2023; Subadyo & Poerwoningsih, 2017).

Contribution to Integrated and Sustainable Agriculture

By linking farm-level income performance (Table 1), cost structure (Table 2), productivity and efficiency (Table 3), and scale properties (Table 4) within an agropolitan agricultural system, this study advances the literature on integrated and sustainable agriculture. The findings demonstrate that economic efficiency constitutes a foundational dimension of sustainability, particularly in smallholder-based horticultural systems. Agricultural economic efficiency constitutes a fundamental dimension of sustainability, particularly within smallholder-based horticultural systems facing resource and market constraints (Kilelu et al., 2024; Lynam, 2019). Unlike conventional farm-level studies, this research highlights how system-level integration shapes efficiency outcomes and sustainability prospects (Spiller et al., 2024). These findings reinforce the role of agropolitan systems as viable pathways for promoting economically sustainable and integrated agricultural development (Wirahayu et al., 2022).

CONCLUSION

This study demonstrates that red chili farming within an agropolitan agricultural system is economically viable and capable of generating sustainable farm-level income. The observed net income and revenue–cost ratios exceeding unity confirm that the agropolitan framework provides a supportive economic environment that enables farmers to maintain production continuity and financial feasibility.

The findings further indicate that productivity performance is constrained primarily by inefficiencies in input use rather than by resource limitations. Moderate productivity levels reflect suboptimal input allocation, particularly in fertilizer management, highlighting production efficiency as a critical lever for improving farm performance and strengthening the economic dimension of sustainability.

Moreover, the presence of increasing returns to scale suggests that red chili farming has not yet reached its optimal production scale within the agropolitan system. This condition implies that, with appropriate system-level coordination and efficiency-oriented interventions, scaling up production can enhance output and income without undermining sustainability. Collectively, these findings underscore the central role of efficiency and scale dynamics in supporting integrated and sustainable agropolitan agricultural development.

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