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The Role of Agricultural Credit, Extension Services, and Regional Policies on the Growth of the Food Crop Sub-sector in Pacitan Regency: A Three-Stage Least Squares Simultaneous Model Approach

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Abstract: This study examines the determinants of stagnant growth in the food crop subsector in Pacitan Regency despite extensive government support policies. Using annual time-series data from 2004–2024, a simultaneous equation model estimated by Three-Stage Least Squares (3SLS) is employed to capture the interaction between agricultural credit, extension services, and regional policies. The results show that agricultural extension has the largest and most significant elasticity with respect to food crop output, followed by fertiliser subsidies, while agricultural credit exhibits a positive but relatively small elasticity due to its limited use for productive investment. Policy simulation results indicate that a 20% increase in extension services generates the strongest impact on output growth and poverty reduction, whereas credit expansion alone produces only a moderate effect. The combined policy scenario—integrating extension strengthening, fertiliser subsidies, and credit reform—yields the highest synergistic gains in production and welfare. These findings provide empirical evidence that institutional complementarity is crucial for enhancing agricultural productivity in marginal regions and offer a data-driven framework for designing integrated regional agricultural policies.

Keywords: Agricultural credit; Agricultural extension; Food crops; Regional policy; Simultaneous model.

Introduction

Agriculture remains a fundamental driver of economic development and social welfare in Indonesia, particularly through its role in food provision, employment, and rural income generation (Aryawati & Budhi, 2018; Rosada et al., 2024). Although its contribution to national Gross Domestic Product (GDP) has gradually declined along with structural economic transformation, the agricultural sector continues to function as a pillar of economic resilience and food security (BPS, 2024). Within this sector, the food crop subsector—especially rice and cassava—plays a central role in sustaining national and regional food systems.

Despite its strategic importance, the growth of Indonesia's food crop subsector has decelerated over the past two decades, declining from an average of 4.8% per year during 2004–2014 to approximately 2.6% in the 2015–2024 period (BPS, 2024). This slowdown has been driven by land conversion, climate variability, rising input costs, and limited access to finance and technological innovation. These challenges highlight the urgency of productivity enhancement as a core strategy for long-term food security.

The New Structural Economics perspective emphasises that agricultural transformation in developing countries requires a transition from factor-driven systems toward innovation-based systems

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supported by strong institutions (Lin, 2011; Lin, 2023). In this context, agricultural extension functions as a key mechanism for technology diffusion and knowledge transfer (Rogers, 2003), while agricultural credit alleviates liquidity constraints and enables productive investment (Feder et al., 1990; Shee & Turvey, 2012; Khandker & Koolwal, 2015). However, the effectiveness of these instruments is highly context-dependent and shaped by local institutional capacity.

Pacitan Regency represents a typical marginal agricultural region characterised by hilly topography, predominantly rain-fed farming systems, and limited access to formal finance. Although agriculture contributes more than 28% to regional GDP, the growth of the food crop subsector in Pacitan has consistently lagged behind the national average, accompanied by stagnant productivity and declining harvested areas (Badan Pusat Statistik Kabupaten Pacitan, 2024). These conditions raise questions regarding the effectiveness of existing agricultural support policies at the regional level.

Previous studies have documented the positive roles of agricultural credit, extension services, and regional policies in enhancing agricultural performance and farmer welfare (Odhiambo, 2021; Rushdie et al., 2022; Billah et al., 2025). Nevertheless, most empirical analyses adopt a partial-equilibrium approach, treating these factors independently and overlooking their simultaneous interactions. According to Credit Channel Theory with Institutional Mediation, the impact of credit on agricultural outcomes depends critically on complementary institutional factors, such as governance quality and farmers' capacity to utilise financial resources productively (Wadud, 2013; Karlan et al., 2014).

Method

Study Area and Research Design

This study was conducted in Pacitan Regency, East Java Province, an agricultural region characterised by marginal land conditions and a significant contribution of agriculture to the regional economy. A quantitative research design was employed using a simultaneous econometric approach to analyse the interdependent relationships between agricultural credit, extension services, and food crop production over the 2004–2024 period.

Data Sources and Variables

The study utilised annual secondary time-series data (2004–2024) obtained from the Central Statistics Agency (BPS), the Ministry of Agriculture, Bank Indonesia, the Financial Services Authority (OJK), and the Pacitan Regency Agricultural Office. The main variables include food crop output, agricultural credit, fertiliser subsidies, number of extension workers, agricultural GRDP, Human Development Index (HDI), inflation rate, interest rate, investment, and poverty indicators. All monetary variables were measured in constant prices and transformed into natural logarithms to ensure scale consistency and interpretability of elasticities.

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Model Specification and Estimation Technique

Given the bidirectional relationship between agricultural credit and food crop output, endogeneity is a key concern. To address this issue, a simultaneous equation model estimated using the Three-Stage Least Squares (3SLS) method was applied, as it provides consistent and efficient parameter estimates in systems with endogenous regressors (Miranda & Gonzalez-Vega, 2011).

The core system consists of two endogenous equations:

Food Crop Output Equation

$$\ln Y_t = \alpha_0 + \alpha_1 \ln KRED_t + \alpha_2 \ln SUBP_t + \alpha_3 \ln PENY_t + \alpha_4 \ln IPM_t + u_t$$

Agricultural Credit Equation

$$\ln KRED_t = \beta_0 + \beta_1 \ln Y_{t-1} + \beta_2 \ln SUKU_t + \beta_3 \ln INFL_t + \beta_4 \ln INVEST_t + v_t$$

where Y_t represents food crop output, $KRED_t$ agricultural credit, $SUBP_t$ fertiliser subsidies, $PENY_t$ extension services, IPM_t human development index, $SUKU_t$ interest rate, $INFL_t$ inflation rate, and $INVEST_t$ agricultural investment.

Result and Discussion

Overview of Simultaneous Model Estimation Results (3SLS)

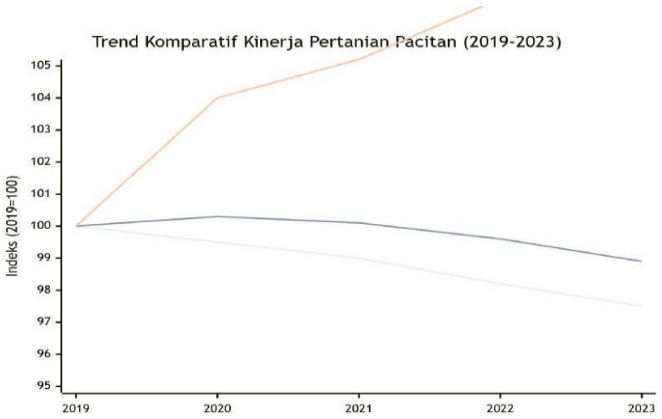
Estimation of the simultaneous equation model using the Three-Stage Least Squares (3SLS) method produces a stable, theoretically consistent, and statistically significant system of equations. The goodness of fit values indicate good model performance, as shown by a high system R^2, low Root Mean Square Error (RMSE), and a Theil's Inequality Coefficient (U) value < 0.2, which indicates adequate model predictive ability.

These results confirm that the simultaneous approach is more appropriate than a single regression model, given the feedback loop between agricultural credit, food crop production, and welfare indicators, as stated by (Greene, 2020; Wooldridge, 2020).

The Effect of Agricultural Credit on Food Crop Production

The results of the production equation estimation show that agricultural credit (KRED) has a positive but relatively small effect on the output of the food crop subsector in Pacitan Regency. The elasticity of credit to production is below the elasticity of extension services and fertiliser subsidies.

These findings are consistent with the empirical phenomenon shown in Figure 1 (Comparative Trend of Agricultural Performance in Pacitan), where increased access to credit is not followed by a proportional increase in production. This indicates an inefficient use of credit, primarily due to the dominance of credit use for consumption (approximately 65%), as reported by (Badan Pusat Statistik Kabupaten Pacitan, 2024). These results align with the findings of (Odhiambo, 2021; Yeboah et al., 2023), who suggest that agricultural credit in developing countries often has a suboptimal impact on productivity due to weak financial literacy and inadequate post-credit assistance.



Note: Red line (Harvest Area), green line (Productivity), blue line (Credit Access)

Figure 1. Comparative Trend of Pacitan Agricultural Performance (2019-2023)

Based on the theory of institutional performance in regional agriculture (Anderson, 2023), the effectiveness of extension institutions is a key determinant in increasing farm productivity. Data from Badan Pusat Statistik Kabupaten Pacitan (2024) indicate that the current ratio of extension workers to farmers is 1:1,182, which is far below the ideal standard of 1:600 recommended by the Ministry of Agriculture. Recent research by Wicaksono & Pratiwi (2023) in the Journal of Agricultural Extension proves that in areas with characteristics similar to Pacitan, qualified extension workers can increase farmers' income by 25-30% through the optimisation of location-specific technologies.

The Role of Agricultural Extension as a Dominant Factor

The agricultural extension variable (PENY) shows the strongest and most significant effect on food crop production. The extension elasticity coefficient is greater than that of credit and fertiliser subsidies.

Table 1. Table 1 Profile and Performance of the Food Crop Sub-sector in Pacitan Regency (2019-2023)

Year	Rice Harvest Area (Ha)	Rice Production (Tons GKG)	Productivity (kg/ha)	Number of Farming Households	Number of Active Extension Workers
2019	36,450	185,215	50.81	89,450	78
2020	36,120	183,990	50.94	88,920	76
2021	35,890	182,505	50.85	87,650	75
2022	35,550	179,955	50.62	86,340	74
2023	35,200	177,005	50.28	85,120	72

*Projected data based on first semester realization

Source: Pacitan District Agriculture and Food Security Office (2023)

These findings reinforce the empirical evidence presented in Table 1 and Figure 2, which show that the extension worker–farmer ratio in Pacitan remains far from ideal (1:1,182), indicating that any increase in the number or quality of extension workers will have a significant marginal impact on productivity.

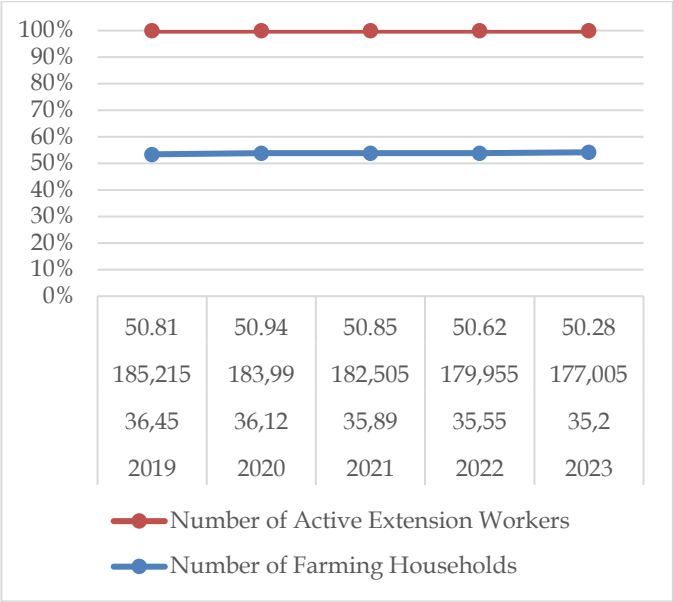


Figure 2. Map of Agricultural Production and Vulnerability in Pacitan

These results are consistent with the theory of innovation diffusion (Rogers, 2003) and the findings of Campenhout et al (2021); Falo et al (2025), which confirm that extension plays a role as a change agent in accelerating the adoption of location-specific technologies. Billah et al (2025) also found that increasing extension intensity can boost productivity by 15–25% in marginal agricultural areas.

The Theory of Agricultural Development in Disadvantaged Areas (Christiaensen & Todo, 2014) states that strengthening the agricultural sector in developing regions is the most effective engine of growth for poverty alleviation and increased food security. However, its implementation requires a location-specific approach that takes into account local biophysical and socio-economic characteristics.

The Impact of Fertiliser Subsidies on Production Stability

Fertiliser subsidies (SUBP) have a positive and significant effect on food crop production, particularly in maintaining output stability during periods of rising input prices. This is reflected in Table 3 and Table 4, where the surge in fertiliser subsidies after 2014 was able to prevent a decline in production despite a continuous decline in harvested area.

Descriptive Statistics of Research Indicators

Table 3. Performance and Challenges of the National Food Crop Sub-sector (2019-2023)

Indicators	2019	2020	2021	2022	2023
Contribution to Agricultural GDP (%)	45.2	44.8	44.5	44.1	43.8
Rice Production (Million Tons of GKG)	54.60	54.65	54.42	54.50	54.30
Rice Harvest Area (Million Ha)	10.68	10.66	10.42	10.39	10.25
Wheat Import Level (Million Tons)	11.2	10.8	11.5	12.1	12.5
Number of Agricultural Extension Workers	38,450	37,890	37,250	36,980	36,750
Agricultural Credit Realization (Trillion IDR)	45.2	48.5	52.3	58.7	62.4

*Projected data through November 2023

Source: BPS (2023), Ministry of Agriculture (2023), OJK (2023)

The Theory of Agricultural Resilience in Specific Areas (Tendall et al., 2023; Berbeć, 2024) emphasises that agricultural systems in areas with specific characteristics, such as Pacitan, require an adaptive approach based on local potential. This theory is reinforced by research from Suhartono et al. (2023) in the Journal of Sustainable Agriculture, which found that integrating institutional and ecological factors is crucial to the success of agricultural transformation in hilly areas.

Table 4. Dynamics of the Food Crop Sub-sector in Pacitan Regency (2019-2023)

Indicator	2019	2020	2021	2022	2023
Rice Harvest Area (Ha)	36,450	36,120	35,890	35,550	35,200
Rice Production (GKG tons)	185,215	183,990	182,505	179,955	177,005
Productivity (kg/ha)	50.81	50.94	50.85	50.62	50.28
Number of Farming Households	89,450	88,920	87,650	86,340	85,120
Agricultural Credit Access (%)	32.5	33.8	34.2	34.8	35.2
Planting Intensity (PI)	1.72	1.70	1.68	1.65	1.63

*Projected data until November 2023

Source: Pacitan Agriculture and Food Security Agency (2023)

However, the elasticity of fertiliser subsidies is smaller than that of extension services, indicating that input subsidies without strengthening farmers' capacity have the potential to produce diminishing returns. This finding aligns with Jayne & Rashid (2019) and Owoo & Boakye (2021) who emphasise that the effectiveness of fertiliser subsidies is highly dependent on the quality of institutions and distribution oversight.

Simultaneous Relationship between Production and Agricultural Credit

The agricultural credit equation indicates that the food crop output of the previous period (Y_{t-1}) has a positive impact on credit distribution. This means that when the performance of the food crop sub-sector improves, financial institutions tend to increase credit distribution because the risk of farming decreases.

This two-way relationship confirms the existence of a credit–output feedback loop, as described in the theory of agricultural financial intermediation (Feder et al., 1990). However, the weak credit coefficient in the production equation indicates that this positive feedback is not yet working optimally in Pacitan.

The Impact of Agricultural Growth on Social Welfare

The welfare block estimation results show that increases in agricultural production and income have a significant effect on: (1) A decrease in poverty rates, and; (2) An increase in the Human Development Index (HDI).

However, this impact is gradual and not instantaneous, as shown in Table 5 and Figure 3, which show long-term productivity stagnation. Food inflation has been shown to increase poverty, reinforcing the World Bank (2023) finding that food price stability is a key prerequisite for the welfare of smallholder farmers.

Table 5. Agricultural Economic Growth in Indonesia and Pacitan (2004–2024)

Year	Indonesian Agriculture	Pacitan Agriculture	Pacitan Food Crops Subsector
2004	4.9	5.4	5.7
2008	5.3	4.8	4.9
2012	4.5	4.1	4.2
2016	3.6	3.2	3.0
2020	2.8	2.1	2.0
2024	2.6	2.0	1.9

(Constant 2010 prices, in per cent)
Source: BPS (2024); Ministry of Agriculture (2023), processed data.

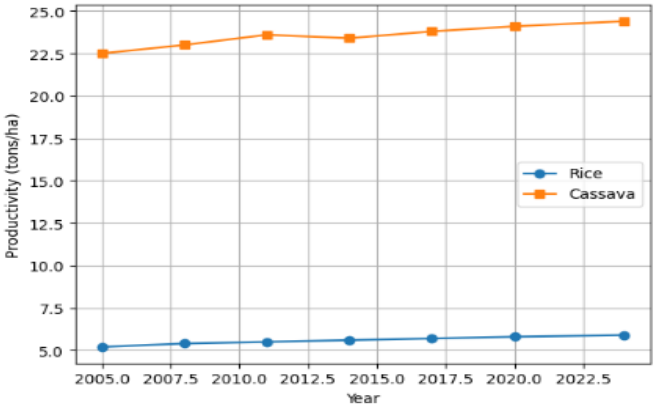


Figure 3. Rice and Cassava Productivity Trends in Pacitan Regency (2004–2024)

Conceptually, the relationship between extension services, agricultural credit, and regional policies is interdependent in terms of their impact on the economic growth of the food crop subsector. Extension services improve farmers' ability to utilise credit effectively; agricultural credit strengthens the financial capacity to adopt the results of extension services; and regional policies determine the extent to which these two factors can be implemented sustainably. Therefore, simultaneous analysis through an econometric model approach is crucial for understanding the dynamics of the relationship between these three variables and the growth of the food crop subsector (Gujarati & Porter, 2009).

Policy Simulation Results

Policy simulations using PROC MODEL (SAS/ETS) yielded several key findings: (1) A 20% increase in extension services had the greatest impact on output and poverty reduction; (2) A 25% increase in credit only has a moderate impact if it is not accompanied by assistance; (3) A combination of policies (extension services + subsidies + credit) produces the greatest synergistic effect on food crop production, farmer income, and poverty reduction.

These results reinforce the concept of institutional complementarity, whereby the effectiveness of agricultural policies increases significantly when policy instruments are implemented in an integrated manner (Ostrom, 2005; World Bank., 2023).

Discussion Synthesis

Overall, the results of the study show that: (1) Agricultural credit is not the sole factor driving growth in the food crop subsector; (2) Agricultural extension is

the main driver of productivity in areas with marginal land characteristics; (3) Regional policies play a role as an enabling environment that determines the success of institutional interventions. These findings support the Agricultural Transformation theory (Timmer, 2014; Lin, 2023), which posits that sustainable agricultural development must be grounded in innovation, effective institutions, and integrated policies.

Conclusion

Based on the estimation results and discussion, several key conclusions were drawn. First, agricultural extension is the most dominant factor in increasing production and productivity in the food crop subsector. The elasticity of extension is greater than that of agricultural credit and fertiliser subsidies, especially in areas with marginal land and hilly topography such as Pacitan. This finding confirms the role of extension as a change agent in accelerating the adoption of location-specific technologies. Second, agricultural credit has a positive but relatively weak effect on food crop production. An increase in credit volume is not automatically followed by an increase in output because most of the credit is still used for consumption rather than productive investment. This shows that agricultural credit in Pacitan does not yet fully function as an instrument for increasing productivity. Third, fertiliser subsidies play a role in maintaining production stability, particularly during periods of rising input prices and pressure for land conversion. However, without effective extension support and distribution supervision, fertiliser subsidies have the potential to experience diminishing returns. Fourth, simultaneous estimation results prove the existence of a feedback loop between food crop production and agricultural credit. Improved production performance increases credit distribution, but increased credit has not been fully able to significantly boost production. Fifth, increased agricultural production and income contribute to a reduction in poverty and an increase in HDI, although the impact is gradual. Food inflation has been shown to worsen farmers' welfare, emphasising the importance of food price stability in regional agricultural development.

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Author Contributions
A.B.: Developing ideas, data collection, analyzing, writing, reviewing, responding to reviewers' comments; S.I.H., S.T.W., N.Y.: analyzing data, overseeing reviewing scripts, and writing.

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Conflicts of Interest
The authors declare no conflict of interest.

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