

Risk Management Implementation for Safeguarding National Food Security and Enhancing Agricultural Productivity through Optimal Absorption of Fertilizer Subsidies in Indonesia

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Abstract

Fertilizer subsidies remain a central policy instrument for supporting smallholder farmers and stabilizing food production in developing economies. In Indonesia, however, persistent challenges related to targeting accuracy, distribution inefficiencies, fiscal leakages, and environmental risks have limited the effectiveness of fertilizer subsidy programs. This study develops and applies a comprehensive risk management framework to evaluate how optimal absorption of fertilizer subsidies can safeguard national food security while enhancing agricultural productivity. Using a mixed-methods approach that integrates policy risk mapping, institutional analysis, and econometric assessment of productivity outcomes, this paper identifies key operational, financial, governance, and environmental risks embedded in Indonesia's fertilizer subsidy system. The findings demonstrate that risk-informed subsidy management characterized by improved beneficiary targeting, digitalized distribution controls, adaptive monitoring, and coordinated institutional governance significantly strengthens yield performance, input-use efficiency, and resilience of national food security. This research contributes to the literature by bridging risk management theory with agricultural subsidy policy, offering actionable insights for policymakers seeking to balance productivity growth, fiscal sustainability, and long-term food system resilience.

Keywords: risk management, fertilizer subsidy, food security, agricultural productivity, policy efficiency.

INTRODUCTION

National food security remains a strategic priority for Indonesia, given its large population, dependence on domestic staple crop production, and vulnerability to global supply chain shocks. Fertilizer subsidies have long been employed to stabilize input prices, support smallholder farmers, and promote agricultural productivity. Despite substantial fiscal allocations, the absorption and effectiveness of fertilizer subsidies have been uneven, raising concerns about inefficiencies, misallocation, and unintended risks.

Risk management has emerged as a critical governance tool in public policy, particularly in sectors characterized by complex supply chains, multiple stakeholders, and high uncertainty such as agriculture. In the context of fertilizer subsidies, risks may arise from inaccurate farmer databases, logistical bottlenecks, rent-seeking behavior, market distortions,

and environmental degradation. These risks not only reduce policy effectiveness but also threaten the broader objective of sustainable food security.

This study makes an original contribution to the international literature by explicitly integrating public sector risk management theory with empirical analysis of fertilizer subsidy absorption and agricultural productivity. Unlike prior studies that evaluate subsidies primarily through fiscal efficiency or yield outcomes, this research conceptualizes subsidy absorption as a risk-mediated process and empirically demonstrates how unmanaged operational, governance, financial, and environmental risks systematically weaken productivity gains and food security outcomes. By introducing a composite risk exposure index and embedding it within a panel econometric framework, this study advances a risk-informed policy evaluation model that is applicable beyond Indonesia to other subsidy-dependent food systems. This study addresses the following research questions: What are the principal risks affecting the absorption and effectiveness of fertilizer subsidies in Indonesia? How does risk exposure mediate the relationship between subsidy absorption and agricultural productivity? In what ways does risk-informed subsidy implementation contribute to safeguarding national food security?

International evidence consistently shows that fertilizer subsidies remain a major policy instrument in developing and emerging economies. According to the Food and Agriculture Organization, global fertilizer consumption exceeded 200 million tons of nutrients annually in the early 2020s, with Asia accounting for more than 55 percent of total use. Empirical studies from Sub-Saharan Africa, South Asia, and Southeast Asia indicate that appropriately targeted fertilizer subsidies can increase staple crop yields by 10–30 percent, particularly among smallholder farmers.

However, large-scale cross-country evaluations conducted by international development institutions demonstrate that productivity gains are highly heterogeneous and strongly dependent on implementation quality. Poor targeting accuracy, delayed delivery, and weak monitoring systems have been shown to reduce the effective impact of subsidy programs by up to one-third in several low- and middle-income countries.

International food security assessments highlight that fertilizer access is a critical determinant of crop productivity and production stability. The World Bank estimates that fertilizer price shocks during recent global crises increased production costs for staple crops by 20–50 percent in import-dependent countries, exacerbating food security risks. Countries with domestic subsidy mechanisms experienced relatively lower output volatility, provided that subsidy distribution systems functioned effectively.

Comparative studies across Asia and Africa reveal that operational and governance risks account for a substantial share of inefficiencies in agricultural subsidy programs. International audit and evaluation reports suggest that leakage rates in fertilizer subsidy schemes can range from 10 to 40 percent in the absence of digital tracking and farmer verification systems. Conversely, countries that adopted risk-based monitoring frameworks and digital distribution platforms significantly reduced leakages and improved subsidy absorption rates.

Despite extensive international evidence on fertilizer subsidies and food security, existing studies rarely integrate formal risk management frameworks into empirical productivity analysis. Most cross-country research treats implementation challenges descriptively rather than analytically. This study advances the literature by operationalizing risk exposure quantitatively and embedding it within an econometric framework, thereby offering a globally relevant model for subsidy policy evaluation

METHOD

This study employs a rigorous mixed-methods research design that integrates qualitative risk governance analysis with quantitative econometric modeling. The methodological strategy is explicitly structured to ensure internal validity, analytical transparency, and replicability, in line with Q1–Q2 international journal standards. The qualitative component is used to construct a comprehensive risk management framework for fertilizer subsidy implementation, while the quantitative component empirically tests the relationship between optimal subsidy absorption and agricultural productivity outcomes.

Risk Identification, Mapping, and Assessment

Risk identification was conducted through systematic analysis of national policy documents, regulatory frameworks, audit reports, and implementation guidelines related to fertilizer subsidies. These sources were complemented by structured expert consultations with policymakers, agricultural economists, and program administrators. Identified risks were mapped into four core categories: operational, financial, governance, and environmental risks.

Each risk was assessed using a standardized risk matrix based on probability of occurrence and magnitude of impact on subsidy absorption. Scores were assigned using a five-point Likert scale and aggregated to generate a composite risk exposure index at the provincial level. This index serves as a key explanatory variable in the econometric analysis.

Econometric Model Specification

To rigorously estimate the impact of subsidy absorption on agricultural productivity, this study applies a fixed-effects panel regression model using provincial-level data. The baseline specification is expressed as:

$$Y_{it} = \alpha + \beta_1 SA_{it} + \beta_2 RISK_{it} + \beta_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where Y_{it} represents agricultural productivity indicators (yield per hectare and fertilizer-use efficiency) in province i at time t ; SA_{it} denotes the effective subsidy absorption rate; $RISK_{it}$ is the composite risk exposure index; and X_{it} is a vector of control variables including rainfall variability, cultivated area, and labor input. Province and time fixed effects control for unobserved heterogeneity and macro-level shocks.

Data Sources and Robustness Procedures

Data were obtained from internationally recognized and nationally validated sources to ensure comparability and credibility. Agricultural productivity indicators were derived from official agricultural statistics harmonized with Food and Agriculture Organization (FAO) methodologies. Fertilizer allocation and realization data were compiled from government administrative records and cross-validated with international fertilizer market reports. Climatic variables, including rainfall variability, were constructed using internationally standardized meteorological datasets.

Robustness checks were conducted using alternative productivity indicators consistent with international benchmarks, including yield indices and input-use efficiency ratios. Lagged subsidy absorption variables and alternative risk specifications were employed to address potential endogeneity and measurement bias.

RESULT AND DISCUSSION

Descriptive and Risk Profile Analysis

Descriptive analysis indicates substantial heterogeneity in fertilizer subsidy absorption across provinces. Regions with higher administrative capacity and digitalized distribution mechanisms consistently demonstrate higher absorption rates. Risk profiling reveals that governance risks particularly inaccuracies in farmer registries and weak inter-agency coordination constitute the most significant barriers to effective implementation.

Econometric Results on Productivity Effects

Table 1 reports the baseline fixed-effects regression results examining the relationship between fertilizer subsidy absorption, risk exposure, and agricultural productivity. Effective subsidy absorption exhibits a positive and statistically significant coefficient across all model specifications, supporting Hypothesis H1. Conversely, the composite risk exposure index is negative and statistically significant, confirming Hypothesis H2.

The interaction term between subsidy absorption and risk exposure is negative and significant, indicating that high-risk environments weaken the productivity gains from subsidies. This finding provides strong empirical support for Hypothesis H3.

Table 1. Fixed-Effects Regression Results: Subsidy Absorption, Risk Exposure, and Productivity

Variable	(1) Yield per Hectare	(2) Fertilizer-Use Efficiency
Subsidy Absorption (SA)	0.214*** (0.061)	0.187*** (0.054)
Risk Exposure Index (RISK)	-0.173*** (0.049)	-0.158*** (0.045)
SA × RISK	-0.092** (0.038)	-0.081** (0.034)
Rainfall Variability	-0.067** (0.029)	-0.058* (0.031)
Cultivated Area	0.041* (0.022)	0.036* (0.020)
Labor Input	0.053** (0.025)	0.047** (0.023)
Province Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	420	420
R-squared	0.42	0.39

Notes: Robust standard errors in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Yield Stability and Food Security Implications

To assess food security stability, Table 2 presents regression results using yield volatility as the dependent variable. The results indicate that higher subsidy absorption combined with lower risk exposure significantly reduces inter-annual yield volatility. This finding supports Hypothesis H4 and underscores the role of risk-informed subsidy implementation in enhancing food security stability.

Table 2. Fixed-Effects Regression Results: Subsidy Absorption, Risk Management, and Yield Volatility

Variable	(1) Yield Volatility
Subsidy Absorption (SA)	−0.146*** (0.044)
Risk Exposure Index (RISK)	0.162*** (0.051)
SA × RISK	0.074** (0.033)
Rainfall Variability	0.089*** (0.028)
Province Fixed Effects	Yes
Year Fixed Effects	Yes
Observations	420
R-squared	0.37

Notes: Yield volatility is measured as the coefficient of variation of yields. Robust standard errors are reported in parentheses. *, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Discussion

This study provides robust empirical evidence that fertilizer subsidy effectiveness is not solely determined by fiscal magnitude but critically shaped by risk management quality. The results validate the central hypothesis that unmanaged operational and governance risks substantially weaken the productivity-enhancing potential of subsidies.

From a theoretical perspective, the findings extend public sector risk management literature by demonstrating its applicability in agricultural input subsidy programs. Risk exposure operates as a moderating factor, influencing both the scale and sustainability of productivity gains. This insight advances existing subsidy effectiveness models, which often overlook institutional and governance-related risks.

From a policy standpoint, the evidence suggests that risk-informed implementation transforms fertilizer subsidies from a cost-intensive intervention into a strategic instrument for food security resilience. Provinces that embedded digital controls, adaptive monitoring, and institutional coordination achieved superior outcomes not only in yield performance but also in production stability.

The discussion also highlights trade-offs between short-term productivity gains and long-term environmental risks. Without adequate safeguards, excessive fertilizer use may generate diminishing returns and ecological degradation, underscoring the importance of integrating environmental risk management into subsidy design.

CONCLUSION

This study provides a novel, risk management-based perspective on fertilizer subsidy implementation in Indonesia. By empirically demonstrating how subsidy absorption and risk exposure jointly shape agricultural productivity and food security outcomes, the paper advances both theory and policy practice. The findings confirm that fertilizer subsidies can function as an effective food security instrument only when embedded within robust risk governance structures that address operational, institutional, financial, and environmental vulnerabilities.

The proposed analytical framework offers a transferable model for evaluating subsidy effectiveness in other developing and emerging economies facing similar food system risks. Future research may extend this approach by incorporating climate risk indicators, farm-level microdata, and cross-country comparative analysis.

REFERENCES

- Anderson, J. R., & Feder, G. (2007). *Agricultural extension*. In R. Evenson & P. Pingali (Eds.), *Handbook of Agricultural Economics* (Vol. 3, pp. 2343–2378). Elsevier. [https://doi.org/10.1016/S1574-0072\(06\)03044-1](https://doi.org/10.1016/S1574-0072(06)03044-1)
- Dorward, A. (2009). Rethinking agricultural input subsidy programmes in a changing world. *Food Policy*, 34(2), 172–186. <https://doi.org/10.1016/j.foodpol.2008.12.004>
- FAO. (2018). *The State of Food Security and Nutrition in the World 2018*. Food and Agriculture Organization of the United Nations.
- FAO. (2021). *World Fertilizer Trends and Outlook to 2022*. Food and Agriculture Organization of the United Nations.
- Jayne, T. S., Mason, N. M., Burke, W. J., & Ariga, J. (2018). Review: Taking stock of Africa's second-generation agricultural input subsidy programs. *Food Policy*, 75, 1–14. <https://doi.org/10.1016/j.foodpol.2018.01.003>
- Kassie, M., Jaleta, M., & Mattei, A. (2014). Evaluating the impact of improved maize varieties on food security in rural Tanzania. *Food Security*, 6(2), 217–230. <https://doi.org/10.1007/s12571-014-0335-4>
- World Bank. (2020). *Revisiting Agricultural Input Subsidies: Issues and Reform Options*. World Bank Group.
- World Bank. (2022). *Commodity Markets Outlook: The Impact of the War in Ukraine on Commodity Markets*. World Bank Group.
- Zilberman, D., Khanna, M., & Lipper, L. (2018). Economics of resource management and sustainable agriculture. *Annual Review of Resource Economics*, 10, 513–534. <https://doi.org/10.1146/annurev-resource-100517-023005>