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Research Paper

Incentive Mechanisms through Payments for Environmental Services in Sustainable Agriculture, Sleman, Indonesia

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Abstract

Food security is a strategic issue heavily influenced by the sustainability of agricultural land. In this context, Sleman Regency has established a Sustainable Food Agriculture Area (KP2B) through Regional Regulation Number 6 of 2020 on the Protection of Sustainable Food Agricultural Land (LP2B). This regulation mandates the provision of incentives to farmers of LP2B, although the Regent Draft Regulation (Raperbup) governing the technical mechanisms of incentives has not been ratified. Therefore, this research aimed to identify key parameters in calculating LP2B incentives as a form of implementing Payments for Environmental Services (PES). The method adopted was Interpretive Structural Modeling (ISM), which included seven experts from academia, government, farmers, and the private sector. The results showed that soil fertility, irrigation availability, and agricultural productivity were key parameters complementing each other. Soil fertility was the basic potential, irrigation was the main supporting factor, and productivity was the tangible output. These results confirmed that the LP2B incentive scheme was an effort to internalize the value of environmental services into public policy. Furthermore, PES-based incentives served as a strategic mechanism based on regulations to maintain regional food security and environmental quality.

Keywords: *Payments For Environmental Services (PES), Incentives, Sustainable Agriculture, Ecosystem Services, Food Security.*

INTRODUCTION

The second Sustainable Development Goal (SDG) is to eradicate hunger (zero hunger) through efforts to increase food security, improve nutrition, and develop sustainable agricultural systems. Ensuring global food security is a critical challenge that requires innovative solutions and advanced technology (Hassoun et al., 2025). Food security is also a strategic issue relevant to all countries, including Indonesia, due to the close connections to social, economic, and political aspects (Fadila et al., 2023). Agriculture is a crucial sector that serves as the backbone of food security and the economy in many countries, including Indonesia (Mendrofa, 2025). Therefore, the government's role is crucial in ensuring the synergy of various supporting parameters to achieve national food security through the agricultural sector. Food security concerns are not only the availability of food, but also the community's ability to access it equitably and sustainably (Fikriman et al., 2020). This correlates with the FAO, which defines food security as a condition where all individuals have physical, social, and economic access to sufficient, safe, and nutritious food according to the nutritional needs and food preferences, enabling LP2B to lead active and healthy lives.

Sleman Regency has designated a Sustainable Food Agriculture Area (KP2B) covering 18,491 hectares in the 2021-2041 Sleman Regency Spatial Plan (RTRW), as stipulated in Sleman Regency Regulation Number 13 of 2021. This area is spread across all kapanewon (sub-districts) except Depok, as well as functions as an agricultural cultivation area comprising Sustainable Food

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Agricultural Land (LP2B) and reserve land, along with supporting parameters. KP2B plays a strategic role in supporting food independence, resilience, and sovereignty at both the regional and national levels (Sleman Regency Regulation Number 6 of 2020).

Payments for Environmental Services (PES) can be an effort to protect LP2B in Sleman Regency. It further plays a crucial role in balancing socio-economic development and environmental protection for sustainability (Jia et al., 2022; Le et al., 2024). In this research, PES is implemented through an incentive scheme provided to landowners, tenant farmers, and farmer groups as service providers for maintaining the functions of the land. Beneficiaries of service providers should be willing to pay for the benefits obtained as part of the services (Clifton et al., 2025), similar to incentive schemes. Incentives are highly effective for environmental protection through the calculation of ecosystem services (Dobšinská et al., 2024). Incentive policy also shows the local government's commitment to supporting food security, as outlined in Sleman Regency Regulation Number 6 of 2020. Incentives in this regulation are based on nine parameters, namely land type, soil fertility, land area, irrigation availability, land fragmentation, farming productivity, location, form of business collective, and the implementation of environmentally friendly agricultural practices. Although these nine parameters have been established, the Sleman Regent Draft Regulation (Raperbub), which technically regulates the incentive mechanism for LP2B farmers, has not been ratified. This Raperbub should be a derivative regulation of Sleman Regency Regulation Number 6 of 2020 on the Protection of Sustainable Food Agricultural Land. Therefore, this research aims to identify and determine the key parameters of the nine established incentive calculation parameters. Key parameters are crucial because this incentive policy relates to financial and cross-sectoral instruments that minimize errors when implemented. This is part of the key to the successful implementation of PES (Dobšinská et al., 2024; Sangha et al., 2024). Consequently, the determined key parameters can provide a stronger basis for supporting incentive policies for LP2B protection in Sleman Regency.

LITERATURE REVIEW

PES Theory

PES functions to internalize positive externalities through payment mechanisms. It also represents a market-based or economic incentive approach designed to encourage conservation and the sustainable management of natural resources. The effectiveness of PES depends on social and cultural values, as well as the relationship between communities and nature (Arias-Arévalo et al., 2025; Vorlaufer et al., 2025). PES can be applied across a wide range of environmental themes, including forest conservation to maintain biodiversity (Dobšinská et al., 2024; Bicudo da Silva et al., 2025); clean water provision in upstream areas (Arias-Arévalo et al., 2025); carbon credits and ecosystem markets (Chamizo-González et al., 2018); climate change adaptation and public policy (Schaefers et al., 2025); as well as cross-regional or international cooperation (Huang et al., 2024). All of these activities can adopt PES to achieve sustainable development goals. In this study, the PES approach is applied to the incentive scheme for Sustainable Food Agricultural Land (LP2B) in Sleman Regency. The PES concept served as an environmental economic method that compensated environmental service providers, such as farmers, for maintaining the ecological function of the land. In the agricultural context, PES not only motivated high food productivity but also internalized the value of environmental services, such as soil conservation, irrigation system maintenance, and implementation of environmentally friendly practices. Therefore, PES was a policy instrument that balanced food security objectives with ecosystem sustainability.

Environmental Services-Based Incentive Theory in Public Policy

The provision of incentives to LP2B farmers in Sleman was a form of PES implementation based on Regional Regulation Number 6 of 2020 on the Protection of Sustainable Food Agricultural Land. This regulation established nine parameters for incentive calculation. However, the key parameters that most significantly influenced the policy's effectiveness have not been determined. Identifying key parameters was crucial to ensuring that incentive instruments were implemented effectively, fairly, and efficiently. The ISM method was used as an analytical framework to determine the key parameters for calculating LP2B incentives. ISM allowed mapping the relationships between parameters in a complex system, thereby showing the hierarchy of influence between parameters. This method provided a theoretical foundation for connecting PES concepts and incentives with practical implementation in LP2B protection. The research aimed to develop more measurable incentive mechanisms that supported long-term food security with the foundation.

However, determining parameters alone is not sufficient; it is necessary to understand the interrelationships among parameters (Le et al., 2024) and to establish a formula for the key parameters to enable implementation (Izquierdo-Tort et al., 2024), similar to the approach used in determining farmer incentives to maintain lake water quality (Supriyanto et al., 2024).

RESEARCH METHOD

The method for determining key parameters for calculating incentives used ISM, which was developed from interactive management. ISM was a computer-assisted learning process that allowed individuals or groups to create complex relationship maps between multiple parameters included in complex situations (Barusman, 2017; Yusuf et al., 2020). It generally consisted of three stages, namely system identification, analysis, and output interpretation. In the system identification stage, the level of contextual relationships between parameters/sub-parameters of incentive calculation was determined by expert respondents. This research included seven experts from academia, government, farmers, and the private sector who were competent in the agricultural industry. The experts determined the contextual relationships of nine parameters of the LP2B incentive calculation, consisting of LP2B type (A1), soil fertility level (A2), land area (A3), irrigation availability (A4), land fragmentation (A5), farming productivity (A6), location (A7), business collectivity form (A8), and the application of environmentally friendly agricultural practices (A9). The output of ISM was analyzed using level interpretation, namely, parameter levels based on values obtained from the driven power and dependence matrices. The key or first level was the parameter with the highest value, as presented in Figure 1.

FINDINGS AND DISCUSSION

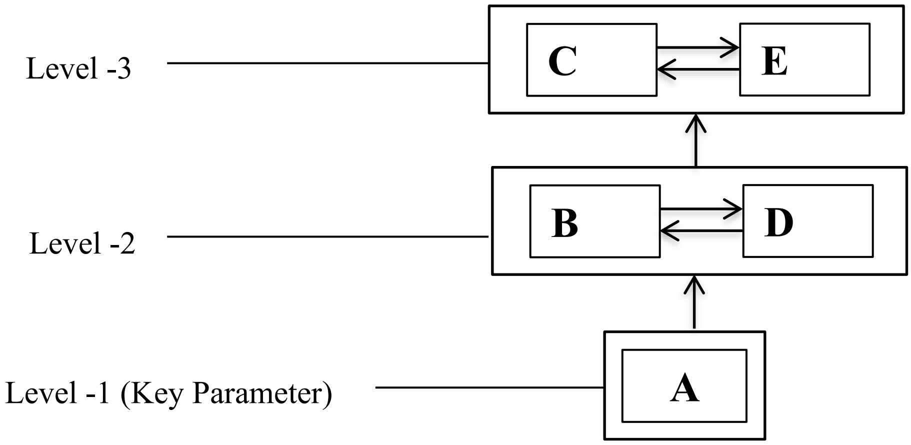

Figure 1. Parameter Levels

Providing incentives for LP2B farmers in Sleman was positioned as a form of PES implementation. In this research, farmers acted as providers of environmental services by maintaining the ecological function of agricultural land, such as maintaining soil fertility, maintaining irrigation systems, preventing land degradation, and supporting regional food security. Meanwhile, the government and the community acted as beneficiaries of these environmental services. LP2B, maintained by farmers or farmer groups, not only ensured food availability but also provided broader environmental benefits. Therefore, the provided incentives served as a value transfer instrument that not only motivated agricultural productivity but also internalized environmental values into LP2B protection policies. The LP2B incentive scheme was viewed as an agriculture-based PES model that supported food self-sufficiency while simultaneously conserving the environment. The conceptual framework of PES with LP2B incentives was presented in Figure 2

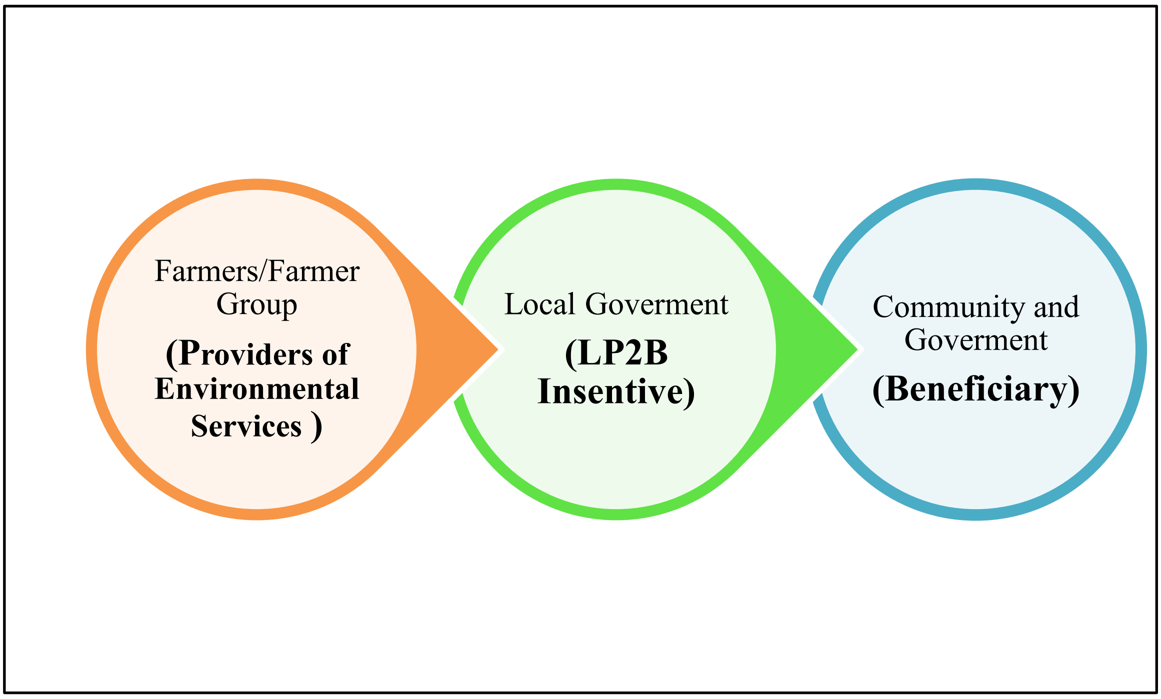

Figure 2. Conceptual PES and LP2B Incentives

The figure showed that farmers or farmer groups acted as providers of environmental services by maintaining soil fertility, using irrigation systems, and adopting sustainable agricultural practices. The local government established an LP2B incentive scheme, which served as a mechanism for transferring environmental value. Furthermore, both the community and the government benefited from increasing food security, self-sufficiency, and ecosystem sustainability. Providing these incentives was also crucial to be implemented based on the principle of fairness for the environmental services provided by farmers or farmer groups. The ISM was a method for realizing these incentives by determining key parameters for the calculation. The analysis showed that soil fertility (A2), irrigation availability (A4), and farming productivity (A6) were key parameters in calculating LP2B incentives, as shown in Figure 3.

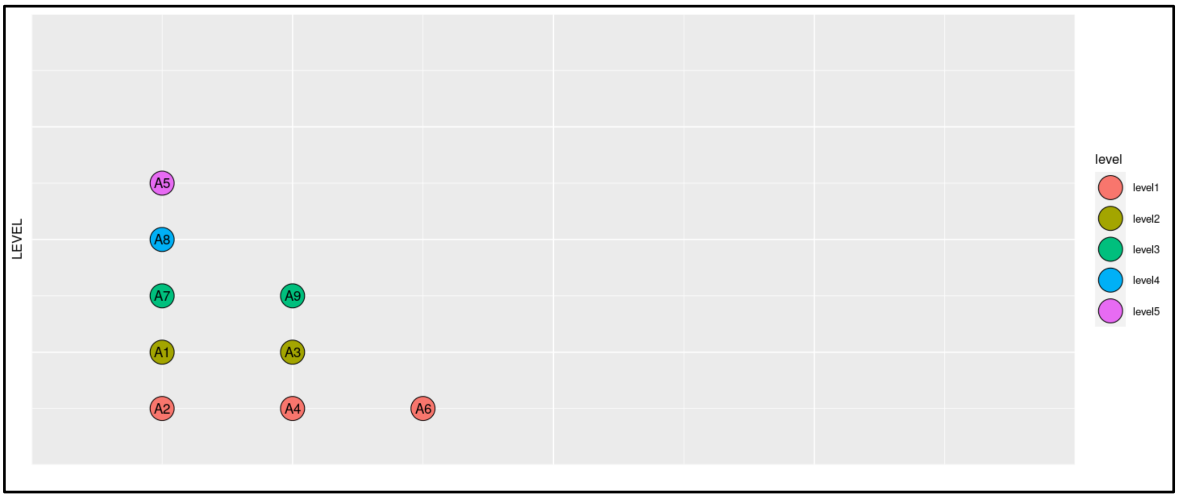

Figure 3. Parameter Levels of LP2B Incentive Calculation

The first key parameter for calculating incentives was soil fertility (A2), defined as a factor that increased agricultural productivity. The physical and chemical conditions of agricultural productivity were dynamic and influenced by plant species and the numbers (Trisnawati, 2022; Fiorentina et al., 2024). Soil fertility was also influenced by continuous soil cultivation by farmers (Sari et al., 2022). Fertile soil rich in nutrients supported optimal plant growth, maintained the balance of the soil ecosystem, and reduced dependence on excessive chemical inputs. In the context of LP2B, fertile land was crucial for ensuring the long-term sustainability of food production. Therefore, soil fertility was a key indicator that should be considered in determining LP2B incentives.

The second key parameter for calculating incentives was irrigation availability (A4). Irrigation was synonymous with water sources in agriculture (Leal Pacheco et al., 2025). Water was an essential component required by the soil to support plant growth. Water sources in agriculture were not solely determined by rainfall, but also obtained from irrigation channels constructed by humans (Safiun et al., 2023). Sustainable irrigation systems enhanced the value of agricultural land. This was because agricultural land with good irrigation access had more stable productivity, a reduced risk of crop failure, and higher land use efficiency. Sustainable irrigation played a role in maintaining ecosystem balance and reducing vulnerability to climate change. Therefore, irrigation availability was a crucial parameter in calculating LP2B incentives because it determined the ecological and economic sustainability of agriculture.

The third key parameter in calculating LP2B incentives was farming productivity (A6), defined as the land's ability to produce crop yields depending on nutrient availability and land management (Wibawati et al., 2024). Agricultural productivity also represented the interaction of various agronomic factors, including soil quality, water availability, technology, and farmer skills (Mendrofa, 2025). Productivity levels reflected the efficiency of agricultural land use and the contribution to regional food security, such as through multiple cropping systems, proven to be a strategy for increasing agricultural productivity (Wen et al., 2025). Farmers who successfully maintain or increase productivity on LP2B land showed good management. Furthermore, land productivity was a critical indicator for assessing the effectiveness of agricultural cultivation systems, particularly in rice cultivation (Pradini et al., 2024), making farming productivity a key parameter in an incentive scheme. Soil fertility, irrigation availability, and farming productivity were key parameters in calculating LP2B incentives because they complemented each other. Soil fertility served as the basic potential, irrigation as the main supporting factor, and farming productivity as the tangible output. Furthermore, incentives allocated more fairly, effectively, and on-target could motivate the achievement of LP2B protection

CONCLUSIONS

In conclusion, the LP2B incentive scheme was perceived as an agriculture-based PES model that supported food self-sufficiency and environmental conservation. In this context, soil fertility (A2), irrigation availability (A4), and farming productivity (A6) were key parameters in calculating LP2B incentives. Soil fertility served as the underlying potential, irrigation as the primary supporting factor, and farming productivity as the tangible output. These three parameters were used to motivate LP2B protection. Future research could develop incentive calculation formula based on the key parameters.

LIMITATIONS & FURTHER RESEARCH

This research was limited to the identification of key parameters in the LP2B incentive scheme. The study has not yet developed a quantitative formula or model for calculating the incentive value based on these parameters. Therefore, further research is required to establish a mathematical or economic formulation that can operationalize the identified parameters in practical policy implementation.

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