

HUMAN RESOURCE CAPACITY DEVELOPMENT AMONG INDEPENDENT OIL PALM SMALLHOLDERS AND RURAL ECONOMIC DEVELOPMENT IN RIAU PROVINCE, INDONESIA: A MIXED-METHODS STUDY

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ABSTRACT

Oil palm agribusiness is the backbone of Riau Province's economy, yet its sustainability depends on the human resource (HR) quality of independent smallholders. This study analyzes HR capacity development among oil palm farmers and its role in rural economic development. A sequential explanatory mixed-methods design combined quantitative data from 300 independent smallholder households in Kampar, Siak, and Indragiri Hulu Regencies with qualitative data from 12 key informants. Farmers' HR capacity was high (mean = 3.71 on a 1–5 scale) and strongly correlated with fresh fruit bunch (FFB) productivity ($r = 0.796$; $p < 0.001$) and the village economic development index ($r = 0.777$; $p < 0.001$). Members of village cooperatives (Koperasi Unit Desa, KUD) showed significantly higher HR capacity, productivity, and village economic contribution than non-members ($p < 0.001$). Mediation analysis indicated that productivity and technology adoption link HR capacity to household income growth, while its effect on village economic development is more direct. Qualitative findings corroborated these results, revealing four themes: technical capacity gaps, KUD institutional dynamics, limited digital literacy, and impacts on Village-Owned Enterprises (BUMDes) and Village Original Income (PADes). It recommends continuous technical training, farmer institution revitalization, and optimal use of oil palm plantation funds (BPDPKS).

Keywords: *HR capacity; oil palm agribusiness; rural economic development; farmer institutions; Riau Province*

INTRODUCTION

Riau Province is one of the largest oil palm production centers in Indonesia. Its plantation area continues to expand every year, making the commodity the main pillar of the regional economy (Syahza & Asmit, 2019). The expansion of oil palm agribusiness has fundamentally transformed the rural economic structure of Riau, from one based on subsistence farming to a commodity-based economy oriented toward exports and integrated into global value chains (Syahza, 2020). Behind these achievements, however, structural challenges continue to threaten the sustainability of the sector, particularly at the level of independent smallholders, who manage more than half of the total oil palm area in Riau without adequate corporate-style management support (Cramb & McCarthy, 2016).

The productivity gap between smallholder (independent) plantations and large private or state-owned estates has been highlighted in numerous studies, and the human resources (HR) of farmers have been identified as one of the main determinants of this gap (Woittiez et al., 2017; Euler et al., 2017). Independent smallholders generally face limited access to technical training

in cultivation in line with Good Agricultural Practices (GAP) standards, limited farm financial management skills, and a limited understanding of institutional networks and supply chain partnerships (Jelsma et al., 2017). This capacity gap, in turn, has direct implications for low fresh fruit bunch (FFB) productivity, which has been empirically shown to affect the welfare of farm households (Gatto et al., 2017; Rifin et al., 2020).

The issue of smallholder HR capacity cannot be separated from broader regional economic development. As a strategic commodity that sustains regional own-source revenue and absorbs local labor, the performance of oil palm agribusiness is closely linked to rural economic development outcomes, including the strengthening of Village-Owned Enterprises (BUMDes), increases in Village Original Income (Pendapatan Asli Desa, PADes), and rural poverty reduction (Raharjo et al., 2021; Edwards, 2019). Santika et al. (2019) even show that oil palm expansion can contribute to reducing multidimensional poverty when accompanied by adequate human capacity building, but may create new inequalities when the economic benefits are enjoyed only by a small number of actors with

superior capital and knowledge (Obidzinski et al., 2012; McCarthy, 2010).

In this context, farmer institutions such as the village cooperative (Koperasi Unit Desa, KUD) and farmer groups play a crucial role as platforms for HR capacity development and as bridges for partnerships with palm oil mills (POMs) (Naim et al., 2021; Jelsma et al., 2019). Strong institutions enable farmers to access training, capital, and markets more equitably, as emphasized in studies on the institutional transformation of smallholder plantations in Indonesia (Dharmawan et al., 2021; Suharno et al., 2018). Conversely, weak institutions tend to trap farmers in informal supply chains dominated by middlemen, which hinders the optimization of the economic benefits of oil palm farming (Ros-Tonen et al., 2019).

Although numerous studies have examined the relationships among HR capacity, productivity, and the welfare of oil palm farmers separately, few have integrated these three dimensions while explicitly linking them to rural economic development indicators within a human resource management (HRM) framework at the farm-household level. Even fewer have used a mixed-methods approach that combines large-scale quantitative evidence with contextual understanding from key actors in the field. This research gap underpins the urgency of the present study.

Based on this background, this study addresses four questions: (1) what is the profile and dynamics of HR capacity among independent oil palm smallholders in Riau Province; (2) how HR capacity, productivity, and farm household income are related; (3) to what extent membership in a farmer institution (KUD) moderates HR capacity and economic outcomes; and (4) how institutional dynamics, policy, and barriers to access to capital and technology influence the contribution of the oil palm sector to rural economic development. The objective of this study is to analyze the dynamics of HR capacity development among oil palm farmers and its role in driving rural economic development in Riau Province, using a mixed-methods approach that integrates quantitative data from farm households with qualitative data from key actors in the oil palm agribusiness ecosystem. The study is expected to contribute theoretically to the human capital literature in the agribusiness sector and practically to the formulation of farmer HR development policies by the Riau Provincial Government, the Provincial Plantation Office, and the Oil Palm Plantation Fund Management Agency (Badan Pengelola Dana Perkebunan Kelapa Sawit, BPDPKS).

LITERATURE REVIEW

Human Capital Theory and Farmer Human Resource Capacity

Human capital theory positions individuals' knowledge, skills, and competencies as a form of capital that can be invested to increase productivity and income (Rist et al., 2010). In the agribusiness context, farmer HR capacity is measured not only by technical cultivation skills but also by farm financial management ability and an understanding of institutional and partnership networks within the supply chain (Subagyo et al., 2020). The technical capacity dimension is reflected in mastery of agronomic practices that meet sustainability standards, including balanced fertilization and pest and disease management, which are the main determinants of yield gaps among farmers (Slingerland et al., 2019; Woittiez et al., 2017). The financial management dimension encompasses the ability to record production costs, calculate the cost of production (Harga Pokok Produksi, HPP), and plan the reinvestment of farm proceeds, which is often a weak point of independent smallholders compared with corporate plantations (Khatun et al., 2020). The institutional-partnership dimension refers to farmers' understanding of FFB supply chain mechanisms, sustainability certification, and partnership schemes with POMs (Pramudya et al., 2020). Investment in human capital in the agricultural sector has been empirically shown to increase household productivity and income across developing-country contexts (Nugroho et al., 2021; Budiono et al., 2022). However, the accumulation of HR capacity does not necessarily increase linearly with practical experience alone; systematic capacity building through formal training, extension support, and education has proven to be a more significant pathway than self-directed learning from experience passed down through generations (Nurfatriani et al., 2019). This finding is relevant given that the ratio of agricultural extension workers (Penyuluh Pertanian Lapangan, PPL) to farmers in many parts of Riau remains far from ideal, so that the transfer of technical knowledge is slow and uneven (Nugroho et al., 2021).

Regional Economic Development Theory and Commodity-Based Rural Economies

From a development economics perspective, regional economic development emphasizes the importance of a leading commodity base as the driver of growth (economic base theory), which subsequently creates a multiplier effect on supporting sectors in the surrounding area (Syahza & Suwondo, 2017). Oil palm in Riau Province functions as a basic sector that stimulates the growth of supporting services in villages, ranging

from trade in agricultural inputs and transportation of harvested crops to downstream processing units (Syahza, 2020). At the micro level, this commodity-based economic growth is reflected in indicators such as farmers' direct market access to POMs without long middleman chains, household business diversification, and farmers' contribution to the village economy through BUMDes and local employment (Raharjo et al., 2021).

Studies on the impact of oil palm expansion on rural economies show mixed results. On the one hand, several studies affirm a significant positive contribution to household income growth and rural poverty reduction (Edwards, 2019; Rifin et al., 2020; Gatto et al., 2017). On the other hand, others warn of the potential economic exclusion of farmers with limited capital and knowledge, causing the economic benefits of oil palm to be distributed unevenly across social groups (McCarthy, 2010; Obidzinski et al., 2012). This situation underscores that oil palm-based rural economic development is not an automatic process but depends heavily on HR quality, institutional governance, and affirmative local government policy (Suryani et al., 2020).

Oil Palm Agribusiness and the Value Chain Dynamics of Independent Smallholders

As a global agribusiness commodity, oil palm involves a complex value chain linking independent smallholders, farmer groups/KUDs, POMs, and export markets (Cramb & McCarthy, 2016). The bargaining position of independent smallholders in this value chain is largely determined by their ability to meet FFB quality standards and sustainability certification such as Indonesian Sustainable Palm Oil (ISPO), which is a prerequisite for access to formal markets (Hutabarat, 2017; Pramudya et al., 2020). Numerous studies show that compliance with such sustainability standards requires substantial strengthening of farmers' administrative and technical capacity, because the certification process requires documentation of land legality, environmentally friendly cultivation practices, and transparent institutional governance (Meijaard et al., 2018; Dislich et al., 2017).

Partnership models between independent smallholders and oil palm companies in Riau generally take the form of limited technical guidance for selected farmer groups, digital weighing systems, and supply chain e-traceability mechanisms to ensure the traceability of harvests (Azzahra et al., 2022; Meyfroidt et al., 2018). Nevertheless, the adoption of digital technology in smallholder supply chains still faces constraints of digital literacy and limited signal infrastructure in rural areas (Daemkoeh et al., 2021; Dammert et al.,

2020). Riau's dispersed geography and uneven network accessibility pose an additional challenge to the implementation of smart farming and digital farmer information systems (Rawa et al., 2022).

Farmer Institutions, Social Capital, and Partnerships as Determinants of Community-Based HRM

From a community-based human resource management (HRM) perspective, farmer institutions such as KUDs and farmer groups serve a dual function: as platforms for developing collective competencies and as instruments for governing shared resources (Naim et al., 2021). Strong institutions facilitate economies of scale in input procurement, access to financing, and price negotiation with POMs, thereby strengthening the bargaining position of individual farmers, who are structurally weak (Jelsma et al., 2019; Ros-Tonen et al., 2019). Studies on the institutional transformation of smallholder plantations affirm that the success of farmer empowerment depends heavily on local institutional leadership and the degree of member participation in decision-making (Dharmawan et al., 2021; Suharno et al., 2018).

Social capital built through farmer institutions is also an important channel for disseminating innovation and best agronomic practices among farmers, as demonstrated in various sustainable oil palm supply chain contexts globally (Brandt & Otte, 2020). Conversely, the absence of solid institutions can trap farmers in individual, exploitative relationships with middlemen, as found in various studies on the heterogeneity of oil palm farmers' capacity in Sumatra (Jelsma et al., 2017). The reallocation of oil palm funds through the Oil Palm Plantation Fund Management Agency (BPDPKS) scheme is also a strategic policy instrument for capacity building and the sustainability of independent smallholders, although its implementation in the field still faces challenges of data validation and equitable distribution of benefits (Nurfatriani et al., 2019).

RESEARCH METHODS

This study employed a mixed-methods approach with a sequential explanatory (integrated) design. The population of the quantitative study comprised all independent oil palm smallholder households in the three study regencies. The quantitative sample consisted of 300 farm households: 107 in Kampar Regency, 108 in Siak Regency, and 85 in Indragiri Hulu Regency, selected using multistage random sampling at the subdistrict and village levels. For the qualitative component, the study involved 12 key informants selected through purposive sampling based on the

diversity of roles within the oil palm agribusiness ecosystem, comprising independent smallholders/farmer group leaders, KUD chairs, village heads, agricultural extension workers (PPL), POM managers, and staff of the Riau Provincial Plantation Office, in order to obtain comprehensive source triangulation. Quantitative data were collected through a structured survey using a questionnaire administered to 300 farm household respondents. Qualitative data were collected through semi-structured in-depth interviews with 12 key informants, which were recorded, transcribed, and coded using an NVivo-style thematic analysis approach to identify recurring themes across informants. The quantitative data were analyzed in several stages: (1) descriptive statistics to map respondent profiles and study variables; (2) Pearson correlation analysis to test the strength of relationships among variables; (3) simple and multiple linear regression analyses to test the direction and magnitude of effects; (4) independent-samples t-tests to compare

outcomes between KUD member and non-member farmers; (5) one-way analysis of variance (ANOVA) to test differences in outcomes across regencies; and (6) testing of the mediating role of Productivity and Technology Adoption (M) in the relationship between HR Capacity (X) and economic outcomes (Y) using stepwise regression (Baron & Kenny) supplemented by the Sobel test to assess the significance of the indirect effect. All statistical tests used a 5% significance level ($p < 0.05$). The qualitative data were analyzed using thematic analysis, comprising data reduction, theme coding, categorization, and conclusion drawing, and were then triangulated with the quantitative findings to obtain a more comprehensive interpretation (mixed-methods integration at the discussion stage).

RESULTS

Respondent Characteristics

A total of 300 independent oil palm smallholder households participated in the study, distributed across Kampar Regency .

Table 1. Demographic and Farm Characteristics of Respondents (N = 300)

Characteristic	Category/Statistic	Value
Number of respondents (N)	Total	300 households
Regional distribution	Kampar Regency	107 (35.7%)
	Siak Regency	108 (36.0%)
	Indragiri Hulu Regency	85 (28.3%)
Land area (ha)	Mean (SD)	3.83 (1.35)
Farmer age (years)	Mean (SD)	44.60 (8.11)
Length of formal education (years)	Mean (SD)	10.03 (2.82)
Farming experience (years)	Mean (SD)	24.18 (8.32)
KUD/Farmer group membership	Member (Yes)	226 (75.3%)
	Non-member (No)	74 (24.7%)

Profile of Farmer Human Resource Capacity

Descriptive analysis showed that the mean farmer HR Capacity score (combining the three dimensions) was 3.71 (SD = 0.75) on a 1–5 scale, which falls in the high category (interval 3.41–4.20). By dimension, the highest score was for

Institutional Partnership (X3), with a mean of 3.95 (SD = 1.05), followed by Technical Training (X1) at 3.73 (SD = 0.75), and the lowest score was for Financial Management (X2) at 3.46 (SD = 0.73), as visualized in Figure 1.

Figure 1. Mean Profile of HR Capacity Dimensions among Independent Oil Palm Smallholders in Riau Province (N=300)

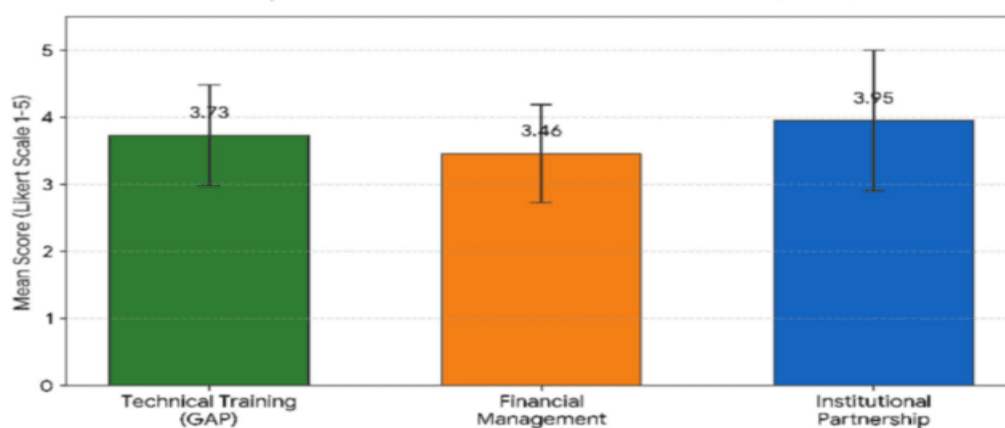


Figure 1. Mean Profile of HR Capacity Dimensions among Independent Oil Palm Smallholders in Riau Province (N = 300)

This pattern indicates that farmers are relatively stronger in relational-institutional aspects than in farm financial management, which is consistent with the qualitative finding (discussed in Section 4.9) that many farmers are not accustomed to keeping systematic cash records and calculating the cost of production (HPP). This finding is also in line with Khatun et al. (2020), who highlighted weak financial literacy as a common constraint among independent smallholders in various oil palm-producing regions.

Further correlation analysis showed that length of formal education was positively but weakly correlated with the HR Capacity score ($r = 0.281$; $R^2 = 0.079$; $p < 0.001$), whereas length of farming experience was not significantly correlated with HR Capacity ($r = 0.011$; $p = 0.851$). This finding is theoretically important because it shows that the accumulation of farmer HR capacity does not arise

automatically from practical experience alone but is determined more by access to formal education and structured training, in line with the argument of Nurfatriani et al. (2019) on the importance of systematic training investment over self-directed learning based on experience passed down through generations.

Relationships among HR Capacity, Productivity, and Household Income

Simple correlation and regression analyses showed a strong and significant relationship between HR Capacity and FFB Productivity ($r = 0.796$; $R^2 = 0.633$; $\beta = 3.01$; $p < 0.001$), as shown in Figure 2. This means that approximately 63.3% of the variation in farmers' FFB productivity can be explained by variation in HR Capacity scores, and each one-point increase in the HR Capacity score is associated with a productivity increase of 3.01 tons/ha/year.

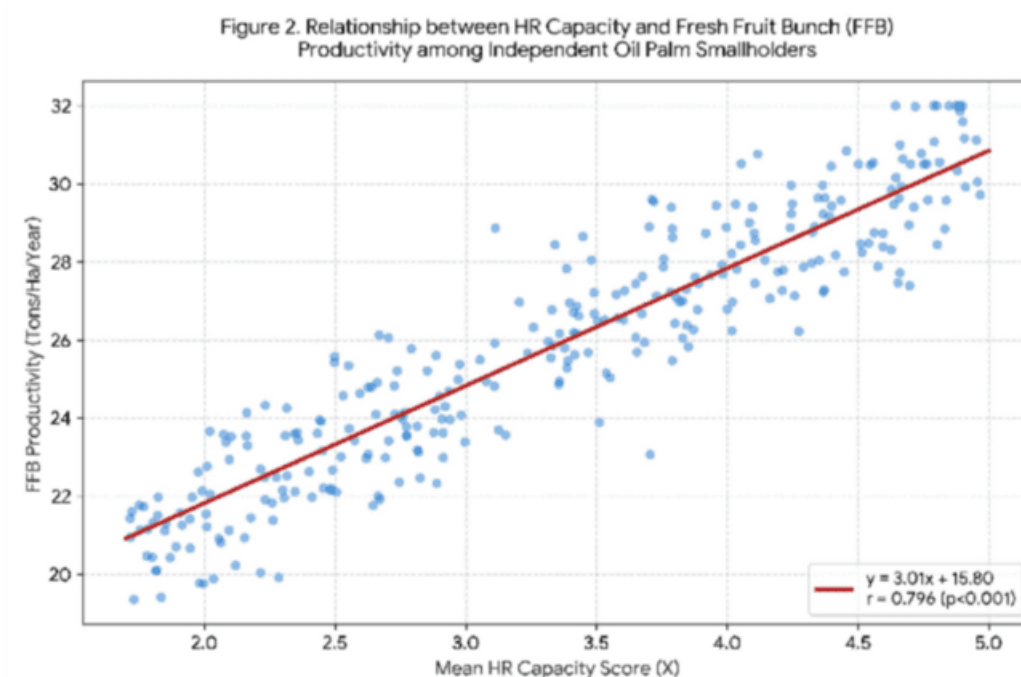


Figure 2. Relationship between HR Capacity and Fresh Fruit Bunch (FFB) Productivity among Independent Oil Palm Smallholders

Furthermore, FFB Productivity was positively and significantly correlated with Monthly Household Net Income ($r = 0.582$; $R^2 = 0.339$; $p < 0.001$), as shown in Figure 3. Interestingly, the direct relationship between HR Capacity and Net Income was relatively weaker ($r = 0.226$; $R^2 =$

0.051 ; $p < 0.001$) than its relationship with Productivity. This pattern indicates that the influence of HR Capacity on household income is not direct but is channeled primarily through increased farm productivity.

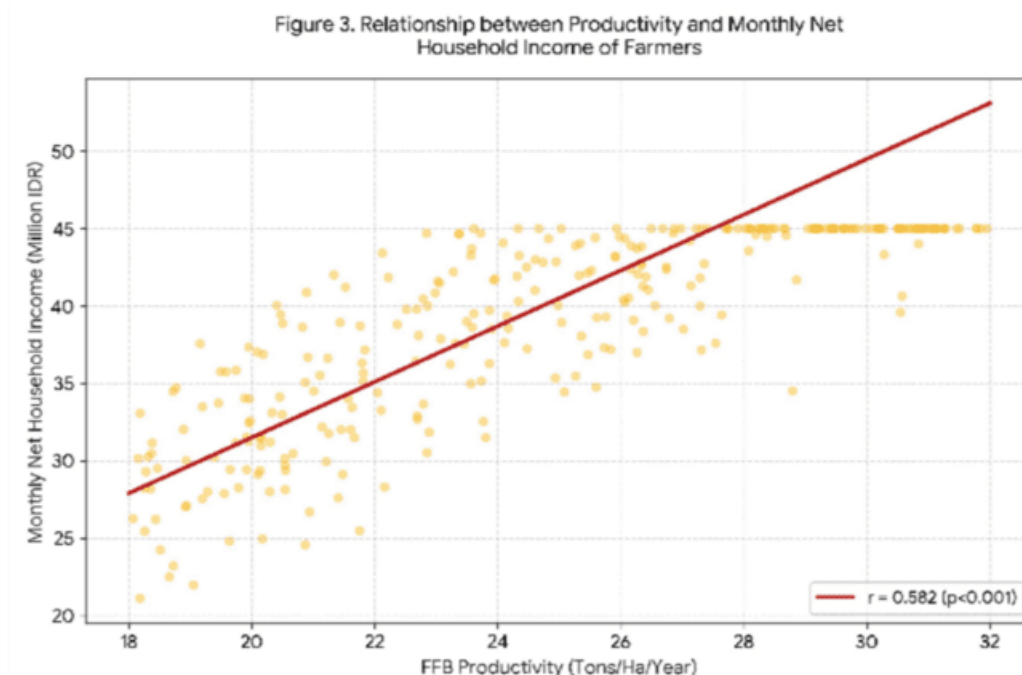


Figure 3. Relationship between Productivity and Monthly Household Net Income of Farmers

The Role of Farmer Institutions (KUD) in HR Capacity and Economic Outcomes

Independent-samples t-tests showed highly significant differences between KUD member and non-member farmers on all main study indicators. KUD member farmers had a mean HR Capacity score of 4.07, far higher than the 2.62 of non-

member farmers ($t = 26.99$; $p < 0.001$). Similar patterns were observed for FFB Productivity (28.02 vs. 23.85 tons/ha/year; $t = 14.01$; $p < 0.001$), Net Income (IDR 25,746,345 vs. IDR 22,208,029 per month; $t = 3.23$; $p = 0.0015$), and the Village Economic Index (3.19 vs. 1.95; $t = 21.62$; $p < 0.001$), as visualized in Figure 4.

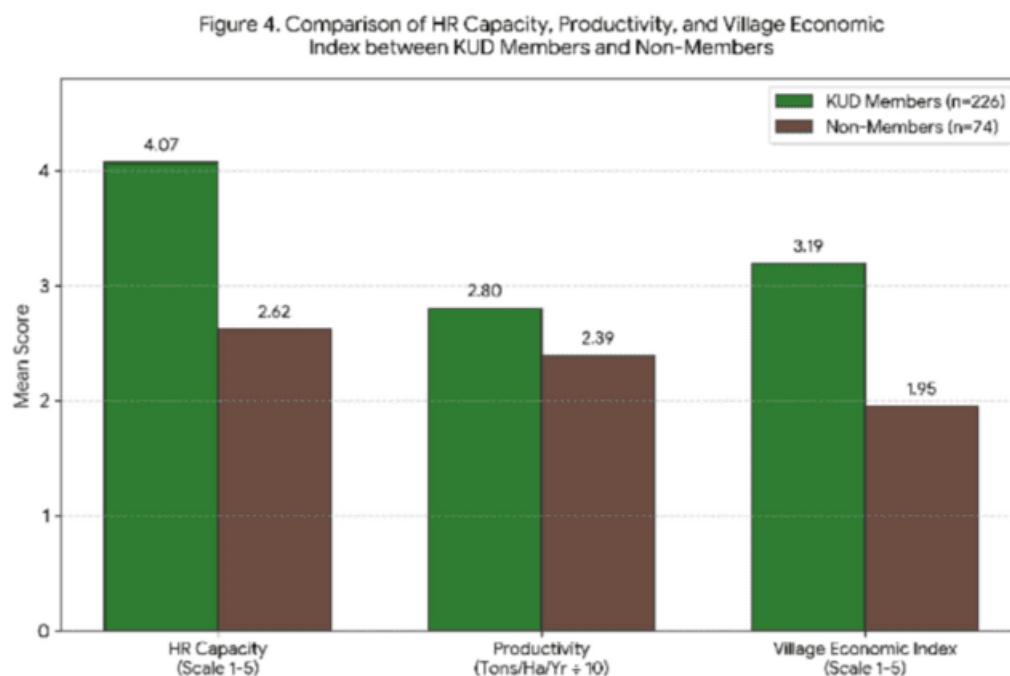


Figure 4. Comparison of HR Capacity, Productivity, and Village Economic Index between KUD Members and Non-Members

This finding empirically confirms the strategic role of farmer institutions emphasized in the literature (Naim et al., 2021; Jelsma et al., 2019; Dharmawan et al., 2021): KUDs function not only as channels for distributing harvests but also as the

main avenue for farmer HR capacity development through access to training, market information, and more structured partnership support from POMs.

Profile of Oil Palm Agribusiness-Based Rural Economic Development Indicators

The four Rural Economic Development indicators showed varying achievement, ranging from moderate to fairly high. The highest score was for Business Diversification (Y3), with a mean of 3.05 (SD = 0.90), followed by Technology/ISPO Adoption (Y1) at 2.92 (SD = 0.74) and Village Economic Contribution (Y4) at

2.84 (SD = 0.82); the lowest score was for Direct Market Access (Y2) at 2.76 (SD = 1.02), as shown in Figure 5. The composite Rural Economic Development Index (mean of Y2, Y3, and Y4) was 2.88 (SD = 0.69), which falls in the moderate category.

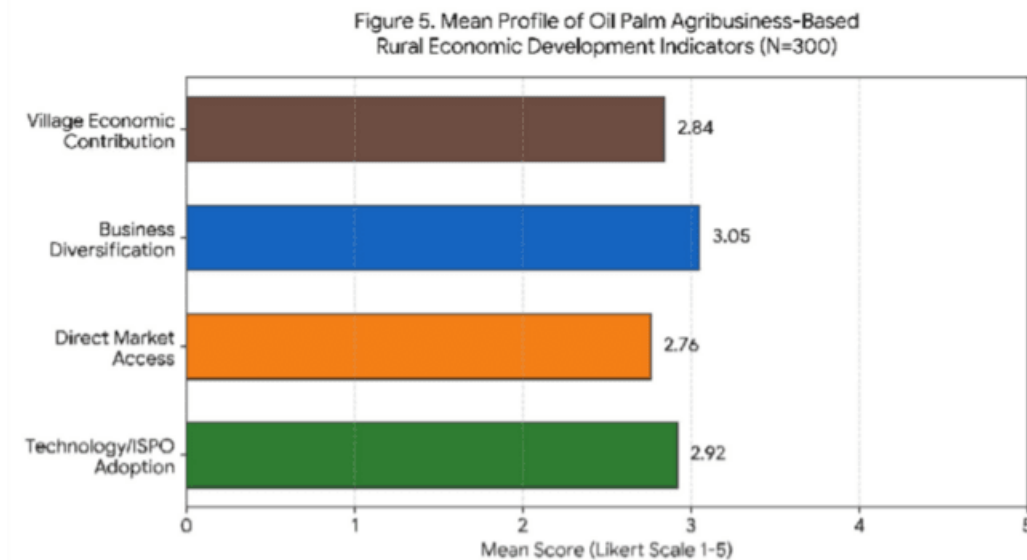


Figure 5. Mean Profile of Oil Palm Agribusiness-Based Rural Economic Development Indicators (N = 300)

The relatively low Direct Market Access score indicates that some farmers still depend on middlemen to sell their harvests, rather than selling directly to POMs or through KUDs, consistent with the qualitative findings from non-KUD-member informants who described dependence on local middlemen (discussed in Section 4.9). Conversely, the relatively good achievement in Business Diversification indicates the emergence of oil palm-derived business units and side businesses among farm households, as confirmed by qualitative findings on palm chip (keripik sawit) enterprises and Women Farmers' Cooperatives (Koperasi Wanita Tani, KWT).

Correlation Matrix among Study Variables

To obtain a comprehensive picture of the interrelationships among variables, Pearson correlation analysis was conducted on all key study variables, as presented in Figure 6. The correlation matrix confirms that HR Capacity has the strongest correlations with Productivity ($r = 0.796$) and the Village Economic Index ($r = 0.777$), followed by Technology/ISPO Adoption ($r = 0.748$). The correlations among the Rural Economic Development indicators (Y1–Y4) were also moderate to strong, indicating good internal consistency of the construct.

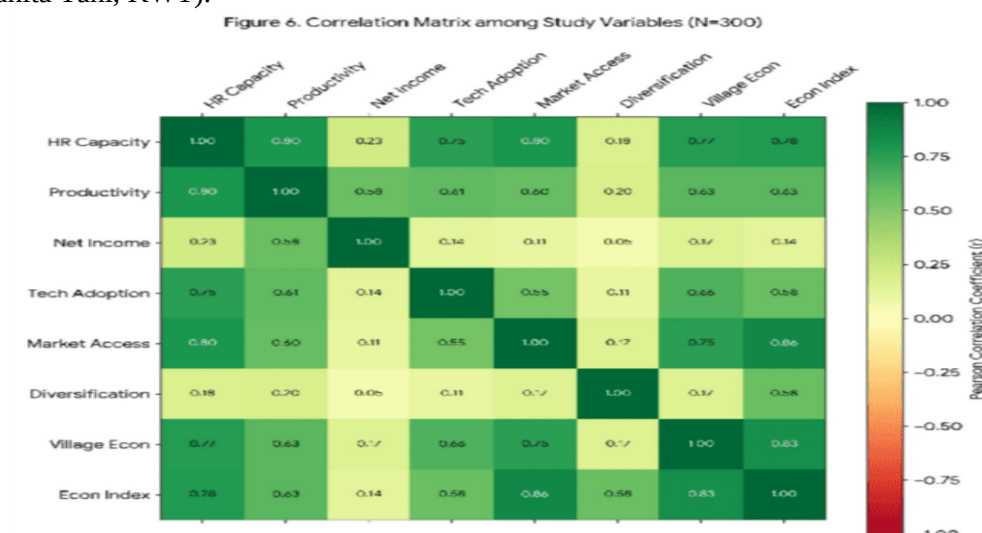


Figure 6. Correlation Matrix among Study Variables (N = 300)

Comparison across Regencies

One-way analysis of variance (ANOVA) showed no significant differences across regencies on any of the main variables: HR Capacity ($F = 0.411$; $p = 0.663$), FFB Productivity ($F = 0.976$; $p = 0.378$), Net Income ($F = 2.143$; $p = 0.119$), and the Village Economic Index ($F = 0.524$; $p = 0.593$), as shown in Figure 7. This finding indicates that

the dynamics of HR capacity development and economic outcomes among oil palm farmers are relatively homogeneous across the three regencies, so the challenges and opportunities identified in this study are representative of independent oil palm-producing areas in Riau Province more broadly rather than specific to any single regency.

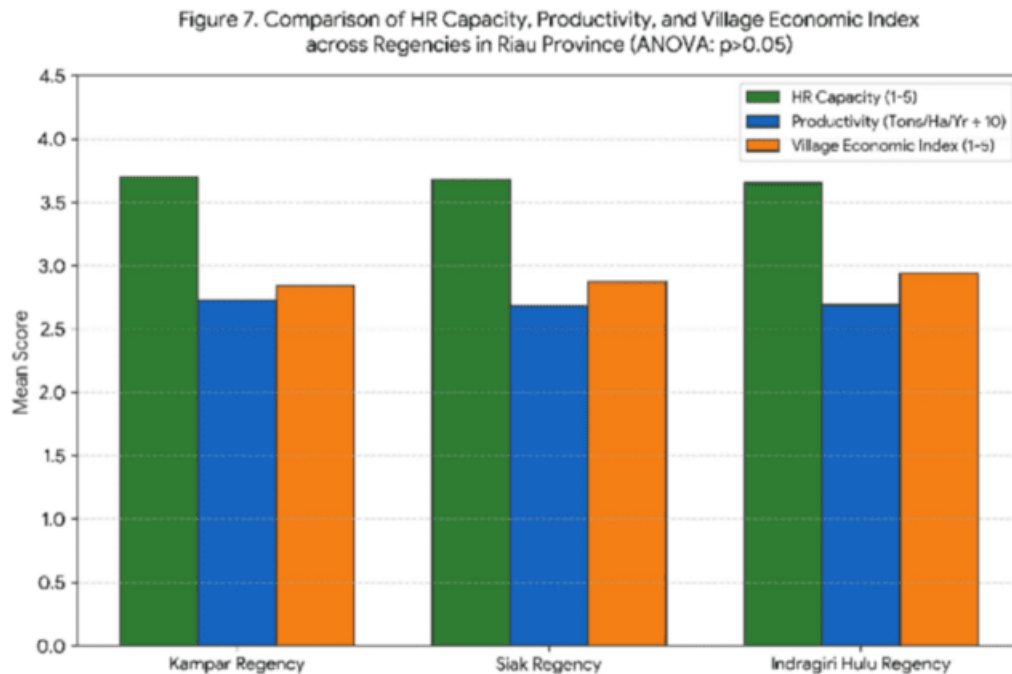


Figure 7. Comparison of HR Capacity, Productivity, and Village Economic Index across Regencies in Riau Province

Testing the Mediating Role of Productivity and Technology Adoption

To test the conceptual framework that positions Productivity and Technology Adoption (M) as a mediating variable between HR Capacity

(X) and economic outcomes (Y), stepwise regression analysis supplemented by the Sobel test was conducted; the conceptual model is presented in Figure 8.

Figure 8. Conceptual Model of the Pathways of HR Capacity Influence on Rural Economic Development through Productivity & Technology Adoption



Figure 8. Conceptual Model of the Pathways of HR Capacity's Influence on Rural Economic Development through Productivity and Technology Adoption

For the pathway to Household Net Income, the Sobel test showed that the indirect effect of HR Capacity through Productivity was significant ($z =$

13.11; $p < 0.001$), whereas the direct effect of HR Capacity on Income was no longer dominant after controlling for Productivity in the multiple

regression model. This pattern is consistent with strong mediation (approaching full mediation); that is, HR capacity influences household income primarily through increased farm productivity rather than through other direct mechanisms. Nevertheless, the high correlation between HR Capacity and Productivity ($r = 0.796$) may cause multicollinearity that limits the precision of coefficient estimates in the multiple regression model, so these results need to be further confirmed using Structural Equation Modeling (SEM) in future research.

Meanwhile, for the pathway to the Rural Economic Development Index, the Sobel test showed no significant mediation through Productivity ($z = 0.355$; $p = 0.723$). HR Capacity continued to show a strong and dominant direct influence on the Village Economic Index ($r = 0.777$), without being fully mediated by Productivity. This finding is substantively reasonable given that the Village Economic Index

is a multidimensional construct encompassing market access, business diversification, and village institutional participation—dimensions more directly related to farmers' institutional and managerial competencies (dimensions X2 and X3) than to the physical output of FFB production alone.

Qualitative Findings: Institutional Dynamics, Policy, and Barriers to Access to Capital and Technology

Thematic analysis of in-depth interviews with 12 key informants—including independent smallholders, KUD chairs, village heads, agricultural extension workers, a POM manager, and staff of the Riau Provincial Plantation Office (Figure 9)—confirmed and enriched the quantitative findings through four main themes:

(1) technical capacity gaps, (2) KUD institutional dynamics, (3) limited access to digital technology, and (4) impacts on the village economy.

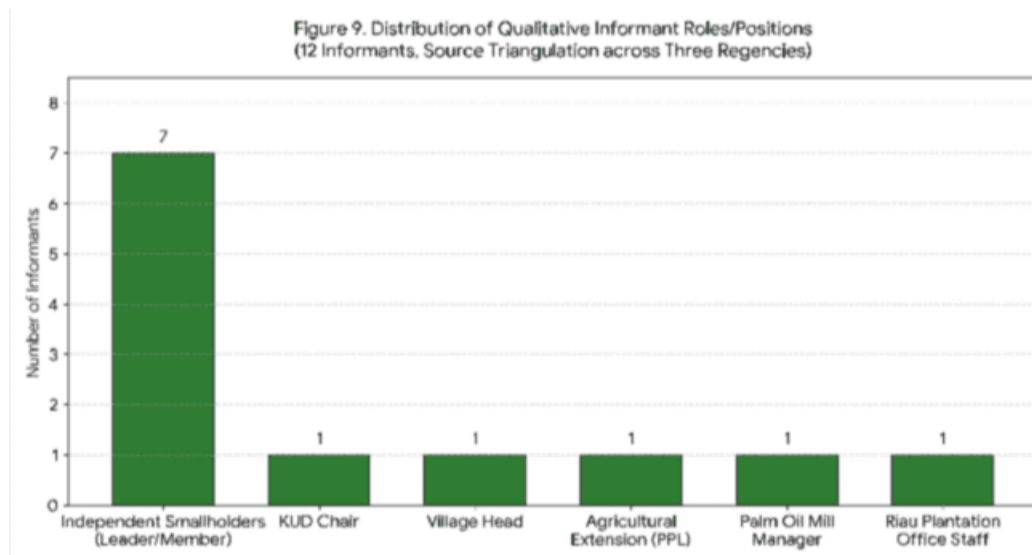


Figure 9. Distribution of Roles/Positions of Qualitative Informants (12 Informants, Source Triangulation across Three Regencies)

a. Technical Capacity Gaps

Most farmer informants acknowledged limited access to systematic technical cultivation training. An independent smallholder in Kampar Regency (INF-01) said that understanding of the correct fertilizer dosage remained limited: “We know how to fertilize, but we don’t know the exact dose for our soil. If the agency provided regular training, our FFB yields could rise by 20%.” This condition was reinforced by the statement of an agricultural extension worker (INF-05), who highlighted the imbalance in the extension ratio: one extension worker must assist up to four villages at once, so the transfer of technical knowledge is uneven. This informant also stressed that farmer HR capacity should ideally not be limited to planting skills but should also include the ability to calculate the cost

of production (HPP) and to understand the FFB supply chain—a finding that directly supports the quantitative result that the Financial Management dimension (X2) had the lowest score among the three HR Capacity dimensions.

At the more extreme end, a non-KUD-member farmer in Indragiri Hulu Regency (INF-07) described having no access to training at all and relying entirely on practices inherited from previous generations: “We’ve never attended any training. We just follow the way our parents did it. When prices fall, we just resign ourselves to it.” This narrative illustrates the economic vulnerability of farmers isolated from formal institutions, consistent with the quantitative finding that non-KUD-member farmers have significantly lower HR Capacity scores (2.62 vs. 4.07 for KUD

members).

b. KUD Institutional Dynamics

The chair of KUD Sawit Makmur in Siak Regency (INF-03) emphasized the central role of HR in achieving sustainability certification: “HR is the key to ISPO. Without strengthening administrative and plantation capacity, certification will not pass.” This statement illustrates that institutional strengthening cannot be separated from investment in members’ HR capacity, in line with the literature on sustainability certification governance for independent smallholders (Pramudya et al., 2020; Hutabarat, 2017). A POM manager (INF-06) also stressed the importance of improving farmers’ HR capacity in FFB quality sorting as a prerequisite for purchase at premium prices: “We are ready to buy at high prices in accordance with the Plantation Office’s stipulation, as long as the quality of farmers’ HR in FFB sorting is improved.”

However, not all institutional experiences have gone smoothly. An agricultural extension worker (INF-05) noted that farmer groups tend to be passive when there is no government assistance in the form of seedlings or fertilizer, indicating a persistently high dependence on external stimuli rather than independent institutional initiative. Meanwhile, a non-member farmer (INF-07) expressed reluctance to join a KUD because of traumatic past experiences with the management of such institutions—a finding that points to the importance of improving the governance and transparency of farmer institutions to increase participation, in line with the argument of Suharno et al. (2018) on the importance of trust-based institutional strengthening.

c. Limited Access to Digital Technology

The theme of access to digital technology showed considerable variation among informants. Some farmers have adopted simple technologies such as WhatsApp groups to monitor daily FFB prices (INF-01) or online marketing applications for oil palm-derived processed products through e-commerce platforms and social media (INF-02). At the more advanced institutional level, a KUD in Siak Regency has adopted a digital FFB weighing management system (INF-03), while POMs apply supply chain e-traceability certification systems (INF-06), in line with the global trend of adopting traceability technology in oil palm supply chains (Meyfroidt et al., 2018). Staff of the Riau Provincial Plantation Office (INF-08) also confirmed the existence of a digital database of Plantation Cultivation Registration Certificates (Surat Tanda Daftar Budidaya, STDB) as an

instrument for farmer registration.

Nevertheless, an agricultural extension worker (INF-05) noted that use of the “Petani Digital” application remains minimal because of limited signal coverage in rural areas, while a non-KUD-member farmer (INF-07) used only a basic mobile phone (not a smartphone). This digital divide reinforces the findings of Daemkoeh et al. (2021) and Dammert et al. (2020) that digital literacy and connectivity infrastructure are critical prerequisites for optimizing digital technology to support market access and supply chain efficiency among smallholder farmers.

d. Impacts on Rural Economic Development

The theme of village economic impact yielded the most compelling narratives, particularly from local leaders. The Village Head of Tapung Jaya in Kampar Regency (INF-04) reported that Village Original Income (PADes) had increased by up to 35% from profit-sharing of oil palm-related BUMDes business units, stating emphatically: “Rural economic development in Riau is oil palm. If the farmers’ human resources are smart, the BUMDes will advance, and the village will no longer be poor.” This narrative illustrates the direct link between strengthening farmer HR capacity and strengthening formal village economic institutions such as BUMDes, reinforcing the quantitative finding that HR Capacity is strongly correlated with the Village Economic Index ($r = 0.777$).

The KUD chair (INF-03) also confirmed the contribution of farmer institutions to village finances and to the establishment of BUMDes savings-and-loan units, while a female farmer entrepreneur who produces palm chips (INF-02) highlighted the socio-economic impact of business diversification on the empowerment of rural women: “From oil palm we learned about diversification. Women in the village no longer just wait for their husbands to come home from the plantation,” and reported having created jobs for six housewives in her village. Another KUD member farmer (INF-09) confirmed the direct economic benefits of strengthened HR capacity: “Improved HR helps us cut plantation operating costs by up to 15%,” while also contributing self-help capital for improving village production roads. Conversely, staff of the Plantation Office (INF-08) pointed to the challenge of policy implementation in the field, particularly the validation of data on farmer beneficiaries of BPD PKS funds, as a structural constraint that must continue to be addressed so that the transformation toward self-reliant villages can proceed optimally.

Table 2. Summary of Qualitative Themes and Their Relationship with Quantitative Findings

Main Theme	Summary of Findings	Related Quantitative Confirmation
Technical Capacity Gaps	Limited GAP training, uneven extension worker-to-village ratio, some farmers entirely self-taught	Lowest X2 (Financial Management) score; non-KUD HR Capacity far lower (2.62)
KUD Institutional Dynamics	KUDs play a key role in ISPO certification and FFB quality development, but some farmer groups are passive without external stimulus	KUD members significantly superior on all indicators ($p < 0.001$)
Access to Digital Technology	Adoption varies: WhatsApp for FFB prices, e-commerce for processed products, POM e-traceability; however, signal coverage and digital literacy are constraints in remote areas	Strong correlation between HR Capacity and Technology/ISPO Adoption ($r = 0.748$)
Rural Economic Impact	PADes up ~35% from oil palm-based BUMDes, business diversification empowers women, ~15% savings in operating costs	HR Capacity strongly correlated with Village Economic Index ($r = 0.777$)

DISCUSSION

The integration of quantitative and qualitative findings in this study confirms that HR capacity among independent oil palm smallholders in Riau Province is a central determinant of the success of oil palm agribusiness-based rural economic development, in line with the human capital theoretical framework that positions investment in human competence as the foundation of economic productivity (Rist et al., 2010; Subagyo et al., 2020). The finding that HR Capacity is very strongly correlated with FFB Productivity ($r = 0.796$) strengthens earlier empirical evidence on the crucial role of agronomic training and managerial competence in closing the productivity gap between independent smallholders and corporate plantations (Woittiez et al., 2017; Euler et al., 2017; Slingerland et al., 2019).

Another important finding of this study, however, is that the influence of HR Capacity on household income is indirect and is channeled primarily through increased farm productivity—a mediation pattern that is theoretically consistent with the economic base model at the micro-household level: increased competence produces increased physical output (productivity), which is then converted into economic value (income) through market mechanisms (Gatto et al., 2017; Rifin et al., 2020). This pattern carries an important policy implication: farmer HR capacity-building programs need to be explicitly designed to deliver real productivity improvements in the field, rather than merely transferring knowledge that is not followed by changes in cultivation practices.

By contrast, the more direct influence of HR

Capacity on the Rural Economic Development Index—without significant mediation by productivity—indicates that the institutional and managerial dimensions of HR capacity (X2 and X3) have their own pathway of influence on strengthening the village economy that does not depend entirely on increases in physical harvest yields. The qualitative findings support this interpretation: farmers' contributions to BUMDes, PADes, and household business diversification (such as palm chip enterprises) are driven more by managerial-institutional competence and entrepreneurial initiative than by FFB production volume alone. This is consistent with the arguments of Raharjo et al. (2021) and Budiono et al. (2022) that agriculture-based rural economic transformation requires multidimensional strengthening of human capital, not limited to the technical aspects of production.

The role of KUD institutions as a significant differentiating factor across all indicators in this study reinforces the central thesis of the agricultural institutions literature that social capital and collective institutions are prerequisites for optimizing the economic benefits to independent smallholders (Naim et al., 2021; Jelsma et al., 2019; Dharmawan et al., 2021). The sharp gap between KUD member and non-member farmers—in HR Capacity (4.07 vs. 2.62), Productivity (28.02 vs. 23.85 tons/ha/year), and the Village Economic Index (3.19 vs. 1.95)—confirms that farmer institutions are not merely administrative vehicles but social infrastructure that substantially shapes the trajectory of capacity development and farmers' economic welfare. This

finding is in line with the thesis of Ros-Tonen et al. (2019) on the importance of institutional inclusion for smallholders in sustainable oil palm supply chains, and it reinforces the concerns of McCarthy (2010) and Obidzinski et al. (2012) that, without inclusive institutions, the economic benefits of oil palm expansion risk being concentrated among farmers with superior access to capital and knowledge, while non-members are left behind in informal relationships with middlemen that tend to be exploitative.

The finding that farming experience was not significantly correlated with HR Capacity ($r = 0.011$), while formal education was correlated, albeit weakly ($r = 0.281$), adds important nuance to the debate on the sources of human capital accumulation in traditional agriculture. This finding indicates that “learning by doing” alone is insufficient to build adequate HR capacity in modern agribusiness contexts that demand sustainability standards (ISPO/RSPO) and managerial and digital literacy; structured external interventions in the form of formal training, extension support, and education are needed, in line with the argument of Nurfatriani et al. (2019) on the importance of optimizing BPDPKS funds for systematic farmer capacity building, and with the recommendation of Nugroho et al. (2021) to strengthen the ratio and quality of agricultural extension.

The absence of significant differences across regencies on all study indicators has important methodological and policy implications. First, methodologically, the findings of this study have relatively strong generalizability to independent oil palm smallholders in the main production areas of Riau in general. Second, in terms of policy, it indicates that the challenges of HR capacity development are structural and systemic at the provincial level, and therefore require coordinated policy interventions at the level of Riau Province—for example, through the BPDPKS scheme and generally applicable FFB trading policies—rather than programs specific to a single regency.

Regarding the limitations of the study, it should be noted that the high correlation between HR Capacity and Productivity ($r = 0.796$) may cause multicollinearity in the multiple regression models used to test mediation, so coefficient estimates in some models should be interpreted with caution and further confirmed through Structural Equation Modeling (SEM) with larger samples and richer formative-reflective indicators in future research. In addition, the cross-sectional nature of the data limits definitive causal claims; longitudinal or experimental designs (for example,

evaluations of BPDPKS training program interventions) would strengthen the internal validity of causal findings in the future.

Conclusions and Recommendations

Conclusions

Based on the mixed-methods analysis of 300 farm households and 12 key informants in three major oil palm regencies of Riau Province, this study draws several main conclusions. First, the HR capacity of independent oil palm smallholders in Riau Province falls in the high category (mean = 3.71 on a 1–5 scale), with the Institutional Partnership dimension being the strongest and the Financial Management dimension the weakest. Second, HR Capacity is very strongly correlated with FFB Productivity ($r = 0.796$) and the Rural Economic Development Index ($r = 0.777$); its influence on household income is channeled primarily through increased productivity (strong mediation), whereas its influence on the broader dimensions of the village economy is more direct. Third, membership in a farmer institution (KUD) proved to be a highly significant differentiating factor across all indicators of HR capacity and economic outcomes, confirming the central role of institutions as social infrastructure for farmer HR development. Fourth, there were no significant differences across regencies, indicating that the identified challenges and dynamics are structural at the regional level of Riau Province. Fifth, the qualitative findings confirm that strengthening farmer HR capacity has tangible impacts on strengthening BUMDes, increasing Village Original Income, diversifying businesses in ways that empower rural women, and improving farm operating cost efficiency, although challenges remain in the digital divide, the uneven extension ratio, and the validation of data on beneficiaries of government programs.

Recommendations

Based on these findings, this study recommends several strategic steps. The Riau Provincial Government and the Plantation Office should strengthen training programs specifically in farm financial management, given that this dimension is the main weakness of farmer HR capacity, and should increase the ratio of agricultural extension workers to the number of villages served. The Oil Palm Plantation Fund Management Agency (BPDPKS) should improve its system for validating data on farmer beneficiaries of HR development programs so that benefits are better targeted and more evenly distributed, including to non-KUD-member farmers, who have so far been left behind. KUD managers and farmer groups should revitalize institutional governance to make it more

transparent and participatory in order to increase the trust and interest of farmers who remain reluctant to join because of poor past institutional experiences. Village governments can replicate more widely, with adaptation to local context, the oil palm-based BUMDes model that has been shown to significantly increase PADes, as found in Kampar Regency. Future researchers are advised to use Structural Equation Modeling (SEM) with larger samples to confirm the mediation model more precisely, as well as longitudinal research designs to strengthen causal claims between HR capacity investment and rural economic development outcomes over the long term.

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