Towards sustainable agriculture: Unveiling the nexus of social capital and knowledge management to supports environmentally friendly agriculture

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Abstract. The agricultural sector's progress, driven by rural farmer groups, is pivotal for national advancement. In Bukit Batu District, Bengkalis Regency, a farmer group holds the potential to emerge as a center for superior agricultural and industrial endeavors. This research assesses Community Social Capital and Knowledge Management Capability as strategies to enhance the competitiveness of farmer groups in Sungai Pakning. Utilizing Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach and a sample of 44 respondents, the study illuminates the current conditions of these factors. It emphasizes the paramount role of community-based social capital and knowledge management in fortifying the competitiveness of farmer groups. The proposed collaborative integration model not only aims to empower farmer groups but also addresses environmental, terrestrial, and energy issues by promoting sustainable agricultural practices. This multifaceted approach positions the farmer groups in Sungai Pakning not only for economic prosperity but also as stewards of the environment, contributing to a sustainable and resilient agricultural landscape.

1 Introduction

Achieving sustainable environmentally based agricultural development which aims to support national progress can start at the rural farmer level, including agricultural businesses managed by farmer groups [1, 2]. One of them is a farmer group in Bukit Batu. Bukit Batu sub-district area is considered suitable for the establishment of agricultural industrial and trade areas and is identified as one of the water trade routes in district and city industrial areas. The vast coastline of Bukit Batu which is located along the Bengkalis Strait and Malacca Strait also contributes to this potential. This sub-district consists of 1 sub-district and 9 sub-districts. The village of Sungai Pakning serves as the city center and administrative capital of the sub-district. It holds a strategic position for development as an exclusive area,

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focusing on superior industrial and agricultural activities that can compete effectively within Bengkalis Regency.

The importance of sustainable agricultural practices is a major highlight in this research. In accordance with Grimm and Diugwu, strategies for developing the competitiveness of farmer groups are associated with increasing individual capabilities and community-based collaboration [3, 4]. Bagagiolo et al., emphasized that knowledge management capabilities and community social capital are key focuses, with the assumption that effective knowledge management is driven by strong social capital [5, 6]. Internal resources of farmer groups, such as the involvement of the private sector, especially Pertamina in Sungai Pakning, provide significant encouragement, both in the form of capital and training, which strengthens the institutional capacity of farmer groups. Teece [7] suggests that all economic activities must build a process of entrepreneurial action based on knowledge resources to achieve sustainable competitiveness.

In the context of knowledge management, the capability of knowledge management relies on community-based social capital. Strong social capital creates an environment conducive to knowledge sharing, collaborative learning, and information exchange among community members [8–11]. When there is a high level of trust, effective cooperation, and positive interdependence among community members, the capability of knowledge management can flourish more effectively. Conversely, knowledge management capabilities can also strengthen community-based social capital [12]. By effectively managing knowledge, a community can enhance its members' abilities to access, utilize, and share relevant knowledge. This can strengthen connections and interdependence among community members, thereby enabling the creation of competitive advantage for the farming groups in Sungai Pakning Bengkalis.

Social capital resources and knowledge management are challenging for competitors to imitate, possessing dynamic attributes [13–15]. It has been proposed by Fatoki [14] and Filser et al. [13] that the farming groups in Sungai Pakning Bengkalis should acquire the capability to generate sustainable competitiveness. Conversely, the current focus of the Indonesian government is on grassroots economics [16]. According to Barney [15], a strategic imperative exists to enhance sustainable competitive advantage, achieved by cultivating resources that are arduous to imitate, irreplaceable, and inherently valuable. This involves developing concepts founded on collaboration among farmers, rooted in community social capital. Collaboration between farmers, private sector support, and implementation of sustainable practices are the keys to achieving economic independence, while contributing to environmental conservation in the region.

This state-of-the-art research refers to the findings of a systematic mapping study [17] on sustainable competitive advantage. Over the last decade, this mapping endeavor involved a thorough examination of prior literature available in reputable publications, particularly within the Scopus database. The selection of articles was based on the investigated topic, categorizing the findings according to the recommendations by Banaeianjahromi & Smolander [18]. The findings indicate that the topic of sustainable competitive advantage primarily focuses on article categories discussing firm resources & capability [18].

The selected topic focuses on the categories of company resources and the ability to create sustainable competitiveness. It is evident that researchers have extensively explored these topics compared to others. The model employed in this study assumes that the bond between entrepreneurs and social network relationships relies on environmental instability. Social capital functions as a driver for the success of business activities due to cooperative values inherent in the concept, particularly in terms of supporting funding sources [19, 20]. Thus, social capital reflects social ties, relationships, and networks [19]. The endeavor to foster sustainable competitiveness is intricately linked with the theoretical framework of entrepreneurial action creation. The endeavor to create sustainable competitiveness is related

to the creation theory of entrepreneurial action [21]. This theory posits that entrepreneurial opportunities are created through the process of learning or knowledge management rather than discovered. This expert opinion serves as the basis for utilizing the resources-based view (RBV) theory [15, 22, 23]. RBV regards internal resources as the catalyst for competitiveness. The antecendent of sustainable competitive advantage can be seen in Table 1.

Table 1. Antecendent of sustainable competitive advantage.

Antecendent	Authors
Competitive Advantage - Sustainable Growth [24-26]	Aaltonen et al. (2015), Takala et al. (2013), Hilmi et al., (2011)
Entrepreneurial Orientation - Sustainable Competitive Advantage [27-32]	Dess & Lumpkin (2005), Hussain et al. (2015), Liu et al. (2011), Mahmood et al. (2013), Martins (2016), Sirivanh et al. (2014).
Firm Performance - Sustainable Competitive Advantage [33-39]	Iraldo et al. (2017), Leal-Rodríguez & Albort-Morant (2016), Tjahjaningsih et al. (2016), Sheehan (2014), Naidoo (2010), Van et al. (2008), Piperopoulos & Scase R (2007).
Firm Resources & Capabilities - Sustainable Competitive Advantage [26, 40-59]	Ajuddin et al. (2017), Valaei (2017), Yunis et al. (2017), Rizos et al. (2016), Samad et al. (2016), Jahanshahi et al. (2015), Krajnakova et al. (2015), Ngah et al. (2015), Widodo, & Shahab M.A (2015), Iturrioz et al. (2015), Cucculelli et al. (2014), Şerbu & Borza (2014), Xie et al. (2013), Eze et al. (2013), Shirokova et al. (2013), Bagheri et al. (2013), Gunasekaran et al. (2011), Campaniaris et al. (2011), Xie et al. (2010), Rodriguez et al. (2010), Hilmi et al. (2010), Gelbmann (2010), Zahra et al. (2009), Rabino et al. (2008), Chen & Hatzakis T (2008), Singh et al. (2007).

Based on research background, the aim of this paper is to evaluate the current condition of Community Social Capital and Knowledge Management Capabilities as a strategy to increase the competitiveness of farmer groups in Sungai Pakning, Bengkalis Regency. Research is also to promote sustainable agricultural practices that can influence environmental issues. Through the application of social capital and knowledge management capabilities, this research encourages environmentally friendly agricultural practices. A focus on community-based social capital can strengthen collaboration for joint understanding and overcoming environmental challenges, such as waste management and biodiversity conservation. The understanding gained through social capital can help farmer groups maintain the balance of terrestrial ecosystems and minimize negative impacts on the land and surrounding ecosystems. Then, the application of knowledge management capabilities can help farmer groups diversify their energy resources, reduce dependence on conventional energy, and optimize energy use efficiently.

2 Methods

The research methodology employed in this study is a descriptive quantitative analysis. The purpose of this approach is to record, process, present, and interpret data to provide a comprehensive understanding of Community Social Capital (X1), Knowledge Management Capability (X2), and Competitiveness (Y) among farmer groups in Sungai Pakning, Bengkalis Regency, Riau Province. The research aims to test hypotheses that establish the relationships between each variable. Two data sources are utilized in this study: primary and secondary data.

Sampling in this research is conducted using the probability sampling technique, a common strategy in quantitative research designed to achieve representativeness [60]. The

probability sampling technique in practice involves "selecting a relatively large number of units from the population, or from specific sub-groups of the population, in a random manner where the probability of inclusion for every member of the population is determinable." The determination of the sample size utilizes the Slovin formula [61].

$$n = \frac{N}{1+Nd^2} = \frac{80}{1+(80)(0{,}10)^2} = 44{,}4 \quad (1)$$

The above calculations can be explained as follows. Based on data from Sungai Pakning Subdistrict in the year 2023, it is known that the total population (N) is 80. With a confidence level of 90%, the margin of error (d) is determined to be 10% or 0.01. The result indicates that the sample size (n) is 44.4, which is rounded up to 44 samples. Subsequently, data analysis is performed using Structural Equation Modeling (SEM), characterized as a technique that emphasizes confirmation rather than explanation [62]. The gathered data are then analyzed using the Partial Least Squares (PLS) model with the assistance of SmartPLS Version 3 computer software [63]. Researchers can specify the modeling structure based on existing theories and examine whether there is empirical support for the formation of the model. According to Suharjo [62], the PLS analysis involves three stages, as follows:

2.1 Outer model

The outer model analysis is conducted to ensure that the measurements used are suitable for validation and reliability. This analysis can be observed through several indicators:

a. Convergent Validity: Convergent validity is assessed by examining the loading factor values of latent variables with their respective indicators. The expected value is >0.6.
b. The expected Average Variance Extracted (AVE) value is >0.5.
c. Cronbach Alpha: The reliability assessment is reinforced through Cronbach's Alpha, aiming for an anticipated value exceeding 0.6 for each variable.

2.2 Inner model

On the other hand, inner model analysis/structural model analysis is performed to ensure the robustness and accuracy of the constructed structural model. The evaluation of the inner model includes several indicators:

a. The Value of Determination (R^2)
b. *Predictive Relevance* (Q^2); to calculate Predictive Relevance (Q^2), the formula used is:

$$Q^2 = 1-(1-R_1^2)\times(1-R_2^2)\times(1-R_n^2) \quad (2)$$

c. *Goodness of Fit Index* (GoF); The GoF value in SEM PLS is manually calculated using the formula:

$$\text{GoF} = \sqrt{AVE^2} \text{ x } R^2 \quad (3)$$

2.3 Structural model or hypothesis analysis

The analysis of hypotheses involves the scrutiny of probability values and t-statistics. Regarding the p-value, significance is attributed to values below 0.05 at a 5% alpha level. The corresponding t-table value for the 5% alpha level is 1.96. Consequently, the hypothesis is accepted if the t-statistic surpasses the t-table value.

3 Results and discussion

Utilizing SmartPLS calculations, the outcomes encompass evaluations of the outer model, inner model, and hypothesis testing. The assessment of the outer model aims to scrutinize the association between indicators and latent variables at the first-order factor. Concurrently, the inner model evaluation is executed to appraise relationships among first-order factors and to gauge the impact among latent variables at the first-order factor level [64]. In the outer model evaluation, there are three latent variables, namely Community Social Capital, Knowledge Management Capability and **C**ompetitiveness with 40 indicators. Ghozali [64] explains that indicators are considered reliable if they have correlation values above 0.70. However, in developmental research, loading factors between 0.50 and 0.60 are still acceptable. Negative values should be excluded from the model as they can lead to unreliable output.

The initial phase involves the evaluation of the outer model, encompassing the analysis of three key criteria: convergent validity, discriminant validity, and composite reliability. Convergent validity assessment entails the examination of loading factor values' reliability, reflecting the strength of the association between first-order constructs and their respective indicators. Indicators with loading factors exceeding 0.50 are deemed reliable, indicating a robust reflection of first-order latent variables. Subsequently, discriminant validity is gauged by comparing the square root of Average Variance Extracted (AVE). According to Ghozali [64], for tested constructs to exhibit validity, AVE values should surpass 0.50. Composite reliability values are then computed to assess the stability and internal consistency of indicators. An outer model is deemed to possess stability and internal consistency if the composite reliability exceeds 0.6 ($\rho c > 0.6$). The outcomes of the PLS analysis reveal that the composite reliability (ρc) values for all outer models surpass 0.6 [64]. The outer model criteria can be seen in Table 2.

Table 2. The outer model criteria.

Variables	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Community Social Capital	0.693	0.793	0.554
Knowledge Management Capability	0.698	0.803	0.539
Competitiveness	0.850	0.889	0.575

The second phase entails the assessment of the inner model to ensure the resilience and precision of the constructed structural model. The evaluation of the inner model encompasses various criteria, including the coefficient of determination (R^2), Predictive Relevance (Q^2), and Goodness of Fit Index (GoF). The computations for each indicator are delineated below. The R^2 is derived from the outcomes of the PLS Algorithms in SmartPLS, where R^2 values of 0.67 (strong), 0.33 (moderate), and below 0.19 (weak) are considered. The R^2 results for the organizational agility construct are 0.203, and for Competitiveness, it is 0.195, signifying a moderate correlation between the constructs.

Predictive Relevance (Q^2) in the structural model (inner model) assesses the model's efficacy in generating observed values based on parameter estimates. As per Chin, a Q^2 value of 0.02 suggests minimal predictive capability, 0.15 indicates moderate predictive capability, and 0.35 signifies substantial predictive capability. The calculation of Q^2 involves utilizing the formula below:

$$Q^2 = 1 - (1 - 0.20^2) \times (1 - 0.19^2)$$
$$Q^2 = 0.07 \quad (4)$$

The next step is calculating the GoF to assess how accurately the regression sample estimates actual values and to evaluate the suitability of the proposed model. The GoF is obtained by multiplying the squared AVE by R^2, with the formula:

$$AVE = \frac{\sum \lambda_i^2}{\lambda_i^2 + \sum_i var(\varepsilon_i)} \quad (5)$$
$$AVE = 0.56$$

Here, λ_i denotes the loading component to the indicator, and $var\ (\varepsilon_i) = 1 - \lambda_i^2$. In SEM-PLS, the Goodness of Fit (GoF) value is manually calculated.

$$GoF = \sqrt{AVE^2 x R^2}$$
$$GoF = \sqrt{0.31^2 x\ 0.20} \quad (6)$$
$$GoF = 0.25$$

GoF value falls within the range of 0-0.25 for a small GoF, 0.25-0.36 for a moderate GoF, and >0.36 for a large GoF [65]. In our case, the calculated GoF value, scoring 0.25, suggests a moderate GoF, indicating that the formulated model effectively represents the observed phenomenon. The evaluation of R^2, Q^2, and GoF underscores the model's robustness and accuracy, laying the groundwork for hypothesis testing. Moving forward, the SEM-PLS output is subjected to hypothesis testing via the bootstrapping process, yielding t-values. A t-value exceeding the critical t-statistic with a 95% confidence level (>1.96) deems the hypotheses in this study as significant. Figure 1 displays the bootstrapping results obtained from the SmartPLS software.

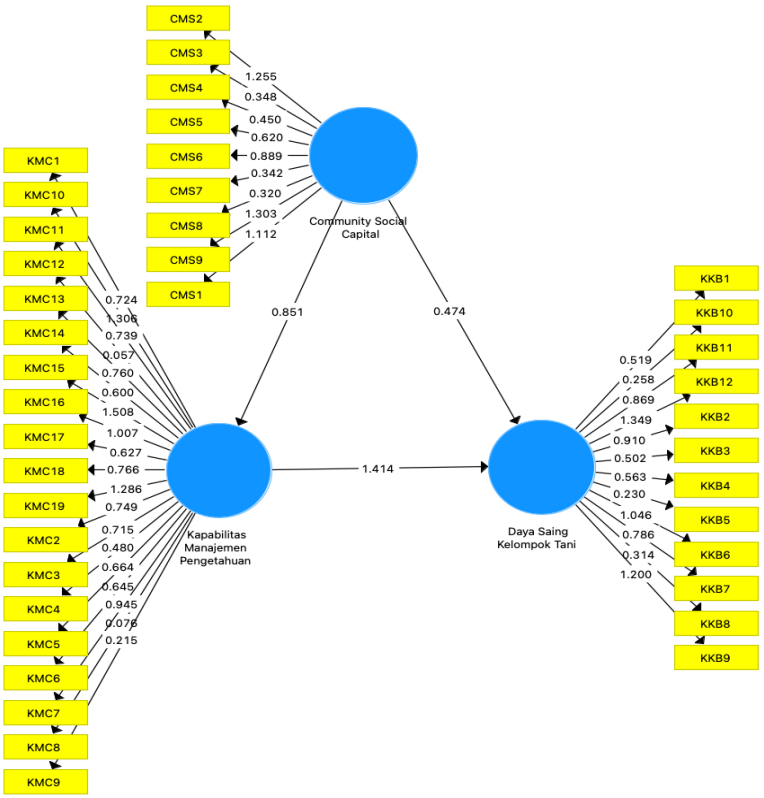

Fig. 1. Bootstrapping output.

The bootstrapping results reveal three effects among variables Community Social Capital, Knowledge Management Capability, and Competitiveness Firstly, the path coefficient value indicating the impact of Community Social Capital on Knowledge Management Capability is 0.851, surpassing the standard path coefficient of 0.5. Path coefficient values, ranging between 1 and -1, signify the strength of a relationship, with values closer to 1 indicating a more robust connection [66]. This result signifies a significant influence of the Community Social Capital variable on Knowledge Management Capability. Secondly, the path coefficient value for the impact of the Community Social Capital variable on Competitiveness is 0.474, falling below the standard path coefficient value. This suggests that Community Social Capital does not exert a significant influence on the Competitiveness of Farmer Groups. Lastly, the path coefficient value reflecting the impact of Knowledge Management Capability on Competitiveness is 1.414, exceeding the standard path coefficient value. This indicates a significant influence of the Knowledge Management Capability variable on the Competitiveness of Farmer Groups.

The results highlight that the two hypotheses show path coefficients exceeding 0.5 and approaching 1, indicating a large positive influence. In contrast, one hypothesis presents a path coefficient below 0.5, indicating that the path coefficient is not significant. The following discussion will explore the theoretical implications, providing interpretations that align the theoretical framework with the findings of the hypotheses.

3.1 The influence of community social capital on knowledge management capability

The variable of Community Social Capital serves as a direct influencer on both knowledge management capability and competitiveness. This discovery aligns with the viewpoints presented by Andriani [19]. Social capital, in this context, is defined as the process of cultivating trusting relationships, fostering mutual understanding, gaining access to resources, and engaging in shared actions that unite individuals, communities, and institutions. This definition corresponds with Putnam's [67] conception of social capital, which identifies it as a feature of social organizations, encompassing networks, norms, and social trust. This characteristic facilitates coordination and cooperation for mutual benefit. In the realm of farmer group activities, social capital emerges as a catalyst for business success, embodying cooperative values that extend to supporting external financial resources and fostering collaborative business endeavors [67].

Research results from Putnam [67], Matthews & Marzec [68] and Gelderen [69] show conformity or confirmatory research with the ideas of Andriani [19] ideas regarding the concept of social capital owned by entrepreneurs for the development of sustainability and environmentally friendly agricultural businesses [67–69]. Andriani [19] concludes that social capital is divided into three grassroots collaborations: bonding social capital, bridging social capital and linking social capital. Based on data collection and field observations, most farmer groups have strong familial ties that build bonds for competitiveness improvement. Farmer groups have relatives who provide information related to business capital, training, empowerment, and financial resources, indicating a quality relationship that positively influences their endeavors. Family ties within the farmer groups in Sungai Pakning sub-district are well-established, with community awareness that social relationships are significant for family ties and ease of accessing resources. This aligns with Gelderen's [69] research, stating that a company's social capital can be utilized to obtain resources such as information, financial capital, colleagues, and mutually beneficial ties between the company and the external community [69, 70]. Based on the social capital theory proposed by Coleman [70].

Social capital influences well-being through the development of social bonding, social bridging, and social linking capital. In the context of grassroots collaboration, social capital is considered a framework for input, process output to generate a collaborative system, both internally and externally. Alongside resources being a crucial element for business success, the collaboration concept must be able to integrate all stakeholders and existing resources. This is evident in the community built by farmer groups with CSR from the private sector, ensuring that access to capital, training, and empowerment provided to farmer groups is distributed evenly. Respondents also expressed awareness that having strong bonds and good relationships between farmer groups, aligned with the grassroots collaboration concept, facilitates access to information about training, business capital, and empowerment. This is also attributed to the involvement of the private sector, particularly Pertamina International Refinery II Sungai Pakning, which actively provides guidance to the community, especially farmer groups, fostering strong ties among farmer groups.

The research implications show the urgency of better policy support to encourage sustainable agricultural practices. Policies that support training, access to resources, and the adoption of environmentally friendly technology can provide encouragement to increase the sustainability of farmers' businesses. In this research, farmer groups function as local empowerment agents. By forming strong ties with local communities, they can strengthen social capital and integrate sustainable farming practices into people's daily lives. Education and raising awareness regarding environmental and energy issues is also an important part of this role.

3.2 The influence of community social capital on competitiveness

The competitiveness variable refers to the theory of sustainable competitive advantage which is rooted in the Resource Based View (RBV). RBV refers to a company's internal environment as a driver of sustainable competitive advantage and considers company resources as the main key to competition. The initial stages of RBV development involve strategic thinking, with a focus on internal factors of the company [71]. Ansoff [72] made important contributions to the early stages of RBV.

Researchers in the Resource-Based View (RBV) argue that resources play a crucial role and should be regarded as the foundation for the emergence of competitiveness within a company [15]. Key competencies [73], unique competencies [74], and strategic assets [75] are identified as the primary resources that form a robust basis for competitiveness. Strategic assets encompass a set of resources that are challenging to trade and imitate, possessing characteristics such as rarity, precision, and specialization, thereby conferring a competitive advantage to the company. Business strategy serves to manipulate resources effectively, thereby creating a Competitive Advantage. Key competencies are resources that are distinctive, rare, and valuable, making them resistant to imitation, replacement, or reproduction by competitors [15, 73]. Unique competencies encompass everything that enables a business to thrive in the market [74].

Community Social Capital has a path coefficient value below 0.5 and is proven to have no significant influence on the competitiveness of farmer groups. Based on the percentage of influence, the given value is 47.4%. Despite being below the significance standard, Community Social Capital still influences competitiveness. This is evidenced by the research findings that well-established Community Social Capital within farmer groups in Sungai Pakning contributes to the development of these groups and enhances their business and competitiveness. With effective Community Social Capital, farmer groups share information related to business development, funding, and various challenges faced by the groups. Consequently, issues encountered by one farmer group become learning opportunities for

others, enhancing the overall competitiveness of farmer groups and contributing to the well-being of the community and local economy.

Although the research results show that the influence of Community Social Capital on **C**ompetitiveness is not significant, the involvement of farmers in close social relationships can have positive implications for environmental issues. Strong social capital can support the exchange of information regarding more environmentally friendly agricultural practices, including the use of renewable energy of natural resources. With a good social network, farmer groups can jointly take initiatives to reduce negative impacts on the environment and increase the sustainability of their business. Based on the research results, farmer groups are in an integrated position, utilizing social capital to gain knowledge about environmentally friendly agricultural practices. With the active involvement of group members, information regarding waste management, use of organic fertilizer, and other sustainable agricultural practices can be effectively implemented.

3.3 The influence of knowledge management capability to supports environmentally friendly agriculture

Capability, as understood by several researchers, refers to the ability of members of farmer groups to perform tasks or activities in a coordinated manner to achieve the company's goals [76–78]. Grant [79] suggests that capabilities consist of individual and team or interdepartmental capabilities. According to Schienstock [80] a company's capabilities allow it to effectively solve its main problems. To formulate the concept of knowledge management capability, it is essential to lay a solid conceptual groundwork. Knowledge management capability is defined as the capacity and opportunities of each member within farmer groups in Sungai Pakning to act in alignment with collective interests or, alternatively, based on individual interests [80]. It was found that Knowledge Management Capabilities have a significant impact on the competitiveness of farmer groups, indicating that informed decision-making supports environmentally friendly agriculture.

The involvement of the private sector, particularly Pertamina Refinery II Sungai Pakning, which provides guidance, training, and empowerment to farmer groups, along with grants in the form of initial capital, strengthens the institutional capacity of farmer groups. Regular CSR initiatives provide initial capital (for newly joined farmer groups) and additional capital in the following years. Farmer groups are also regularly provided with training related to improving soft skills that support business management, such as computer training for financial reporting and budget usage, complete with facilities (computers and printers). Consequently, groups understand the use of technology, which is beneficial for administrative management and serves as a gateway for farmer groups to seek investors or additional funding from banks. This not only aids in administrative management but also provides an avenue for farmer groups to present their value proposition to investors or secure additional capital from financial institutions.

In the context of energy and environmental issues, understanding and implementation of efficient and sustainable agricultural practices can be improved through good knowledge management. Information regarding environmentally friendly agricultural technology, use of renewable energy resources, and sustainable land management strategies can be integrated into daily agricultural practices. Thus, improving knowledge management capabilities can make a positive contribution to business and environmental sustainability. To improve sustainability in the agricultural sector, educational approaches and increasing awareness regarding environmental and energy issues need to be emphasized. Training and education programs can provide farmers with information and skills to adopt more sustainable farming practices. This research proves that farmer groups play a central role in the sustainability of agricultural businesses. By leveraging communities' social capital, they can build strong

cooperation, share knowledge, and support resource exchange. Strengthening knowledge management capabilities helps in operational efficiency and decision making that supports economic sustainability. In the perspective of ecosystem balance, farmer groups play a key role in maintaining environmental sustainability. They are responsible for understanding and implementing agricultural practices that support biodiversity and ecosystem balance. Through the use of sustainable farming methods, farmer groups contribute to the conservation of local flora and fauna.

4 Conclusion

This research unveils the complexity of the relationship between Community Social Capital, Knowledge Management Capability, and Sustainable Competitive Advantage in the context of farmer groups in Sungai Pakning, Bengkalis Regency. Community Social Capital, which includes strong family ties and external cooperation, turns out to have a significant impact on the development of farmer groups and plays a role in supporting environmentally friendly agricultural practices. The concept of social capital with elements of bonding, bridging and linking is the basis for collaboration that integrates internal and external resources to achieve economic and environmental sustainability. Although its impact on Sustainable Competitive Advantage is not statistically proven, it shows that there are other factors that also contribute to increasing the competitiveness of farmer groups, including involvement in environmental and energy issues.

In this context, this research emphasizes the important role of Knowledge Management Capabilities in supporting environmentally friendly and sustainable agriculture. Assistance in optimal and informed decision making in implementing sustainable agricultural practices, integrating terrestrial aspects, and supporting the sustainability of terrestrial ecosystems. The involvement of the private sector, especially the Pertamina II Sungai Pakning Refinery, in providing guidance, training and empowerment to farmer groups, as well as grants in the form of initial capital, strengthens the institutional capacity of farmer groups. This makes a positive contribution to its competitiveness and sustainability, in line with efforts to overcome environmental problems such as waste management and the use of renewable energy.

The implications of this research indicate the need for better policy support to encourage sustainable agricultural practices that have a positive impact on environmental, energy, terrestrial and overall sustainability issues. Training, access to resources, and the application of environmentally friendly technology need to be prioritized in policies to increase the sustainability of farmers' businesses while responding to global environmental challenges. Farmer groups as local empowerment agents can not only strengthen social capital and competitiveness but also play an active role in maintaining the balance of terrestrial ecosystems, managing energy efficiently, and providing solutions to local environmental problems. Awareness of these issues, through education and awareness-raising programs, is critical in establishing deeper understanding among farming communities.

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