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Partnership Model Based on the Utilization of Oil Palm Empty Fruit Bunches for Straw Mushroom and Compost Production

Sarono[1], Sri Astuti[2], Supriyanto[3], Bayu Murti[4]

[1]Department of Agricultural Technology, Politeknik Negeri Lampung, Bandar Lampung, Indonesia
[2]Department of Economics and Business, Politeknik Negeri Lampung, Bandar Lampung, Indonesia
[3] Department of Plantation Crop Cultivation, Politeknik Negeri Lampung, Bandar Lampung, Indonesia
[4]P4S Bumi Alam Purba, East Lampung Regency, Indonesia

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ABSTRACT

The palm oil industry generates a large amount of oil palm empty fruit bunches (EFB), which remain underutilized and pose potential environmental problems. On the other hand, EFB has lignocellulosic characteristics that make it suitable for use as a growing medium for straw mushrooms and as a raw material for compost production. This study aims to develop a partnership model based on technological implementation for utilizing EFB as a substrate for straw mushroom cultivation and compost production. The research employed a mixed-methods approach combining qualitative and quantitative analyses. SWOT analysis was used to identify internal and external factors, the Analytical Hierarchy Process (AHP) was applied to determine strategic priorities. The results indicate that the core actors in the partnership include the government, palm oil mills, and small and medium enterprises engaged in mushroom and compost production. The IFE score of 3.38 and EFE score of 3.53 place the partnership in an aggressive *grow and build* position. Priority strategies include scaling up EFB-based straw mushroom production, developing compost processing units from spent mushroom substrate, and strengthening upstream–downstream integration between palm oil mills and SMEs.

Keywords: compost, model, oil palm empty fruit bunches, partnership, straw mushroom

INTRODUCTION

The palm oil industry is one of the strategic sectors in the Indonesian economy, contributing significantly to foreign exchange earnings, employment generation, and rural development. The export value of Indonesia's palm oil products exceeds USD 45 billion per year, making it the largest contributor to non-oil and gas foreign exchange earnings (Muhammad Retdhito, 2026). In addition, the industry employs approximately 16–20 million people, both directly and indirectly (Obidzinski et al., 2012). In terms of rural development, around 40–45% of oil palm plantations are managed by smallholders, contributing to increased household income, infrastructure development, and poverty reduction in rural areas (Okarda et al., 2024).

Indonesia is recorded as the largest producer of palm oil in the world, with crude palm oil (CPO) production exceeding 45 million tons per year (Yaro et al., 2022). However, the high production volume is directly proportional to the increase in waste generated from

*Corresponding author:
Email: sarono@polinela.ac.id

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the processing of fresh fruit bunches (FFB), particularly oil palm empty fruit bunches (EFB), which account for approximately 23–25% of the weight of processed FFB (Nabila et al., 2023).

The accumulation of EFB that has not been optimally managed leads to various environmental problems, including increased greenhouse gas emissions, soil and water pollution, and social conflicts around palm oil mills (POM)) (Febriani, 2025). In fact, based on its chemical and biological characteristics, EFB contains high levels of lignocellulosic compounds (cellulose, hemicellulose, and lignin), making it highly potential to be converted into value-added products through biotechnology and circular economy approaches (Liu et al., 2023).

Various studies have shown that EFB can be utilized as raw material for organic fertilizer, soil conditioners, and as a cultivation substrate for edible mushrooms, particularly straw mushrooms (Volvariella volvacea). Straw mushrooms have advantages as a source of plant-based protein, dietary fiber, inerals, and low fat, thereby having the potential to support food security and improve community nutrition (Merdivan & Lindequist, 2017); (Sarono et al., 2023). The utilization of EFB as a substrate for straw mushroom cultivation not only increases the economic value of waste but also creates an environmentally friendly food production system based on local resources (Febriani, 2025).

Straw mushrooms (Volvariella volvacea) grow optimally under warm, humid conditions and in environments rich in organic matter. The ideal temperature ranges from 30–35°C with relative humidity of 70–90%, and the growing medium should be moist but not waterlogged (Li et al., 2021). The substrate should consist of fermented organic materials such as rice straw or oil palm empty fruit bunches, with a neutral to slightly alkaline pH (approximately 6.5–7.5) (El-Ramady et al., 2022). In addition, straw mushroom growth requires good air circulation to ensure adequate oxygen supply, as well as low or indirect light to stimulate fruiting body formation. These conditions are commonly found in tropical lowland areas, making them highly suitable for optimal straw mushroom cultivation (Jacob et al., 2025).

Although the technological potential has been widely studied, the implementation of EFB utilization at an economic scale still faces several constraints, including weak partnership institutions between palm oil mills and small and medium enterprises (SMEs), limited access to technology and financing, and the absence of regulations that explicitly encourage cross-actor collaboration in palm oil waste management. As a result, most palm oil mills still prefer conventional management of EFB for internal needs or simply accumulate it in the mill area (Ali Azizan et al., 2022).

In the context of national development, the implementation of the Free Nutritious Meals Program (FNMP) = *Program Makan Bergizi Gratis (MBG)* in Indonesia is aligned with several regulatory frameworks, including Presidential Regulation No. 72 of 2021 on the Acceleration of Stunting Reduction provides a specific policy basis for nutrition interventions, while institutional support is strengthened through Presidential Regulation No. 66 of 2021 on the National Food Agency (Maaruf & Triadi, 2023). This program requires a sustainable, affordable, and easily produced supply of nutritious food at the regional level. Straw mushrooms, as a functional food with a short production cycle, have significant potential to become part of the FNMP supply chain if supported by an appropriate production and partnership model (Kemenkopolkam, 2025).

However, to date, research specifically examining partnership models based on the implementation of EFB

processing technology that integrates the interests of the palm oil industry, waste-processing SMEs, government as regulator, and palm oil mills remains limited. Most previous studies have emphasized technical processing aspects or partial economic analyses, without formulating comprehensive institutional and policy strategies.

Based on this research gap, this study aims to develop a partnership model based on the implementation of technology for the utilization of EFB into food (straw mushrooms) and compost. More specifically, the objective is to determine the key actors, criteria, and strategic aspects in the partnership for utilizing EFB as a substrate for straw mushroom cultivation and compost production.

RESEARCH METHODS

This study employed a mixed methods approach that combines descriptive qualitative methods and quantitative approaches based on multi-criteria decision-making. This approach was selected because the issue of utilizing oil palm empty fruit bunches (EFB) is not only technical in nature but also involves institutional, economic, social, technological, and environmental dimensions that interact with one another. The use of mixed methods enables researchers to obtain a comprehensive understanding of the empirical context while producing structured and evidence-based strategic recommendations (Holub et al., 2025).

Specifically, the Analytical Hierarchy Process (AHP) method was used to determine the priority strategies for developing a partnership model based on the implementation of technology for processing EFB into straw mushrooms and organic fertilizer. AHP was chosen because it can simultaneously accommodate qualitative and quantitative considerations and is effective for decision-making problems involving multiple actors and criteria (Erdil & Erbıyık, 2015).

The research was conducted in Lampung Province, focusing on areas with a high concentration of palm oil mills (POM) and small and medium enterprises (SMEs) producing straw mushrooms using EFB as the cultivation substrate, particularly in Central Lampung Regency and East Lampung Regency. The research object includes the partnership system between POM as producers of EFB waste, SMEs as processors of waste into food products and organic fertilizer, as well as supporting institutions such as local governments, academics, and financial institutions.

This study utilized both primary and secondary data. Primary data were obtained through direct observation of the EFB management process and straw mushroom cultivation using EFB as a substrate, in-depth interviews with key stakeholders, and pairwise comparison questionnaires for AHP analysis completed by experts (expert judgment). Meanwhile, secondary data were obtained from government agency reports, scientific publications, policies related to waste management and sustainable agriculture, as well as relevant literature. The combined use of primary and secondary data aimed to increase the validity and depth of the analysis (Holub et al., 2025).

Respondents in the AHP analysis were determined using the purposive expert sampling method, which involves selecting respondents based on their competence, experience, and direct involvement in palm oil waste management or agro-industrial SME development. The number of expert respondents in this study was 14, in accordance with AHP recommendations that emphasize the quality of judgments rather than the number of respondents (Islam et al., 2025). The expert respondents consisted of 3

representatives from local government (regulators), 3 from palm oil mill management, 3 straw mushroom SME actors, 3 academics/consultants in the agro-industry field, and 2 representative from a financial institution. The stages of the research are presented in Figure 1, with the following explanation.

SWOT analysis was used to identify the strengths, weaknesses, opportunities, and threats in the development of partnerships for the utilization of oil palm empty fruit bunches (EFB). These factors were organized into a SWOT matrix to generate alternative strategies, namely SO, WO, ST, and WT strategies. SWOT analysis was selected because it is effective for formulating strategies based on the internal and external conditions of an organization (Hermiyanto et al., 2025) and (Gurl, 2017).

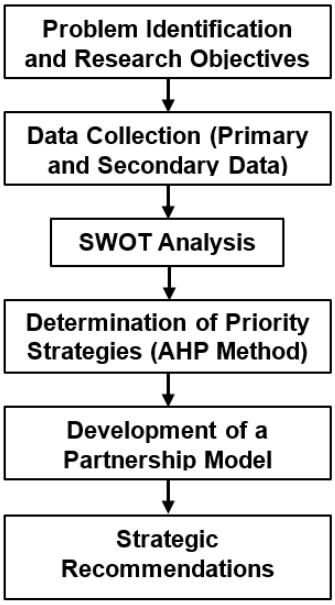


Figure 1.
Stages of Research Implementation

The AHP method was used to determine the priority of strategies generated from the SWOT analysis. The stages of AHP include the development of a hierarchical structure, the preparation of pairwise comparison matrices using a scale of (1–9) in calculating priority weights, and a consistency test using the Consistency Ratio (CR). The matrix is considered consistent if CR ≤ 0.10 (Islam et al., 2025). Kusrini et al., (2022) previously applied the AHP method in formulating policies related to the management of oil palm empty fruit bunches with promising results.

The QSPM method was used to evaluate the relative attractiveness of priority strategies by combining the weights of internal and external factors with the attractiveness score. This method allows researchers to determine the most feasible strategy to be implemented quantitatively (David, F. R., and David, 2017).

This study also employed descriptive qualitative analysis to interpret the social, institutional, and policy contexts influencing the implementation of the partnership model. This analysis was conducted by grouping, comparing, and linking field findings with theories of

circular economy, business partnerships, and public policy. This approach is important to ensure that the resulting strategic recommendations are not only mathematically optimal but also realistic and applicable (Miles et al., 2020).

The results of the SWOT, AHP, and QSPM analyses were synthesized to formulate a partnership model for utilizing EFB as a substrate for straw mushroom cultivation and as raw material for compost. This model illustrates the roles of actors, the flow of waste utilization, cooperation mechanisms, and the integration of strategies within the framework of a circular economy and zero waste (Cities & Pacific, 2021).

RESULTS AND DISCUSSION

Analysis of Key Actors

The results of the study (Table 1) indicate that partnerships in the development of straw mushroom businesses using oil palm empty fruit bunches (EFB) as a cultivation substrate can empirically operate only if they involve three core actors that are indispensable, namely the government, palm oil mills (POM), and SMEs producing straw mushrooms and compost. These three actors have relatively balanced importance weights and cumulatively account for more than 86% of the total importance weight, indicating that the success of the partnership is largely determined by the direct interaction among these actors.

The government ranks first with a weight of 29.03%, confirming its role as a key actor in establishing the institutional framework of the partnership. The government has a strategic function as a regulator, facilitator, and mediator that ensures a balanced relationship between palm oil mills (POM) and SMEs. Several studies emphasize that without government intervention, partnerships between large industries and SMEs tend to be unequal and are at risk of failure due to disparities in bargaining power and uncertainty in resource access (Ali Azizan et al., 2022). In the context of EFB utilization, the government's role is also crucial in ensuring the certainty of raw material supply, preventing conflicts of interest, and opening market access through food policies and national strategic programs such as the Free Nutritious Meals Program (FNMP).

Table 1.
Key Actors in the Partnership for Utilizing EFB as a Cultivation Substrate for Straw Mushrooms and Compost

Key Actors in the Partnership	Weight (%)	Ranking
Government	29.03	1
Palm Oil Mills	28.31	3
EFB-Based Straw Mushroom SMEs	28.82	2
Academics / Consultants	8.73	4
Financial Institutions	5.12	5

EFB-based straw mushroom SMEs rank second with a weight of 28.82% and represent an indispensable actor because they function as the main operators who convert EFB waste into value-added products. The high weight assigned to SMEs indicates that the availability of raw materials and regulations will not generate economic benefits without the technical capacity and business sustainability at the actor level. This finding is consistent with the view of

Kusumawardani et al., 2024), who state that SMEs constitute the core of innovation based on local resources, although their success largely depends on direct and operational institutional support.

Palm Oil Mills (POM) are ranked third with a weight of 28.31% and are still categorized as indispensable actors because they represent the only source of EFB in large and continuous quantities. Without the active involvement of POM, SMEs would not have certainty in raw material supply, and therefore the partnership could not operate effectively. The close weight values between POM and SMEs indicate a relationship of direct interdependence that requires a clear and well-coordinated partnership mechanism. This condition is consistent with the findings of Raya et al. (2021), who argue that value creation within supply chains largely depends on functional relationships among key actors.

In contrast, academics/consultants and financial institutions have relatively lower importance weights, at 8.73% and 5.12%, respectively. These results indicate that both actors are not primary prerequisites for the formation and sustainability of the core partnership. The role of academics is more supportive, particularly in the form of technology transfer, human resource capacity building, and scientific recommendations, but it does not directly determine the sustainability of the partnership. This finding is consistent with critiques of the Triple Helix implementation in developing countries, which state that the role of academics is often indirect and limited to advisory functions (Schocair et al., 2023).

Similarly, although financial institutions play a role in accelerating business scale, they are not decisive actors because SMEs can still operate on a limited scale through internal capital, raw material partnerships, or government support. Several studies indicate that access to formal financing is not the primary determinant of SME success but rather a reinforcing factor once production and market systems have been established (Beck & Demirguc-Kunt, 2006).

Therefore, the results of this study emphasize that the design of partnership models for the development of straw mushroom cultivation using EFB as a substrate should focus on strengthening the structural relationship among the government, POM, and SMEs. Meanwhile, the involvement of academics and financial institutions should be positioned as supporting actors. This approach results in a partnership model that is simpler, more realistic, and easier to replicate, particularly in oil palm-producing regions that have limited access to financial institutions and academic support.

Identification of Internal Factors Determining Partnership Success

Before conducting the analysis of partnership development strategies, factors influencing the planned partnership model were first identified, including both internal and external factors. Based on the research results, the key internal factors obtained are presented in Table 2.

From Table 2, the total score of 3.38 indicates a strong internal condition, particularly in terms of raw material availability and partnership commitment. The description of these internal factors is as follows:

(1) **Availability and Continuity of EFB Raw Materials**

The sustainability of the partnership is largely determined by the guaranteed supply of EFB from palm oil mills, both in terms of volume, continuity, and quality. Consistent raw material supply is a primary prerequisite for the stability of straw mushroom and compost production.

(2) **Technological Capacity and Standard Operating Procedures**

Mastery of EFB-based straw mushroom cultivation technology as well as technology for processing spent substrate into quality compost determines the efficiency and success of the business. Standardized and easily replicable SOPs strengthen trust among partners.

Table 2.
IFE (Internal Factor Evaluation) of the Partnership for Utilizing EFB as a Substrate for Straw Mushroom Cultivation and Raw Material for Compost

No	Key Internal Factors	Weight	Rating*	Weighted Score
1	Availability & continuity of EFB raw materials	0.20	4	0.80
2	Technological capacity & SOP for mushroom cultivation and compost production	0.18	3	0.54
3	Quality & competence of human resources	0.17	3	0.51
4	Commitment, trust & communication among partners	0.18	4	0.72
5	Institutional structure & partnership governance	0.15	3	0.45
6	Value chain integration & business management	0.12	3	0.36
Total		**1.00**		**3.38**

IFE Rating Description:
1 = major weakness; 2 = minor weakness; 3 = minor strength; 4 = major strength

(3) **Quality and Competence of Human Resources**

Technical expertise, managerial experience, and entrepreneurial capabilities of mushroom and compost business actors are key internal factors. Competent human resources are able to maintain product quality and adapt to technological innovations.

(4) **Commitment, Trust, and Communication among Partners**

Sustainable partnerships require trust, transparency, and a shared vision among the main actors (POM and SMEs). Effective communication prevents conflicts and strengthens long-term cooperation stability.

(5) **Institutional Structure and Partnership Governance**

A clear institutional structure, business legality, and a proportional division of roles and responsibilities are important internal factors in reducing partnership risks and improving coordination efficiency.

(6) **Value Chain Integration and Business Management**

Upstream–downstream integration among POM, mushroom cultivation units, and compost processing enables the implementation of zero waste and circular economy principles sirkular (Xu et al., 2023). Efficient business management increases economic value added and the competitiveness of the partnership.

Identification of External Factors Determining Partnership Success

Based on the research results, the key external factors identified are presented in Table 3.

From Table 3, the total score of 3.53 indicates that the external

environment is highly supportive, particularly in terms of policy, market conditions, and sustainability demands. The description of these external factors is as follows:

(1) **Government Policies and Support**
Regulations related to oil palm industry waste management, SME development, sustainable agriculture, and the circular economy greatly influence the sustainability of partnerships. Incentives, assistance programs, and supportive environmental regulations become key external factors.

Table 3.
EFE (External Factor Evaluation) of the Partnership for Utilizing EFB as a Substrate for Straw Mushroom Cultivation and Raw Material for Compost

No	Key External Factors	Weight	Rating*	Weighted Score
1	Government policies & support	0.20	4	0.80
2	Market demand for mushrooms & organic compost	0.18	4	0.72
3	Social acceptance & community support	0.15	3	0.45
4	Development of technology & external innovation	0.15	3	0.45
5	Access to financing & investment climate	0.17	3	0.51
6	Global sustainability pressure & standards (ESG)	0.15	4	0.60
Total		**1.00**		**3.53**

EFE Rating Description:
1 = poor response; 2 = below average response; 3 = above average response; 4 = very good response

(2) **Market Conditions and Product Demand**
Market demand for fresh/processed straw mushrooms and environmentally friendly organic compost determines the scale and stability of the partnership. Trends toward healthy food consumption and organic agriculture represent significant external opportunities.

(3) **Social Environment and Community Acceptance**
The level of acceptance of communities surrounding palm oil mills toward the utilization of EFB affects operational continuity. Social support strengthens partnerships, while social resistance can become an external barrier.

(4) **Development of Science and Technology**
Advances in mushroom cultivation technology, composting technology, and innovations in agro-industrial waste management are external factors that influence the efficiency and competitiveness of partnerships, although the sources of innovation often originate outside business actors.

(5) **Access to Financing and Investment Climate**
The availability of financing schemes from banks, financial institutions, and green financing programs significantly determines the sustainability of

partnership development, particularly during the scale-up phase.

(6) **Global Environmental Pressure and Standards**
Global demands for sustainable palm oil industry practices, waste reduction, and the implementation of ESG (Environmental, Social, Governance) principles constitute external factors that encourage palm oil mills to engage in partnerships for productive EFB utilization.

The initial interpretation indicates that an IFE value > 3.0 means the partnership possesses dominant internal strengths. An EFE value > 3.0 indicates that external opportunities are greater than threats. This combination places the partnership in an aggressive strategy (Grow & Build) within the IE Matrix (Table 4).

Table 4.
IE (Internal–External) Matrix of the Partnership for Utilizing EFB as a Substrate for Straw Mushroom Cultivation and Raw Material for Compost

	High EFE (3.0–4.0)	**Medium EFE (2.0–2.99)**	**Low EFE (1.0–1.99)**
High IFE (3.0–4.0)	I (Grow & Build)	II	III
Medium IFE (2.0–2.99)	IV	V	VI
Low IFE (1.0–1.99)	VII	VIII	IX

Table 4 shows that the partnership for utilizing EFB as a substrate for straw mushroom cultivation and as a raw material for compost is positioned in Cell I (Grow and Build Strategy). The strategic implication is to focus on growth, expansion, institutional strengthening, and increasing the scale of business, both in straw mushroom production and compost processing based on the principles of the circular economy and zero waste.

Formulation of Strategies Determining the Success of the Partnership

The formulation of strategies determining the success of the partnership was conducted using the SWOT analysis method. The SWOT matrix can formulate alternative strategies by combining strategic factors of SO (Strengths–Opportunities), ST (Strengths–Threats), WO (Weaknesses–Opportunities), and WT (Weaknesses–Threats) (Dyson, 2004). The formulation of the SWOT matrix strategies can be seen in Table 5.

Based on the SWOT strategy matrix (Table 5), strategies SO1, SO2, and SO3 are considered priority strategies because they utilize the internal strengths of the partnership to optimally capture external opportunities. Meanwhile, strategies WO1, WO2, and WO3 function as internal improvement strategies aimed at strengthening the long-term sustainability of the partnership.

The ST strategy is a strategy that utilizes the internal strengths of an organization to address or overcome existing external threats. This strategy focuses on leveraging the advantages already possessed by the organization to minimize the impact of threats in the external environment. This approach is sometimes referred to as the Maxi–Mini Strategy because it maximizes strengths to minimize threats.

Table 5.
SWOT Strategy Matrix for Formulating Partnership Strategies for Utilizing EFB into Straw Mushrooms and Compost

Internal / External Factors	**Strength (S)**	**Weakness (W)**
Opportunities (O)	**SO Strategy (Aggressive)** (1) SO1: Expansion of straw mushroom production scale based on EFB through partnerships between palm oil mills and SMEs. (2) SO2: Development of compost production units from spent mushroom substrate as an implementation of the circular economy. (3) SO3: Strengthening upstream–downstream integration between palm oil mills as EFB suppliers and SMEs as production operators.	**WO Strategy (Turn-around)** (1) WO1: Improving human resource capacity through technical and managerial training in mushroom cultivation and compost processing. (2) WO2: Standardization of SOPs for straw mushroom cultivation and compost production based on EFB. (3) WO3: Strengthening partnership institutions through certification, mentoring, and government regulatory support.
Threats (T)	**ST Strategy (Diversification)** (1) ST1: Differentiation of straw mushroom and compost products derived from palm oil waste to enhance competitiveness. (2) ST2: Implementation of quality and sustainability standards (GMP and ESG) to address market and regulatory demands. (3) ST3: Strengthening environmentally friendly product branding based on the zero-waste principle of the palm oil industry.	**WT Strategy (Defensive)** (1) WT1: Improvement of financial management in mushroom SMEs and compost units to increase business resilience. (2) WT2: Diversification of markets and products to reduce the risk of demand and price fluctuations. (3) WT3: Strengthening coordination and communication among partners (palm oil mills–SMEs–government) to minimize conflicts and institutional risks.

According to (Hermiyanto et al., 2025), the ST strategy is applied when an organization faces threatening conditions that may hinder its strategy if not addressed by effectively utilizing internal resources. In the context of partnerships in utilizing oil palm empty fruit bunches (EFB) for straw mushroom cultivation and compost production, threats may include competition from other agricultural substrates, changes in environmental regulations, or fluctuations in market demand. The ST strategy is directed toward utilizing advantages in production capacity, cultivation technology, and partnership networks to address these threats—for example by improving product quality, obtaining environmental

certification, or creating strong product differentiation.

The ST strategies that have been formulated (e.g., ST1: Differentiation of mushroom and compost products; ST2: Quality standards and ESG; ST3: Environmental branding) are consistent with the objectives of the ST strategy because all three utilize internal strengths to reduce the negative impacts of external threats and transform threats into competitive opportunities.

Determination of Strategic Priorities

The results of the actor analysis indicate that the most influential actors in realizing the partnership are the government, EFB-based straw mushroom SMEs, and palm oil mill owners (Table 1). Meanwhile, the roles of academics/consultants and financial institutions are relatively limited.

The results of the criteria analysis show that the most important criteria for ensuring that the partnership for utilizing EFB into straw mushrooms and compost operates effectively are the economic and social impact criteria, followed by the environmental sustainability criteria. Meanwhile, the other criteria have equal values, namely technical implementation feasibility, institutional and partnership strengthening, and local government revenue (PAD) (Table 6).

The ST strategy is a strategy that utilizes an organization's internal strengths to address or overcome existing external threats. This strategy focuses on leveraging the organization's existing advantages to minimize the impact of threats in the external environment. This approach is sometimes referred to as the Maxi-Mini Strategy, as it maximizes strengths to minimize threats.

According to (Hermiyanto et al., 2025), the ST strategy is applied when an organization faces threats that may hinder its strategy if not addressed through the effective use of internal resources. In the context of partnerships utilizing empty fruit bunches (EFB) for straw mushroom cultivation and compost production, threats may include competition from alternative agricultural media, changes in environmental regulations, or fluctuations in market demand. The ST strategy is directed toward leveraging production advantages, cultivation technology, and partnership networks to mitigate these threats—for example, by improving product quality, obtaining environmental certifications, or creating strong product differentiation.

The ST strategies you have established (e.g., ST1: Product differentiation of mushrooms and compost; ST2: Quality standards and ESG; ST3: Environmental branding) are aligned with the objectives of the ST strategy, as all three leverage internal strengths to reduce the negative impact of external threats and transform those threats into competitive opportunities.

Determination of Strategy Priorities

The results of the actor analysis show that the actors who play the most significant role in realizing the partnership are the government, SMEs of oil palm empty fruit bunch (EFB)-based straw mushrooms, and entrepreneurs who own palm oil mills (Table 1). Meanwhile, the roles of academics/consultants and financial institutions are relatively minor. The results of the criteria analysis indicate that the most important criteria for ensuring the successful implementation of the partnership in utilizing EFB for straw mushroom cultivation and compost production are the criteria of economic and social impact, followed by the sustainability of environmental aspects. Other criteria have equal values, namely the feasibility of technical implementation, institutional and partnership strengthening, and regional original revenue (PAD) tax (Table 6).

The research results on determining the priority scale of partnership strategies in utilizing EFB as

a growing medium for straw mushrooms and compost can be seen in Table 7. Table 7 shows that, in general, there are three groups of strategy priorities, namely:

(1) **Main Priority (High Weight)**, namely: Expansion of EFB-based straw mushroom production scale, development of compost units from spent mushroom substrate, and upstream–downstream integration between palm oil mills and straw mushroom SMEs. These expansion and integration strategies are aligned with the IE position (grow & build) (Table 4).

Table 6.
Criteria and Priority Weights for the Partnership in Utilizing EFB into Straw Mushrooms and Compost

Code	Criteria	Priority Weight
C1	Economic & Social Impact	35%
C2	Environmental Sustainability	20%
C3	Feasibility of Technical Implementation	15%
C4	Institutional & Partnership Strengthening	15%
C5	Regional Original Revenue (PAD) Tax	15%
	Total	**100%**

Table 7.
Priority Weights of Partnership Strategies in Utilizing EFB into Straw Mushrooms and Compost

Rank	Code	Strategy	Priority Weight (%)
1	SO1	Expansion of EFB-based straw mushroom production scale	11.8
2	SO2	Development of compost units from spent mushroom substrate	10.7
3	SO3	Upstream–downstream integration between palm oil mills and straw mushroom SMEs	9.8
4	WO1	Improvement of human resource capacity	9.1
5	ST2	Implementation of GMP & ESG standards	8.5
6	WO2	Standardization of cultivation and compost SOPs	7.9
7	ST1	Differentiation of mushroom and compost products	7.4
8	WO3	Strengthening institutional aspects and certification	7.0
9	ST3	Environmentally friendly product branding	6.6
10	WT1	Improvement of financial management	6.0
11	WT2	Market and product diversification	5.4
12	WT3	Improvement of coordination among partners	4.8
		Total	**100.0**

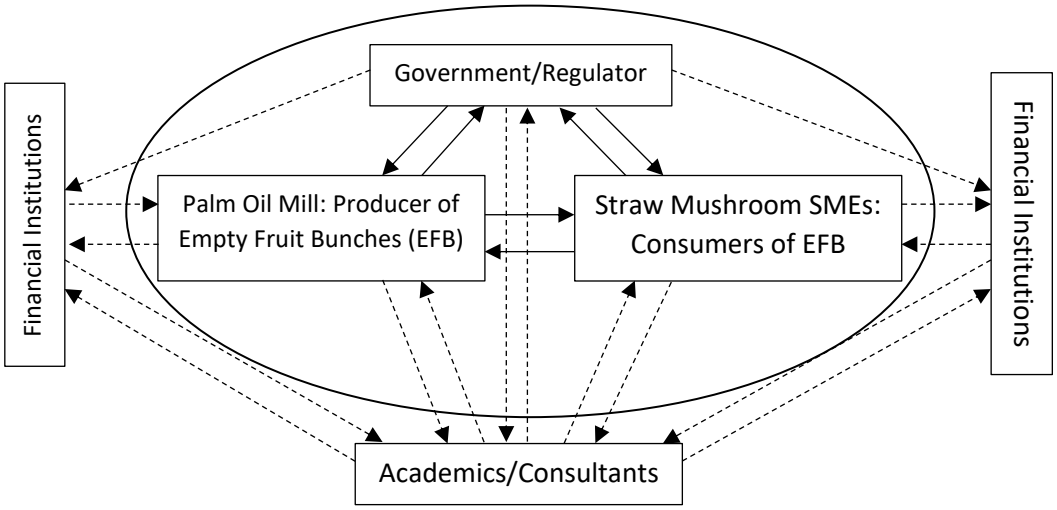
(2) **Medium Priority**, namely: Improvement of human resource capacity, implementation of GMP & ESG standards, standardization of cultivation and compost SOPs, and differentiation of mushroom and compost products. These strategies focus on strengthening capacity, quality, and competitiveness.

(3) **Supporting Priority**, namely: Strengthening institutional aspects and certification, environmentally friendly product branding, improvement of financial management, diversification of markets and products, and improvement of coordination among partners. These strategies are defensive and aimed at long-term sustainability.

The results of the analysis indicate that the development of partnerships in utilizing EFB as a growing medium for straw mushrooms and compost is most effectively carried out through an expansion strategy based on upstream–downstream integration and a circular economy approach. The medium-priority strategies function as implementation strengthening, while the final group of strategies serves as supporting strategies to maintain the stability and long-term sustainability of the partnership.

Partnership Model for Straw Mushroom Business Using EFB as Growing Medium

The proposed partnership model for the development of straw mushroom cultivation using oil palm empty fruit bunches (EFB) as a growing medium is presented in **Figure 2**.



Description:
- Elements inside the oval circle are mandatory in nature.
- Elements outside the oval circle are complementary.
- Dashed arrows indicate coordinative relationships.
- Solid arrows indicate mandatory relationships.

Figure 2.
Partnership Model for the Development of Straw Mushroom Business Using EFB as a Growing Medium

The proposed partnership model adopts the Triple Helix Collaboration principle involving industry (palm oil mills), SMEs/farmers processing EFB, and

government/academia. The partnership structure includes:

(a) Palm oil mills (PKS) as providers of EFB raw materials and logistical facilities;
(b) SMEs/farmers as processors of waste into food products (straw mushrooms) and organic fertilizer;
(c) Government and academia as supervisors, technology facilitators, and providers of policy incentives;
(d) Financial institutions as providers of business capital access and financing.

Abidin and Nurhasanah (2019) emphasize that the development of business partnerships is a necessity in addressing the complexity of problems faced by small and medium enterprises (SMEs) in Indonesia, particularly the limited access to raw materials, technology, markets, and capital (Fidanoski et al., 2022). In the context of utilizing oil palm empty fruit bunches (EFB), the results of this study indicate that an effective partnership must involve key actors who have complementary and structural roles.

Palm oil mills (PKS), as producers and owners of EFB, act as providers of the main raw material, while straw mushroom SMEs serve as processors that convert waste into value-added products in the form of edible mushrooms and organic fertilizer. The government occupies a strategic position as a regulator and mediator that bridges the interests of industry and SMEs so that partnerships operate fairly and sustainably. These three actors—PKS, SMEs, and the government constitute mandatory actors in the partnership model, as shown in the core structure (oval circle) in Figure 5.

Meanwhile, academics/consultants and financial institutions act as complementary actors that strengthen the effectiveness of the partnership. The involvement of academics and research institutions contributes to the development and dissemination of straw mushroom cultivation technology using EFB as a growing medium, the improvement of human resource capacity, and the evaluation of production system sustainability. These findings are consistent with (Kusumawardani et al., 2024) and (Noya et al., 2023), who state that the sustainability of SMEs is largely determined by simultaneous support from the government, academics, and other supporting institutions.

Table 1 indicates that financial institutions rank fifth among the initial requirements of the partnership model. However, their role becomes increasingly critical in the subsequent stages of business development, particularly in providing SMEs with access to capital through various financing schemes, such as soft loans, commercial financing, and corporate social responsibility (CSR) grants. Adequate access to financing enables SMEs to scale up their operations, improve production quality, and sustain long-term performance. Without sufficient financial support, the potential of available technology and market opportunities cannot be fully realized.

The proposed partnership model for the development of straw mushroom businesses using EFB as a growing medium (Figure 5) illustrates the relationships among actors that are both mandatory and coordinative. Solid arrows indicate structural and binding relationships, such as the flow of EFB raw materials from palm oil mills to SMEs, while dashed arrows indicate coordinative relationships, such as technological assistance and policy facilitation. This structure emphasizes that the success of the partnership does not only depend on bilateral relationships between palm oil mills and SMEs but also on integrated multi-stakeholder coordination.

Operationally, the partnership process begins with the provision of EFB by palm oil mills as the main raw material

for straw mushroom SMEs. The SMEs then process the EFB into straw mushrooms as food products and organic fertilizer as a by-product. The government and academics provide support through regulatory frameworks, applied research, and technological training, while financial institutions provide business financing and working capital. The final products are subsequently absorbed by the Free Nutritious Meals Program (FNMP) and the local market, thereby forming a circular and inclusive value chain.

Conceptually, this partnership model adopts the principle of Triple Helix Collaboration, which refers to the synergy between industry, government, and academia in promoting innovation and development based on local resources (Schocair et al., 2023) and (Beck & Demirguc-Kunt, 2006). In the context of this study, the Triple Helix approach is expanded by involving SMEs as the main actors of the people's economy and financial institutions as supporters of financial sustainability, making the partnership model more adaptive to field conditions.

CONCLUSION

Based on the research objectives, it can be concluded that the development of a technology-based partnership model for utilizing oil palm empty fruit bunches (EFB) into straw mushrooms and compost requires the involvement of key actors, appropriate criteria, and integrated strategies. The results indicate that the most influential actor in this partnership is the government, serving as the main regulator and facilitator, followed by EFB-based straw mushroom SMEs and palm oil mills as the primary suppliers of raw materials. Meanwhile, academics/ consultants and financial institutions play supporting roles in technical assistance and financing.

In terms of criteria, economic and social impact is identified as the top priority in establishing the partnership, followed by environmental sustainability, technical feasibility, institutional strengthening, and contributions to regional revenue. This suggests that the success of the partnership is not solely determined by economic factors, but also by the balance between environmental sustainability and institutional support.

Furthermore, the priority strategies emphasize strengthening the entire value chain, starting from scaling up EFB-based straw mushroom production, developing compost units from spent mushroom substrate, to enhancing upstream–downstream integration between palm oil mills and SMEs. Additional strategies include improving human resource capacity, implementing quality and sustainability standards (GMP & ESG), standardizing production processes, and strengthening product differentiation and environmentally friendly branding. Overall, the proposed partnership model demonstrates that synergy among stakeholders, supported by appropriate technology, clear standards, and well-defined strategies, can enhance the value-added utilization of EFB and promote sustainable agro-industrial development.

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