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Replanting Initiative Strategy for Sustainable Oil Palm

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Abstrak

Tanaman Ulang merupakan strategi penting untuk meningkatkan produktivitas kelapa sawit jangka panjang, terutama ketika pohon mencapai akhir masa produktif optimalnya, biasanya antara 20 dan 25 tahun. Pada tahap ini, terjadi penurunan hasil dan kandungan minyak yang signifikan, sehingga diperlukan penanaman ulang secara sistematis untuk mempertahankan tingkat produksi dan memastikan efisiensi serta keberlanjutan industri kelapa sawit. Studi ini menganalisis strategi penanaman ulang dengan penekanan pada keberlanjutan lingkungan, sosial, dan ekonomi, dengan memprioritaskan pendekatan berbasis komunitas dan adopsi teknologi ramah lingkungan. Desain penelitian kuantitatif digunakan, yang melibatkan pengumpulan dan analisis data terkait produktivitas, efisiensi biaya, dan indikator keberlanjutan dari perkebunan yang menerapkan program penanaman ulang. Penilaian strategis dilakukan menggunakan analisis SWOT, yang menjadi dasar pengembangan Evaluasi Faktor Internal (IFE), Evaluasi Faktor Eksternal (EFE), Matriks Profil Kompetitif (CPM), dan Matriks Perencanaan Strategis Kuantitatif (QSPM). Temuan menunjukkan bahwa faktor internal dan eksternal secara signifikan memengaruhi keberhasilan program penanaman ulang. Mengintegrasikan faktor-faktor ini ke dalam pengambilan keputusan menghasilkan hasil keberlanjutan yang lebih tinggi. Selain itu, penerapan inisiatif berbasis komunitas dan teknologi ramah lingkungan meningkatkan efektivitas jangka panjang program penanaman kembali. Kasus PTPN IV menunjukkan bahwa strategi tersebut dapat menghasilkan dampak lingkungan, sosial, dan ekonomi yang positif, memperkuat peran penanaman kembali sebagai langkah keberlanjutan utama di sektor minyak sawit.

Kata kunci: minyak sawit; strategi tanaman ulang; keberlanjutan; analisis SWOT; QSP; pendekatan berbasis komunitas; PTPN IV

Abstract

Replanting is a critical strategy to improve long-term palm oil productivity, particularly when trees reach the end of their optimal productive lifespan, typically between 20 and 25 years. At this stage, a significant decline in yield and oil content occurs, necessitating systematic replanting to maintain production levels and ensure the efficiency and sustainability of the palm oil industry. This study analyzes replanting strategies with an emphasis on environmental, social, and economic sustainability, prioritizing a community-based approach and the adoption of environmentally friendly technologies. A quantitative research design was employed, involving the collection and analysis of data related to productivity, cost efficiency, and sustainability indicators from plantations implementing replanting programs. Strategic assessment was conducted using a SWOT analysis, which informed the development of the Internal Factor Evaluation (IFE), External Factor Evaluation (EFE), Competitive Profile Matrix (CPM), and Quantitative Strategic Planning Matrix (QSPM). The findings reveal that both internal and external factors significantly influence the success of replanting programs. Integrating these factors into decision-making leads to higher sustainability outcomes. Moreover, implementing community-based initiatives and environmentally sound technologies enhances the long-term effectiveness of replanting programs. The case of PTPN IV demonstrates that such strategies can generate positive environmental, social, and economic impacts, reinforcing the role of replanting as a key sustainability measure in the palm oil sector.

Keywords: palm oil; replanting strategy; sustainability; SWOT analysis; QSPM; community-based approach; PTPN IV

1. Introduction

Oil palm replanting at PTPN IV presents a major challenge in maintaining both plantation productivity and long-term sustainability. Key issues include the aging of plantations, the high financial burden of replanting, and the potential social and

environmental impacts. Furthermore, the company must ensure the application of environmentally responsible replanting practices, such as a strict zero-burning policy, to avoid harming ecosystems.

To address these challenges, PTPN IV has adopted several strategic measures. The company utilizes superior seedlings with higher production potential, applies precision farming technologies, and collaborates with government agencies as well as financial institutions to secure replanting funds. In addition, PTPN IV is committed to adhering to sustainability standards, such as the Indonesian Sustainable Palm Oil (ISPO) certification and the Roundtable on Sustainable Palm Oil (RSPO), ensuring that replanting practices are carried out responsibly. Through these efforts, the company aims to increase plantation productivity while maintaining a balance between economic, social, and environmental considerations.

As part of its sustainability initiatives, PTPN IV prioritizes environmental protection, community empowerment, and employee welfare. Sustainability principles are integrated throughout the company's production chain, from oil palm cultivation to crude palm oil (CPO) processing. To minimize its environmental footprint, PTPN IV actively works to reduce greenhouse gas emissions, manage waste more effectively, and protect biodiversity within and around its plantation areas.

Moreover, the company actively supports national and international certification programs, such as ISPO and RSPO, to ensure its products meet recognized sustainability standards. This commitment reflects PTPN IV's broader goal of achieving high productivity while delivering long-term benefits for the environment and surrounding communities.

Economically, PTPN IV plays a vital role in Indonesia's palm oil supply chain by producing high-quality CPO to meet both domestic and export demand. With its substantial production capacity, the company helps maintain supply and price stability, thereby contributing to national food and energy security, particularly given the growing use of palm oil as a biofuel.

At the regional level, particularly in North Sumatra, PTPN IV contributes significantly to local economic development. Managing thousands of hectares of oil palm plantations, the company generates employment opportunities for surrounding communities, spanning both cultivation and processing activities. This, in turn, directly improves the livelihoods of local residents. Furthermore, PTPN IV implements various corporate social responsibility (CSR) programs, including infrastructure development, educational support, and vocational training, all of which enhance the socio-economic well-being of local communities.

On a national scale, as a state-owned enterprise, PTPN IV contributes to state revenue through taxes and dividends while also generating foreign exchange through palm oil exports. The company's adherence to sustainability certifications further promotes best practices within Indonesia's palm oil sector, reinforcing its role as an agent of change towards more sustainable and environmentally friendly industry standards.

Replanting, or rejuvenating plantations, is a crucial long-term strategy for improving palm oil productivity, especially when trees reach the end of their productive lifespan, typically at 20–25 years. At this age, oil palm yields decline significantly, and the harvested fruit contains lower oil content. Therefore, replanting is essential to maintaining high and efficient production levels.

At PTPN IV, the replanting program is particularly important, as many plantations have already reached maturity, leading to declining productivity. By replacing old trees with superior seedlings that are more productive, disease-resistant, and nutrient-efficient, the company improves yield per hectare and enhances operational efficiency. Utilizing advanced cultivation techniques not only increases productivity but also reduces maintenance costs, contributing to the achievement of both economic and sustainability targets.

Furthermore, replanting allows the implementation of more sustainable agricultural practices, such as environmentally friendly planting patterns, improved water management, and optimized fertilization. Over time, these efforts enhance soil quality, restore ecosystems, and support the long-term viability of the plantation business.

The replanting program also brings socio-economic benefits to surrounding communities. It creates employment opportunities during the replanting process, thereby stimulating the local economy. Consequently, replanting is not merely an agricultural strategy but also a broader sustainability initiative that encompasses economic growth, environmental stewardship, and social development for both the company and the communities in its operational areas.

The objectives of this problem-solving include:

- a. To analyze internal and external factors that influence the sustainable replanting of oil palm plants.
- b. To determine the best strategy so that replanting can run optimally.
- c. To determine the best sequence of sustainable oil palm replanting initiative strategies to be implemented at PTPN 4

To achieve sustainable oil palm rejuvenation, several critical data points and measurements are required as the foundation for effective planning. First, accurate information on land area and plant age is essential to identify sections that require replanting, particularly those exceeding their optimal productive age of approximately 25 years. Second, the human resource dimension must encompass the availability of skilled labor as well as the implementation of training programs for farmers and plantation workers on rejuvenation techniques and sustainable agricultural practices. Third, financial capacity serves as a determining factor, involving both the estimation of replanting costs and access to funding sources, including government support programs or financial institutions. Fourth, the success of replanting initiatives is also contingent on the availability of superior, certified, and legally approved seedlings with high productivity potential. Fifth, supporting infrastructure—such as access roads, storage

facilities, and palm oil mills (PKS)—must be adequately developed to ensure smooth distribution and processing of fresh fruit bunches (FFB). Lastly, government policies play a pivotal role through the provision of replanting incentives, the enforcement of environmental regulations, and the implementation of sustainability standards such as the Indonesian Sustainable Palm Oil (ISPO) and the Roundtable on Sustainable Palm Oil (RSPO) certifications.

Without these fundamental components, the implementation of oil palm rejuvenation strategies cannot be executed optimally or sustainably.

2. Literature Review

A theory is a set of constructs (concepts), limitations, and propositions that present a systematic view of a phenomenon by detailing the relationships between variables, to explain and predict those phenomena. Ideally, a literature review outlines the theoretical development from its inception to its current development and provides a critical appreciation or analysis to highlight its strengths and weaknesses, as well as its relevance to the research topic being studied (Ervin Waty et al., 2023).

Rejuvenation is carried out based on the theory of palm oil production. Data obtained from the Central Statistics Agency (BPS) (2014) shows that in 2014, the area of large oil palm plantations reached 10.9 million hectares. Theoretically, oil palm production per unit area shows a sharp increasing trend at the age of 4-7 years, levels off at the age of 8-15 years, and begins to decline at the age of >16 years. This theory indirectly states that production per hectare per year of oil palm will be optimal if the average age of the plant is 15 years. This reference is based on the fact that at 15 years the plant will reach peak production. Maximum production conditions throughout the crop cycle will also ensure that all fixed costs borne by the company will function optimally (Pahan, 2008).

Of the various theoretical concepts underlying the oil palm replanting strategy, the concept of sustainability is the most dominant theoretical concept in the sustainable oil palm replanting strategy at PTPN 4.

The concept of sustainability. According to the original definition (Brundtland, 1987), sustainability is defined as "meeting the needs of the present without compromising the needs of future generations." Referring to this basic definition, it has been empirically proven that oil palm plantations have been sustainable across generations (Purba JHV, 2018).

Nurkhoiry et al. (2006) added that decisions about oil palm rejuvenation must consider the plantation's productivity level, including plant density per hectare and the level of pest and disease infestation. If productivity falls below company standards, rejuvenation becomes mandatory. Furthermore, rejuvenation is also considered when harvesting becomes increasingly difficult due to plant height exceeding the optimal limit (Wibowo & Junaedi, 2017).

Analysis of unproductive plantations in Sumatra revealed that community-led smallholder replanting improves several SDGs, including health, education, and environmental preservation (spatial econometrics study, Nature, 2023).

Barriers to successful replanting include insufficient training, limited access to quality seedlings, and unequal funding eligibility; policy-level solutions are recommended (Springer Link, 2023).

Sustainability assessments of Indonesian smallholder plantations show that more than 50% of plantations score below sustainable thresholds, particularly in institutional, environmental, and welfare dimensions.

The EFE Matrix is used to summarize and evaluate external factors (David et al., 2023). These external factors are derived from the opportunities and threats analysis in the SWOT analysis. The EFE Matrix provides an empirical assessment of how well a company handles external factors overall, including the company's effectiveness in exploiting opportunities and threats. The EFE Matrix is formed by quantifying the weight and rating of each point in the opportunity and threat analysis.

Meanwhile, the IFE matrix is used to summarize and evaluate internal factors (David et al., 2023). These internal factors are derived from the strengths and weaknesses analysis in the SWOT analysis. The IFE matrix allows companies to focus carefully on unique strengths and weaknesses, leading to the maintenance of a competitive advantage. The IFE matrix is formed by quantifying the weight and rating of each point in the strengths and weaknesses analysis.

3. Method

Quantitative research is a method that focuses on collecting and analyzing numerical data. The primary goal of this approach is to measure variables numerically, identify causal relationships, and generalize findings to a broader population. In quantitative research, data is collected measurably and then analyzed using statistics to test formulated hypotheses (Anjarwati, 2024).

The SWOT (Strengths, Weaknesses, Opportunities, and Threats) method is a strategic analysis technique used to identify and categorize internal and external factors that influence organizational performance. Through this analysis, companies can understand their internal strengths, address existing weaknesses, seize external opportunities, and anticipate potential threats.

The EFE Matrix serves to summarize and evaluate external factors affecting a company (David et al., 2023). These external factors are derived from the SWOT analysis of opportunities and threats. This matrix provides an empirical overview of a company's ability to respond to external dynamics, including its ability to capitalize on opportunities and manage threats.

In contrast, the IFE Matrix is used to summarize and evaluate a company's internal factors, consisting of its strengths and weaknesses (David et al., 2023). Through this matrix, organizations can focus on their competitive advantages while identifying areas for improvement.

Data collection is carried out after defining the background and problem formulation in the research (Tolmie and

McAteer, 2011). There are two types of data collection techniques, namely:

1. Primary data collection

Primary data is information collected directly from sources without intermediaries. Primary data collection in this study was conducted through interviews, focus group discussions (FGDs), and questionnaires distributed to management leaders at PT Perkebunan Nusantara IV to obtain an overview of the strategy for sustainable oil palm replanting initiatives.

2. Secondary data collection

Secondary data is data obtained from sources other than the source, such as through intermediaries, documents, or archives. Secondary data collection in research is conducted by reading and studying company documents, archives, books, and literature.

3.1 Data Analysis Techniques

Strategy formulation is carried out in 3 stages, adopting the stages in The Strategy Formulation Analytical Framework (David et al., 2023), which are shown in:

Table 1. The Strategy Formulation Analytical Framework

Stage	The Strategy Formulation Analytical Framework	
Stage 1 : The Input Stage	External Factor Evaluation Matrix (EFE Matrix)	Internal Factor Evaluation Matrix (IFE Matrix)
Stage 2 : The Matching Stage	Internal-Exxternal Matrix (IE Matrix)	Strenghts-Weakness-Opportunities (SWOT) Analysis
Stage 3 : The Decision Stage	Quantitative Starategic Planning Matrix (QSPM)	

4. Results and Discussion

4.1 Input Stage:

IFE Matrix: 4 strengths and 3 weaknesses identified from employee responses.

EFE Matrix: 4 opportunities and 3 threats derived from external environment analysis.

4.2 Matching Stage:

The IE Matrix placed the results in Quadrant I (grow and build strategy).

SWOT quadrant analysis supports the need for new strategy development.

4.3 Decision Stage (QSPM):

Strategies ranked by Total Attractiveness Score (TAS).

The top strategy involves securing funding, embracing efficient technology, and leveraging global market demand. These findings reflect broader literature: Sustainable strategies combining technology adoption and institutional support boost productivity while addressing social equity (Qaim et al., 2020; Supriatna et al., 2024).

In the first stage, namely the Input Stage, an IFE matrix was produced that describes the weight and rating of internal factors (strengths and weaknesses) and an EFE matrix that describes the weight and rating of external factors (opportunities and threats) that influence the oil palm replanting initiative strategy. The results of the questionnaire that had been distributed to 10 employees of PT Perkebunan Nusantara IV obtained 4 factors that were included in the strengths factor, 3 factors that were included in the weaknesses factor, 4 factors that were included in the opportunities factor, and 3 factors that were included in the threats factor so that overall 14 factors were obtained.

These 14 internal and external factors are input to the IFE and EFE matrices. Four strengths and three weaknesses are input to the IFE matrix, and four opportunities and three threats are input to the EFE matrix. The results of the IFE matrix can be seen in the following table:

Table 2. The Result of The IFE Matrix

No	Factor	Score	Weight	Rating	Weighted Score
Strengths					
1	Availability of funds for replanting investment, sourced from both internal cash flow and external financing (S1).	36	0.14	3.60	0.51
2	Availability of skilled labor capable of implementing sustainable replanting practices (S2).	37	0.15	3.70	0.54
3	Company capability to adopt new technologies, such as disease-resistant superior varieties and more efficient replanting techniques (S3).	37	0.15	3.70	0.54
4	Supportive land characteristics, including fertile soil conditions, suitable topography, and nutrient availability, which provide advantages in replanting implementation (S4).	37	0.15	3.30	0.43
Total Strengths		143	0.57		2.02
Weakness					
5	Alignment between management's sustainability commitment and long-term strategic planning remains challenging, particularly regarding consistency of implementation at the	36	0.14	3.60	0.51

No	Factor	Score	Weight	Rating	Weighted Score
	operational level (W1).				
6	Strategic infrastructure conditions, such as access roads, industrial facilities, and irrigation systems, still require improvement to optimally support operational needs (W2).	37	0.15	3.70	0.54
7	Compliance with sustainability standards (RSPO and ISPO) remains an area requiring improvement, both in administrative compliance and field-level technical implementation (W3).	37	0.15	3.70	0.54
Total Weaknesses		110	0.43		1.59
Total Internal Factors		253	1.00		3.62

Next, the results of the EFE matrix produced can be seen in the following table:

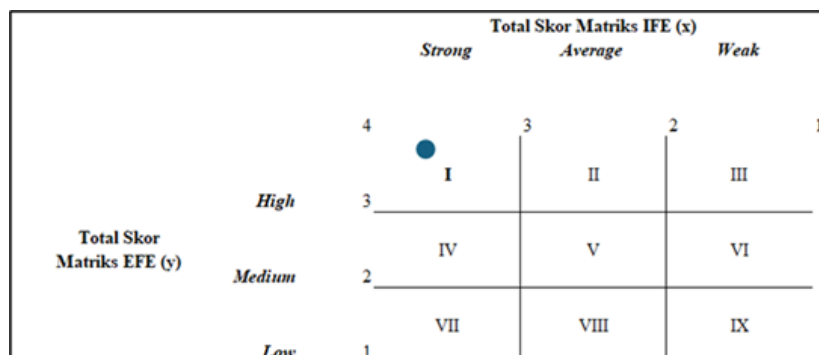
Table 2. The Result of The IFE Matrix

No	Factor	Score	Weight	Rating	Weighted Score
Oppoortunities					
1	Government policies related to smallholder oil palm replanting (PSR), tax incentives, and environmental regulations that must be complied with (O1).	37	0.16	3.70	0.58
2	Access to funding from banking institutions, investors, or grant programs to support replanting activities (O2).	33	0.14	3.30	0.46
3	Growing global market demand for sustainable palm oil, along with pressure from consumers and environmental organizations (O3).	33	0.14	3.30	0.46
4	Replanting strategies implemented by other plantation companies that may influence the competitive position of PTPN IV (O4).	30	0.13	3.00	0.38
Total Oppoortunities		133	0.57		1.89
Threats					
5	Risks of extreme weather, soil degradation, and water availability that may affect the success of replanting programs (T1).	34	0.14	3.40	0.49
6	Relationships with surrounding communities, partnerships with plasma farmers, and social impacts of replanting programs (T2).	33	0.14	3.30	0.46
7	Rapid adoption of new technologies in the agribusiness sector, such as drones and biotechnology, which may threaten the competitiveness of companies that are slow to innovate (T3).	35	0.15	3.50	0.52
Total Threats		102	0.43		1.48
Total External Factors		235	1.00		3.37

The second stage, namely the Matching Stage, produces an IE matrix that helps determine whether the company will implement a new strategy, maintain the existing strategy, or enhance the strategy's efficiency. Additionally, at this stage, a SWOT quadrant is also produced, which functions similarly to the IE matrix to determine whether the company will implement a progressive strategy, diversify its strategy, change its strategy, or adopt a defensive strategy. Furthermore, the results of the IE matrix and the SWOT quadrant can serve as a reference for forming a SWOT matrix that describes four types of strategies based on a combination of Strengths-Opportunities (SO), Weaknesses-Opportunities (WO), Strengths-Threats (ST), and Weaknesses-Threats (WT).

In the IE matrix, the value on the x-axis is obtained from the total score of the IFE matrix, which is 3.62, indicating a strong value, while the value on the y-axis is obtained from the total score of the EFE matrix, which is 3.37, indicating a high value. After obtaining the coordinates, it can be concluded that the results are in Quadrant I of the IE Matrix, so the recommendation is to build new strategies (grow and build).

Table 3. IE Matrix Results



Next, a SWOT quadrant is formed from the difference between internal and external factors. The calculation to obtain the value is similar to the IFE matrix and EFE matrix, but in the IFE matrix and EFE matrix, the weighting is done by dividing the number of each factor by the total value of strengths and weaknesses or dividing the number of each factor by the total value of opportunities and threats. While in the SWOT quadrant, the weighting is done by dividing each factor by its category, namely strengths, weaknesses, opportunities, and threats. The rating and score assessment are carried out in the same way as those done in the IFE matrix and EFE matrix. The results of the SWOT quadrant calculation can be seen in the following table:

Table 4. The Results of The SWOT Quadrant

No	Factor Codes	Amount	Weight	Rating	Score
Strengths					
1	S1	36	0,25	3,60	0,91
2	S2	37	0,26	3,700	0,96
3	S3	37	0,26	3,700	0,96
4	S4	33	0,23	3,30	0,76
	Total Strengths	143	1,00		3,58
Weaknesses					
5	W1	36	0,33	3,60	1,18
6	W2	37	0,34	3,70	1,24
7	W3	37	0,34	3,70	1,24
	Total Weaknesses	110	1,00		3,67
Opportunities					
8	O1	37	0,28	3,70	1,03
9	O2	33	0,25	3,30	0,82
10	O3	33	0,25	3,30	0,82
11	O4	30	0,23	3,00	0,68
	Total Opportunities	133	1,00		3,34
Threats					
12	T1	34	0,33	3,40	1,13
13	T2	33	0,32	3,30	1,07
14	T3	35	0,34	3,50	1,20
	Total Threats	102	1,00		3,40

From internal factors, the total score for strengths is 3.58, while for weaknesses it is 3.67. Meanwhile, from external factors, the total score for opportunities is 3.34, and for threats, it is 3.40. Therefore, on the x-axis, the calculation is 3.58 minus 3.67, resulting in -0.09. On the y-axis, the calculation is 3.34 minus 3.40, resulting in -0.06. The results of the SWOT quadrants are as follows:

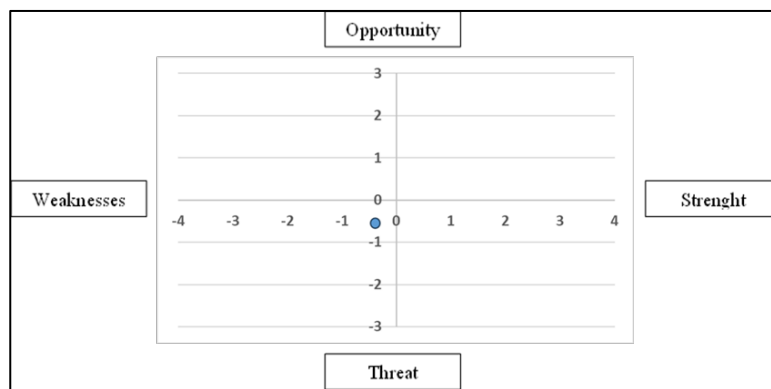


Figure 1. The Result of The SWOT Quadrants

The coordinates are in quadrant III, and the recommendation is to modify existing strategies by developing new ones. The recommendations from this SWOT quadrant are the same as those from the IE matrix. The SWOT matrix results are shown in the

following table:

Table 5. The SWOT Matrix Results

Faktor Internal Faktor Eksternal		<i>Strengths</i>	<i>Weaknesses</i>
		The availability of funds, the ability to adopt efficient technology, access to external funding, and high global market demand for sustainable palm oil provide strategic opportunities for replanting (S1, S3, O2, O3)	Challenges of sustainability alignment, suboptimal infrastructure, and the influence of PSR policies, incentives, and competitors' replanting strategies affect PTPN IV's competitive position (W1, W2, O1, O4)
Opportunities		The availability of skilled labor and favorable land characteristics are advantages of replanting, but the risks of extreme weather, soil degradation, water availability, and the acceleration of agribusiness technology that	Suboptimal infrastructure, RSPO-ISPO compliance, social relations, and the acceleration of agribusiness technology are the main challenges to successful replanting (W2, W3, T2, T3)
Threats			

In the final stage, called the Decision Stage, the attractiveness score and total attractiveness score are calculated in the QSPM. The Attractiveness Score (AS) is obtained from the questionnaire in the Appendix, which assesses 10 respondents with manager-level positions on 10 new strategies for each factor, both internal and external. Next, the Total Attractiveness Score (TAS) is calculated by multiplying the AS by the weight (from the IFE matrix and the EFE matrix) of each factor, representing internal and external factors. The results of the QSPM are shown in the table below:

Table 6. The Results of The QSPM

FACTOR CODES	Weight	S1		S2		W1		W2		
		AS	TAS	AS	TAS	AS	TAS	AS	TAS	
STRENGTHS										
S1	0,10	2	0,21	2	0,19	2	0,21	2	0,19	
S2	0,09	2	0,20	2	0,18	2	0,19	2	0,20	
S3	0,07	3	0,18	3	0,18	3	0,19	3	0,18	
S4	0,06	3	0,19	3	0,18	3	0,19	3	0,16	
WEAKNESSES										
W1	0,07	3	0,19	3	0,21	3	0,22	3	0,19	
W2	0,07	3	0,20	3	0,18	3	0,19	2	0,17	
W3	0,05	4	0,19	4	0,21	5	0,23	4	0,21	
OPPORTUNITIES										
O1	0,09	2	0,22	2	0,19	2	0,20	3	0,23	
O2	0,08	2	0,19	3	0,20	2	0,19	2	0,17	
O3	0,07	3	0,19	3	0,18	3	0,20	2	0,16	
O4	0,06	4	0,21	3	0,17	3	0,18	3	0,15	
THREATS										
T1	0,07	3	0,18	3	0,18	3	0,18	3	0,21	
T2	0,07	3	0,21	3	0,19	3	0,18	3	0,18	
T3	0,05	4	0,19	4	0,20	4	0,18	4	0,22	
TOTAL	1	2,75		2,64		2,73		2,67		

Finally, strategies are ranked based on the total TAS value, resulting in the order shown in the table. The strategy with the highest TAS value is recommended. The table above shows that strategy 1 has the highest TAS value.

PTPN 4's policy in supporting the availability of funds, adoption of efficient technology, access to external funding, and high global market demand is a strategic opportunity for sustainable oil palm replanting.

5. Conclusion

1. Success in oil palm replanting hinges on the strategic management of internal strengths (e.g., funding readiness, infrastructure, workforce) and external opportunities (e.g., policy support, market access, innovation).
2. Replanting initiatives must integrate diverse funding mechanisms, eco-efficient technology, labor empowerment, and environmental conservation aligned with ISPO and RSPO standards.
3. Based on QSPM analysis, the optimal strategy emphasizes funding availability, technology adoption, external financing access, and global demand alignment.

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