ASIAN JOURNAL OF AGRICULTURE
Volume 10, Number 1, June 2026 E-ISSN: 2580-4537
Pages: 9 https://doi.org/10.13057/asianjagric/g100103

SWOT-AHP analysis of youth participation in South Sulawesi, Indonesia, palm sugar agroforestry

ERNAWATI, SYAHIDAH, A. MUJETAHID♥
Department of Forestry, Faculty of Forestry, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km. 10 Makassar 90245, South Sulawesi, Indonesia.
Tel./fax.: +62-411-588566, ♥email: mujetahid@unhas.ac.id

Manuscript received: 16 November 2025. Revision accepted: 16 January 2025.

Abstract. *Ernawati, Syahidah, Mujetahid A. 2026. SWOT-AHP analysis of youth participation in South Sulawesi, Indonesia, palm sugar agroforestry. Asian J Agric 10: g100103. https://doi.org/10.13057/asianjagric/g100103.* Youth disengagement from agroforestry-based livelihoods threatens the continuity of palm sugar production and the broader non-timber forest product economy in South Sulawesi, Indonesia. This study examines factors influencing youth participation in palm sugar agroforestry and prioritizes actionable strategies to strengthen youth engagement in the Universitas Hasanuddin Educational Forest (KHDTK) landscape. Data were collected through household surveys, semi-structured expert interviews, and field observations in Rompegading and Limapoccoe Villages. An integrated SWOT-AHP approach was applied to (i) identify internal and external factors shaping youth participation, (ii) formulate strategic alternatives, and (iii) rank strategies based on expert judgments and derived priority weights. The results highlight that the most influential strategic priorities focus on value-added product innovation and the expansion of digital/social-media marketing, supported by capacity building and institutional strengthening to improve product quality, coordination, and market access. Taken together, the results suggest that palm sugar agroforestry becomes more appealing to young people when it is framed as a market-oriented agribusiness, with roles beyond traditional production such as product development, branding, and online customer engagement. The prioritized strategy package provides practical guidance for local stakeholders. It highlights targeted, youth-focused interventions that upgrade palm sugar enterprises and strengthen the attractiveness and viability of agroforestry-based livelihoods.

Keywords: Digital marketing, NTFPs, palm sugar agroforestry, SWOT-AHP, youth participation

Abbreviations: AHP: Analytic Hierarchy Process, EFAS: External Factor Analysis Summary, IFAS: Internal Factor Analysis Summary, KHDTK: Special Purpose Forest Area, NTFP: Non-Timber Forest Products, SWOT: Strengths, Weaknesses, Opportunities, Threats

INTRODUCTION

Palm sugar (*Arenga pinnata* (Wurmb) Merr.) is a key Non-Timber Forest Product (NTFP) within Indonesia's agroforestry systems, providing an important source of income for forest-adjacent rural communities (Mogea et al. 1991; Derebe and Alemu 2023; Makarennu et al. 2023). Beyond income generation, sugar palm agroforestry contributes to multifunctional landscapes through perennial tree cover, mixed-species cultivation, and traditional management practices that enhance ecological stability and sustainable forest use. However, the long-term sustainability of palm sugar agroforestry increasingly depends on the continued participation of younger generations in production and marketing activities. Given its dependence on experiential knowledge transfer, intergenerational skill transmission, and labor continuity, declining youth participation directly threatens the sustainability of palm sugar agroforestry systems.

Youth engagement in agriculture, community forestry, and NTFP-based livelihoods is declining across Asia as many young people shift toward non-agricultural employment (Robson et al. 2020; Griffin et al. 2024). Similar patterns are observed in palm sugar-producing areas surrounding the Universitas Hasanuddin Educational Forest (KHDTK) in South Sulawesi, Indonesia, where many young people seek employment outside agroforestry, weakening the regeneration of skilled palm sugar producers (Hopid et al. 2023; Mujetahid et al. 2023). This disengagement is reinforced by weak knowledge transfer, low adoption of improved processing technologies, dependence on fluctuating markets, and the persistence of labor-intensive traditional practices. Together, these factors reduce the perceived attractiveness of palm sugar agroforestry as a viable and modern livelihood option for rural youth. For many young people, palm sugar activities are associated with physically demanding work, unstable income, and limited opportunities for innovation, entrepreneurship, or social mobility. Such perceptions discourage youth from viewing agroforestry as a long-term career pathway rather than a residual or transitional occupation.

Previous studies show that youth disengagement from agriculture and NTFP-based livelihoods is shaped by economic uncertainty, limited innovation opportunities, and weak institutional support (Robson et al. 2020; Bannor et al. 2021; Pratiwi et al. 2024). In palm sugar and other NTFP contexts, research has documented value-chain characteristics and production constraints, but many studies remain descriptive and provide limited guidance on which

combinations of interventions, such as product upgrading, digital marketing, training, and institutional strengthening, should be prioritized to re-engage youth and improve sector performance (Pasaribu et al. 2021; Dou et al. 2023; Makarennu et al. 2023). As a result, development programs often propose multiple recommendations without clear sequencing, making implementation difficult under limited resources and coordination capacity. This lack of prioritization is particularly problematic in smallholder agroforestry systems, where households and local institutions must carefully allocate labor, capital, and time.

Strategic planning tools such as SWOT (Strengths, Weaknesses, Opportunities, Threats) are widely used to translate complex internal and external conditions into feasible development strategies in agriculture and forestry (Rahman et al. 2020; Bayraktar and Yüksel 2023; Manaf et al. 2025). Conventional SWOT, however, is often criticized for being overly qualitative and for its limited ability to rank strategic alternatives, which can produce long lists of actions without clear priorities (Shrestha et al. 2004).

Integrating SWOT with the Analytic Hierarchy Process (AHP) addresses this limitation by using pairwise comparisons to derive factor weights and prioritize strategies transparently (Saaty 1977; Ishizaka and Labib 2011). This integration is especially suitable for youth participation issues because decisions must balance household, market, technology, and institutional constraints while transparently prioritizing competing interventions based on stakeholder judgments. The SWOT-AHP approach has been applied in forestry and NTFP contexts, including forest certification, joint forest management, silvopasture adoption, and NTFP commercialization (Kurttila et al. 2000; Etongo et al. 2018; de Alcântara et al. 2022; Kafle et al. 2023). Nevertheless, applications that explicitly focus on youth participation in palm sugar agroforestry remain scarce, particularly in Indonesia.

This study addresses that gap by applying an integrated SWOT-AHP framework in Rompegading and Limapoccoe Villages within the KHDTK area of South Sulawesi to identify key internal and external factors, formulate strategic alternatives, and prioritize those alternatives for implementation. Accordingly, this study aims to: (i) identify internal and external factors influencing youth participation in palm sugar agroforestry; (ii) formulate strategic alternatives to enhance youth involvement and sector performance; and (iii) prioritize these strategies using an integrated SWOT-AHP approach.

MATERIALS AND METHODS

Research location

The study was conducted in Rompegading and Limapoccoe Villages, Cenrana Subdistrict, Maros Regency, South Sulawesi, Indonesia. Both villages are located within the Universitas Hasanuddin Educational Forest Special Purpose Forest Area (KHDTK), which covers approximately 1,460.50 ha. The area lies at around 04°59′55.3″ S and 119°46′33.1″ E, at approximately 500 m above sea level, with hilly terrain and a humid tropical climate (Schmidt-Ferguson type C) (Mujetahid et al. 2023).

The landscape is dominated by sugar palm-based agroforestry systems intercropped with other tree species and annual crops. The site was selected purposively due to the high density of sugar palm stands, active palm sugar processing, and long-standing community engagement in traditional agroforestry management. A map of the study location is provided in Figure 1.

Research design and data collection

This study employed an explanatory, descriptive quantitative design using a cross-sectional survey approach to examine factors influencing youth participation in palm sugar agroforestry. Because data were collected at a single point in time, the findings describe associations and perceptions and do not support causal inference or assessment of changes over time. Data were collected through: (i) household surveys, (ii) semi-structured expert interviews, and (iii) field observations in Rompegading and Limapoccoe Villages. The household survey captured socioeconomic characteristics, participation roles (tapping, processing, marketing), and perceptions of youth and adult household members involved in palm sugar activities.

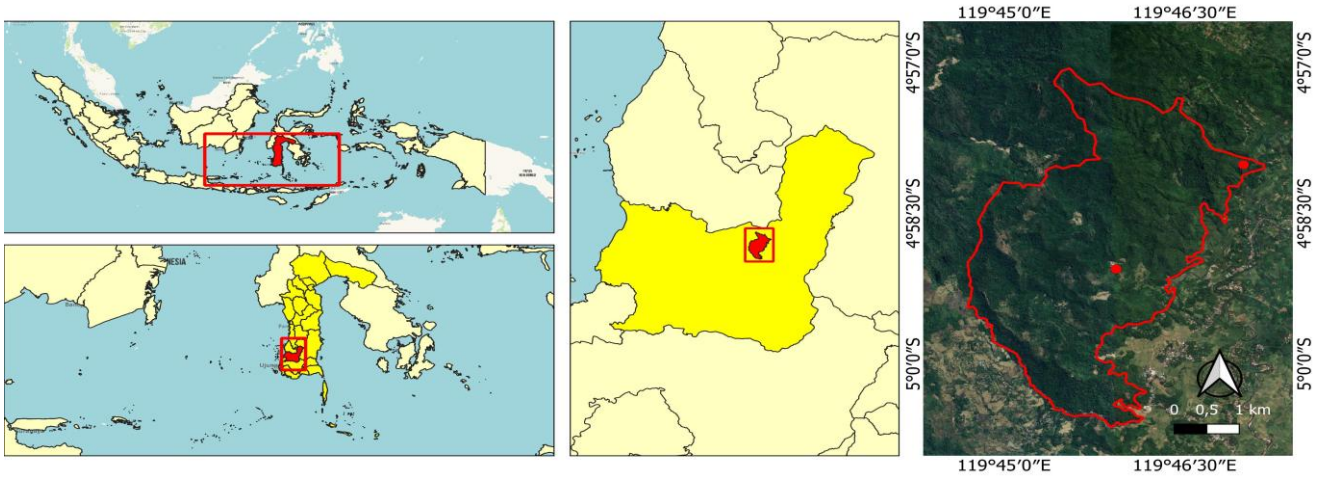

Figure 1. Map of the research location within the Universitas Hasanuddin Educational Forest (KHDTK), South Sulawesi, Indonesia

Field observations were conducted to verify survey and interview information and to document processing practices and local institutional arrangements. A total of 51 household respondents participated in the survey across the two villages, including both youth (18-35 years) and adult producers (Amelia et al. 2024). Household respondents were selected purposively from households engaged in palm sugar agroforestry, as the producer population in the KHDTK area is relatively small and specialized. To capture generational perspectives, the sample was stratified to include youth (18-35 years) and adult producers, with attention to variation in gender, experience, and spatial distribution across the two villages. Because the sampling was non-random, the findings should be interpreted as context-specific and may not be generalizable beyond similar palm sugar agroforestry settings. Expert interviews involved five key informants (one palm sugar tapper, one community leader, two KHDTK managers, and one academic specialzing in community forestry). Experts were selected based on their knowledge of palm sugar production, local institutions, and youth livelihoods in the KHDTK area. The same expert panel also participated in the AHP pairwise comparison exercise to validate the SWOT factors and support the prioritization of strategic alternatives. Participation was voluntary. Respondents were informed about the study objectives and procedures, and verbal informed consent was obtained prior to data collection. The study followed institutional research ethics procedures; documentation of ethics review/approval or exemption can be provided in accordance with the target journal's requirements. Responses were recorded anonymously and used only for research purposes.

Research variables and indicators

The study focused on internal and external factors that influence youth participation in palm sugar agroforestry. Internal factors describe household and livelihood-related conditions, while external factors represent broader technological, market, environmental, and institutional aspects. The variables and indicators were derived from recent studies on rural livelihoods, youth engagement in agriculture, and non-timber forest product value chains, and were adjusted to reflect the specific conditions of palm sugar agroforestry and youth participation in the KHDTK area. A summary of the internal and external variables and indicators used in this study is presented in Table 1.

Survey items were developed from the variables and indicators listed in Table 1 and adapted to the palm sugar agroforestry context. Perceptions and self-reported conditions were measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Items covered internal dimensions such as family support, perceived occupational status, access to social networks and capital, income and market dependence, workload, and intention to continue the business, as well as external dimensions such as availability of tools and technology, training access, ease of tapping, resource availability, topographical constraints, and environmental awareness. The questionnaire was reviewed with local experts to ensure clarity and contextual relevance prior to field implementation.

To support subsequent SWOT and AHP steps, these indicators were operationalized into survey items and expert interview prompts. Information from household surveys, interviews, and field observations was used to inform factor ratings in the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices, while the expert panel validated the inclusion of internal and external factors and supported prioritization through pairwise comparisons in the AHP stage.

SWOT analysis

SWOT analysis was used to identify internal and external conditions of palm sugar agroforestry as the basis for strategy formulation (Rahman et al. 2020; Bayraktar and Yüksel 2023; Dey et al. 2024). Field data and expert judgements were used to classify each indicator into one of the SWOT components and to construct the IFAS and EFAS matrices. In both matrices, each factor was assigned a weight (0-1) representing its relative importance and a rating derived from the household survey using a 1-5 Likert scale (higher values indicating more favorable conditions). Total IFAS and EFAS scores were then obtained by summing the weighted scores for internal and external factors, respectively, and were used to position palm sugar agroforestry within the SWOT strategic quadrants and to generate strategic alternatives for subsequent prioritization using AHP.

Deriving IFAS/EFAS ratings and weights. Ratings were obtained by summarizing household survey responses for each indicator statement on a 1-5 Likert scale and computing the mean score for each factor (reported as the factor rating in the IFAS/EFAS tables). Factor weights were elicited from the expert panel and normalized so that weights within each matrix summed to 1.00. Weighted scores were calculated as weight × rating. Total IFAS and EFAS scores were derived by summing weighted scores across internal and external factors, respectively, and were subsequently used for SWOT positioning and strategy formulation prior to AHP prioritization.

Table 1. Research variables and indicators

Variables	Indicators	Source
Internal Factors	Family support; perceptions of occupational social status; access to social networks; income; access to capital; dependence on local markets; participation in production and marketing; working hours; intention to continue the business.	(Bannor et al. 2021; Harianja et al. 2023; Pratiwi et al. 2024; Widiono et al. 2024; Chin et al. 2025)
External Factors	Availability of tools and technology; technology training; ease of tapping; availability of palm trees; topographical conditions; environmental awareness.	(Griffin et al. 2024; Widiono et al. 2024)

Integration of SWOT and AHP

To prioritize strategic alternatives, the SWOT results were integrated with the Analytic Hierarchy Process (AHP) following established procedures (Saaty 1977; Kurttila et al. 2000; Ishizaka and Labib 2011). A hierarchical structure was developed consisting of the overall goal (enhancing youth participation in palm sugar agroforestry), the four SWOT groups, the factors within each group, and the strategic alternatives derived from the SWOT matrix. The expert panel conducted pairwise comparisons using Saaty's 1-9 scale to assess relative importance at each level. Individual judgements were aggregated using the geometric mean to obtain a single comparison matrix for each level (Saaty 2008). Priority weights were then derived to obtain global weights for SWOT factors and to generate the final ranking of strategic alternatives.

Consistency of pairwise comparison matrices was evaluated using the Consistency Ratio (CR). Following standard AHP guidance, matrices were considered acceptable when CR≤0.10 (Saaty 2008). All matrices met the consistency threshold; when initial values exceeded the criterion, comparisons were revisited with the experts until acceptable consistency was achieved.

RESULTS AND DISCUSSION

Respondent characteristics and roles in participation

Results are based on survey responses from 51 households engaged in palm sugar agroforestry in Rompegading and Limapoccoe Villages. Respondents included youth (18-35 years) and adult producers, and reported involvement across tapping, processing, and marketing. This respondent profile underpins the IFAS/EFAS assessment and the subsequent prioritization of strategies using the integrated SWOT-AHP approach.

Identification of internal and external factors

Internal factors (strengths and weaknesses)

The IFAS indicates that palm sugar agroforestry in the study area has a relatively strong internal base. Table 2 reports the weights, mean ratings, and weighted scores for each internal factor.

Based on factor weights, the most influential strengths were the high economic value of palm sugar (S3) and the perceived naturalness of production (S4), followed by palm sugar as a key source of household livelihood (S6) (Table 2 and Figure 2). The most influential weaknesses were low youth interest in palm sugar enterprises (W3), limited technical knowledge on cultivation and management (W4), and continued reliance on traditional processing methods (W5) (Table 2 and Figure 3).

External factors (opportunities and threats)

The EFAS shows that opportunities slightly outweighed threats overall (Table 3). Table 3 provides the weights, mean ratings, and weighted scores for all external factors. Among opportunities, access to information technology for promotion and marketing (O7) and opportunities for innovation and derivative products (O6) received the highest weights, with family and social support for preserving traditions (O5) also notable (Table 3; Figure 4). Among threats, limited product innovation to attract modern consumers (T7) and youth migration to other employment sectors (T6) were most influential, alongside policy and regulatory constraints (T5) (Table 3 and Figure 5).

SWOT-AHP integration and strategic position

Using the combined internal and external indices, the overall scores were IFAS=3.71 and EFAS=3.67, placing palm sugar agroforestry in Quadrant I (aggressive) of the SWOT diagram (Figure 6).

SWOT matrix and strategic alternatives

Based on the SWOT matrix, strategic alternatives were formulated and grouped into four types: SO, WO, ST, and WT (Table 4).

Table 2. Average scores for internal factors (strengths and weaknesses)

Code	Indicator	Statement	Weight	Rating	Score
S	S1	Potential of NTFPs (palm sugar) that has not been optimally utilized.	0.12	2.90	0.36
	S2	The advantages of NTFPs in terms of small to medium capital and simple technology	0.12	2.78	0.33
	S3	Palm sugar products are known to have high economic value.	0.17	4.08	0.71
	S4	Natural palm sugar production.	0.17	4.08	0.71
	S5	Utilization of forest resources without altering the ecological conditions.	0.12	2.92	0.36
	S6	The condition of palm sugar, which has become a source of livelihood for the community	0.15	3.55	0.54
	S7	Support for the availability of abundant raw materials (palm sap).	0.13	3.16	0.42
Total			1.00	23.47	3.43
W	W1	Lack of coordination between relevant parties (government, community, researchers).	0.09	2.51	0.24
	W2	Lack of promotion and marketing networks.	0.10	2.73	0.28
	W3	Lack of interest among the younger generation in palm sugar.	0.17	4.47	0.75
	W4	Lack of information about proper and correct palm sugar cultivation.	0.17	4.49	0.75
	W5	Palm sugar processing is still traditional.	0.17	4.51	0.76
	W6	Unstable fluctuations in palm sugar prices.	0.16	4.29	0.69
	W7	Limited capital to develop the palm sugar business.	0.14	3.78	0.53
Total			1.00	26.78	3.99

Table 3. Average scores for external factors (opportunities and threats)

Code	Indicator	Statement	Weight	Rating	Score
O	O1	Environmental sustainability awareness is beginning to grow among producers	0.12	3.22	0.39
	O2	The existence of financial support from the government or the private sector	0.14	3.75	0.53
	O3	Market demand for palm sugar products is increasing.	0.14	3.78	0.54
	O4	Wide market potential (local, national, global).	0.13	3.33	0.42
	O5	Strengthening the role of family and social environment in preserving traditions.	0.15	3.86	0.56
	O6	Opportunities for innovation and development of palm sugar derivative products (e.g., syrup, sweets, beverages)	0.16	4.12	0.64
	O7	The availability of information technology for promotion and marketing	0.17	4.49	0.76
Total			1.00	26.55	3.84
T	T1	Competition with other sweetener products.	0.12	2.82	0.33
	T2	Climate change is affecting the availability of palm sap	0.12	2.84	0.34
	T3	Raw material availability is dwindling due to insufficient tree regeneration	0.13	3.22	0.43
	T4	Difficulties in maintaining stable palm sugar quality	0.14	3.43	0.49
	T5	Regulations or policies that do not support palm sugar management efforts	0.15	3.49	0.51
	T6	Migration of young people to other, more promising employment sectors	0.16	3.82	0.61
	T7	Lack of product innovation that can attract modern consumers	0.18	4.33	0.78
Total			1.00	23.96	3.50

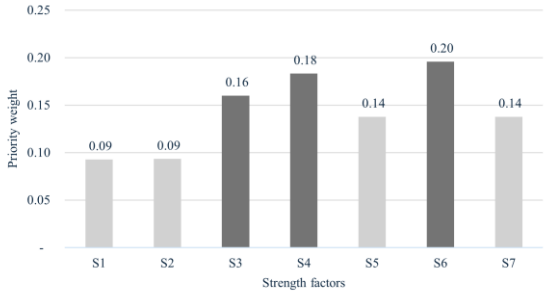

Figure 2. Relative importance (weights) of strength factors (S1-S7) from the IFAS matrix

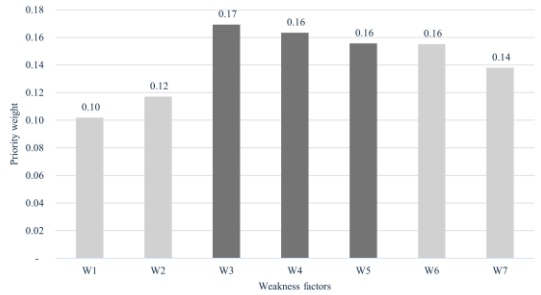

Figure 3. Relative importance (weights) of weakness factors (W1-W7) from the IFAS matrix

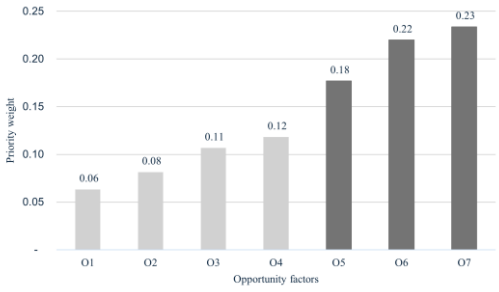

Figure 4. Relative importance (weights) of opportunity factors (O1-O7) from the EFAS matrix

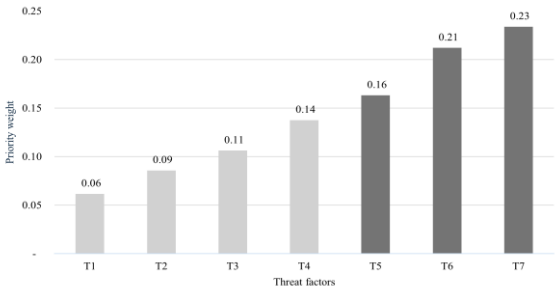

Figure 5. Relative importance (weights) of threat factors (T1-T7) from the EFAS matrix

Strategic ranking from SWOT-AHP

The SWOT-AHP results produced a ranked set of strategic priorities (Figure 7). Derivative-product innovation (SO2) and expanded digital/social-media marketing (SO3) received the highest global priority weights, indicating they should be treated as the primary entry points for strengthening youth participation.

Discussion

This study provides an evidence-based prioritization of strategies to enhance youth participation in palm sugar agroforestry in the KHDTK landscape of South Sulawesi. The SWOT-AHP results indicate that the highest priorities are derivative product innovation (SO2) and digital/social-media marketing (SO3). These findings suggest that youth engagement is more likely to increase when palm sugar agroforestry is positioned not only as a traditional production activity, but as a market-oriented agribusiness with opportunities for innovation, branding, and entrepreneurship.

Table 4. Summarizes the SO, WO, ST, and WT strategy options generated from the SWOT matrix

Strategy type	Strategic focus
SO (Strengths-Opportunities)	• Involve families and community leaders in palm sugar business training activities to preserve local traditions and knowledge while increasing the economic value of palm sugar. • Develop new, natural, and healthy derivative products from palm sugar that are more appealing and easier to market. • Use social media platforms (such as Facebook, Instagram, and WhatsApp) to expand the reach and effectiveness of palm sugar product marketing.
WO (Weaknesses-Opportunities)	• Encourage younger generations to engage in palm sugar enterprises through family-oriented approaches that emphasize cultural values and parental heritage • Provide simple training on palm cultivation and management alongside training on the production of higher-value derivative products. • Use social media and online applications to promote palm sugar products, pairing simple processing methods with more attractive packaging to increase buyer interest. • Process palm sugar into value-added products with longer shelf life to stabilize prices relative to conventional granulated sugar.
ST (Strengths-Threats)	• Develop and implement local quality standards and training programs to ensure more consistent and higher-quality palm sugar production, thereby maintaining favorable selling prices. • Innovate new palm sugar product forms such as granulated sugar, liquid sugar and improved packaging that remain natural and healthy while responding to market competition. • Engage youth in the palm sugar business by introducing appropriate technologies and online sales methods so that the sector is perceived as a promising source of income. • Establish farmer groups or cooperatives to channel producers' aspirations to government agencies and facilitate access to technical assistance and training.
WT (Weaknesses-Threats)	• Promote palm sugar as an attractive income-generating opportunity for youth through modern packaging, social media campaigns and online stores. • Strengthen palm sugar farmer groups or communities to support peer learning and collective submission of proposals to the government for training and tangible support. • Improve processing methods to be more hygienic and attractive while maintaining product authenticity and introducing innovations in form and flavor. • Develop and implement common quality standards and cooperative-based mechanisms to stabilize prices through producer groups or cooperatives.

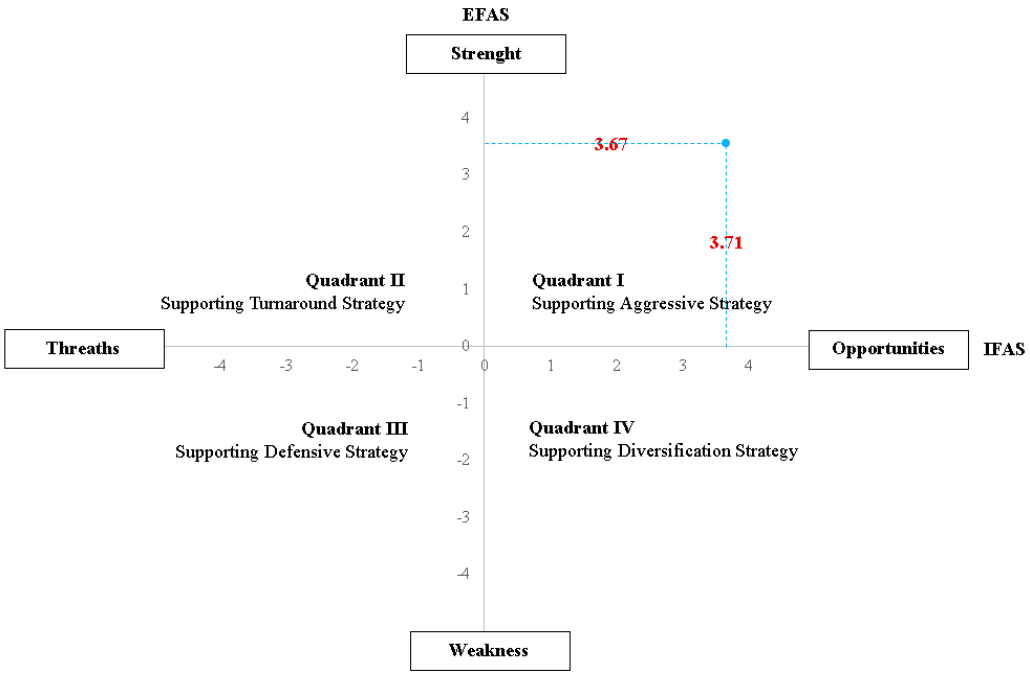

Figure 6. Strategic position of palm sugar management based on IFAS (3.71) and EFAS (3.67) scores (Quadrant I, aggressive)

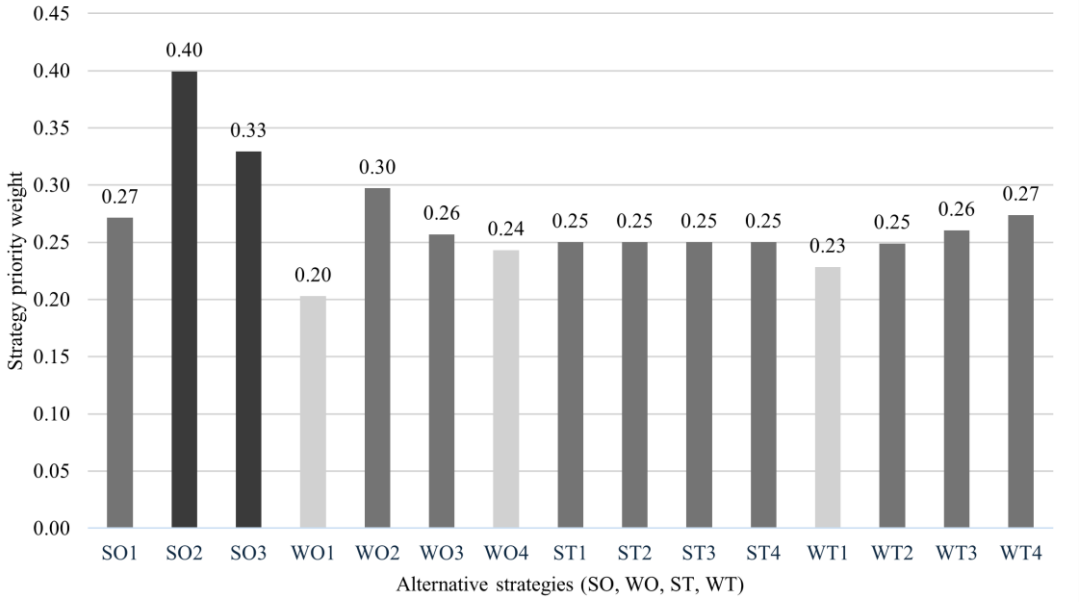

Figure 7. Global priority weights and rank order of strategies from the SWOT-AHP analysis for enhancing youth participation

SWOT mapping can help identify strategic directions, but implementation depends on market support and institutional readiness. Consistent with value-chain research, upgrading through product diversification and improved marketing channels can strengthen producer benefits and sustain smallholder agribusiness opportunities.

Innovation, digitalization, and enabling conditions for sustained youth engagement

The prominence of SO2 and SO3 points to a clear mechanism: youth participation increases when the value chain offers roles that align with youth aspirations (e.g., creativity, learning, recognition, and scalable income) (Acharya et al. 2023; Du et al. 2025). Product innovation expands participation pathways beyond tapping and basic processing into activities such as product design, packaging, branding, quality assurance, digital content creation, and customer engagement. This aligns with the opportunity structure in the EFAS results, where innovation opportunities (O6) and information technology for promotion/marketing (O7) are among the most influential opportunities.

Digital and social-media marketing complements innovation by lowering market-entry barriers and reducing dependence on local intermediaries. It allows producers to reach new consumers, test products, and build brand identity at relatively low cost. For youth, digital tools can also increase visibility and perceived occupational status, helping reposition agroforestry work toward entrepreneurship and market engagement.

However, innovation and digital marketing are unlikely to be sustained without enabling support. Traditional processing constraints, inconsistent product quality, and weak coordination can limit the benefits of upgrading by undermining reliable supply and quality-two conditions required to expand beyond local markets. Strengthening coordination through youth-inclusive groups or cooperatives can support basic standardization in processing and packaging, facilitate shared procurement and branding, and improve bargaining power as markets expand.

Addressing threats: migration, innovation deficit, and policy gaps

The results also highlight risks that can weaken long-term youth engagement, especially when returns are uncertain or products remain poorly differentiated. Limited upgrading reduces competitiveness and can accelerate youth exit, while declining youth participation reduces the sector's capacity for renewal. These dynamics reinforce the need to implement strategies as a coherent package: (i) product innovation and upgrading (SO2), (ii) market expansion through digital channels (SO3), and (iii) coordination and capability support so that innovation translates into stable returns.

Policy and management implications (prioritized and actionable)

To translate the priorities into practice, three actions are proposed: (i) Youth-focused product innovation and micro-enterprise support: Implement short-cycle product development and testing programs targeted to youth, combining practical training (food safety, shelf life, packaging, pricing) with market validation (local fairs, online pre-orders, pilot retail partnerships). (ii) Digital market enablement with mobile-first delivery: Provide hands-on training in product photography, storytelling, customer service, and simple order management on commonly used platforms. To reduce individual burden and sustain performance, support a shared youth-managed

brand/account for collective marketing. (iii) Institutional strengthening for quality assurance and price resilience: Facilitate youth-inclusive groups/cooperatives to coordinate quality standards, hygienic processing practices, packaging procurement, and buyer negotiation to stabilize returns and reduce perceived risk.

This recommendation also reflects policy-oriented findings that stakeholder coordination and agricultural program effectiveness often remain strong on the production side but weaker in marketing support, implying the need to explicitly strengthen market governance, feedback mechanisms, and farmer group relationships (Rozaki et al. 2025). In practice, combining extension/mentoring with collective marketing arrangements can improve market access outcomes and reduce implementation gaps for smallholder-based innovations (Orejudos et al. 2022). Implementation should be adapted to local institutional capacity, existing market linkages, and available resources, rather than applied as a one-size-fits-all prescription.

Contribution and transferability

Methodologically, this study shows how a structured prioritization approach can convert internal-external conditions into a ranked and actionable strategy set. Substantively, the findings indicate that youth participation can be strengthened when palm sugar agroforestry is framed as an enterprise pathway with innovation and market-facing roles, supported by basic institutional and capability foundations. While this case is specific to the KHDTK landscape, the underlying mechanism, value-chain upgrading coupled with technology-enabled market access, may be transferable to other NTFP systems seeking to improve youth engagement and enterprise viability.

Limitations

This study has several limitations. First, the cross-sectional design captures perceptions and associations at a single point in time; it does not allow causal inference or assessment of changes in youth participation over time. Second, the sample is modest and drawn from two villages in the KHDTK area of South Sulawesi, which may limit generalizability to other settings. Third, the AHP prioritization is based on respondent and expert judgments; although consistency checks were applied, the resulting weights may still reflect local preferences and contextual assumptions. Future research could use longitudinal designs, larger multi-site samples, and mixed-method validation to test the robustness and broader applicability of the strategy rankings.

In conclusion, this study used an integrated SWOT-AHP approach to prioritize strategies for strengthening youth participation in palm sugar agroforestry in the KHDTK landscape of South Sulawesi. The highest priorities were value-added derivative product innovation and digital/social media marketing, indicating that youth participation is more likely to increase when palm sugar agroforestry is positioned as a market-oriented enterprise pathway rather than solely a traditional production activity. These findings provide a focused basis for local stakeholders to design and sequence youth-oriented interventions that align with local conditions and implementation capacity.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Faculty of Forestry, Universitas Hasanuddin, Indonesia, for the institutional support and research permits provided for this study. Special thanks are also extended to the managers of the Universitas Hasanuddin Educational Forest (KHDTK) and to the communities of Rompegading and Limapoccoe Villages for their valuable time, information, and collaboration during fieldwork. The authors further thank their academic supervisors and colleagues who assisted in data collection and provided constructive suggestions throughout the research process.

REFERENCES

Acharya N, Chaurasia J, Kandel P. 2023. Value-chain analysis of the ginger sub-sector in Salyan District, Nepal. Asian J Agric 7 (2): 76-82. https://doi.org/10.13057/asianjagric/g070202.

Amelia SP, Alzahrah AP, Safira D. 2024. Pengaruh persyaratan usia terhadap peluang kerja bagi tenaga kerja di Indonesia. Terang Jurnal Kajian Ilmu Sosial, Politik dan Hukum 1 (3): 66-75. https://doi.org/10.62383/terang.v1i3.363. [Indonesian]

Bannor RK, Ros-Tonen MAF, Mensah PO, Derkyi M, Nassah VF. 2021. Entrepreneurial behavior among non-timber forest product growing farmers in Ghana: An analysis in support of a reforestation policy. For Policy Econ 122: 102331. https://doi.org/10.1016/j.forpol.2020.102331.

Bayraktar M, Yüksel O. 2023. Analysis of the nuclear energy systems as an alternative propulsion system option on commercial marine vessels by utilising the SWOT-AHP method. Nucl Eng Des 407: 112265. https://doi.org/10.1016/j.nucengdes.2023.112265.

Chin D, Hor S, Seng S, Pok S, Hin L, Yin C, Kin S, Sek N, Nou S, Chhe S, Chhoengsan T, Mol P, Chea C, Eun S, Long L, Shinjo H. 2025. Examining the impacts of land resources and youth education on agricultural livelihood in Battambang Province. Sustainability 17 (15): 6866. https://doi.org/10.3390/su17156866.

de Alcântara MS, de Lucena RFP, da Cruz DD. 2022. Toward sustainable production chain by SWOT-AHP analysis: A case study of Fava d'anta (*Dimorphandra gardneriana* Tulasne) production chain. Environ Dev Sustain 24 (2): 2056-2078. https://doi.org/10.1007/s10668-021-01520-y.

Derebe B, Alemu A. 2023. Non-timber forest product types and its income contribution to rural households in the Horn of Africa: A systematic review. For Sci Technol 19 (3): 210-220. https://doi.org/10.1080/21580103.2023.2231963.

Dey B, Ador MAH, Haque MMU, Ferdous J, Halim MA, Uddin MB, Ahmed R. 2024. Strategic insights for sustainable growth of mushroom farming industry in Bangladesh: A comprehensive evaluation using SWOT-AHP and TOPSIS frameworks. Heliyon 10 (17): e36956. https://doi.org/10.1016/j.heliyon.2024e36956.

Dou Y, Wu J, Li Y, Chen X, Zhao X. 2023. Has the development of the non-timber forest products industry achieved poverty alleviation? Evidence from lower-income forest areas in Yunnan Province. Forests 14 (4): 40776. https://doi.org/10.3390/f14040776.

Du Y, Fujiwara T, Habuer, Zhou Y, Wang J. 2025. Optimising cell phone recycling process: A design science approach integrating blockchain framework, SWOT-AHP strategy, and NFT incentives. Process Saf Environ Prot 197: 107004. https://doi.org/10.1016/j.psep.2025.107004.

Etongo D, Kanninen M, Epule TE, Fobissie K. 2018. Assessing the effectiveness of joint forest management in Southern Burkina Faso: A SWOT-AHP analysis. For Policy Econ 90: 31-38. https://doi.org/10.1016/j.forpol.2018.01.008.

Griffin C, Sirimorok N, Dressler WH, Sahide MAK, Fisher MR, Faturachmat F, Muin AVF, Andary PM, Batiran KB, Rahmat, Rizaldi M, Toumbourou T, Suwarso R, Salim W, Utomo A, Akhmad F, Clendenning J. 2024. The persistence of precarity: Youth livelihood struggles and aspirations in the context of truncated agrarian change, South Sulawesi, Indonesia. Agric Human Values 41 (1): 293-311. https://doi.org/10.1007/s10460-023-10489-5.

Harianja AH, Adalina Y, Pasaribu G, Winarni I, Maharani R, Fernandes A, Saragih GS, Fauzi R, Tampubolon AP, Njurumana GN, Sukito A, Aswandi A, Kholibrina CR, Siswadi S, Kurniawan H, Hidayat MY, Wahyuni R, Koeslulat EE, Heryanto RB, Kuspradini H. 2023. Potential of beekeeping to support the livelihood, economy, society, and environment of Indonesia. Forests 14 (2): 321. https://doi.org/10.3390/f14020321.

Hopid, Ridwan AR, Hamzah A, Rahman SA, Wahyuni PR. 2023. Analisis penyebab rendahnya produksi gula merah Siwalan di Desa Karduluk Kecamatan Pragaan Kabupaten Sumenep. Jurnal Agroteknologi Merdeka Pasuruan 7 (2): 49-53. https://doi.org/10.51213/jamp.v7i2.89. [Indonesian]

Ishizaka A, Labib A. 2011. Review of the main developments in the analytic hierarchy process. Expert Syst Appl 38 (11): 14336-14345. https://doi.org/10.1016/j.eswa.2011.04.143.

Kafle A, Binfield L, Paudel SK. 2023. The commercialization of timber bamboo in Nepal: A SWOT-AHP analysis. Adv Bamboo Sci 4: 100036. https://doi.org/10.1016/j.bamboo.2023.100036.

Kurttila M, Pesonen M, Kangas J, Kajanus M. 2000. Utilising the Analytic Hierarchy Process (AHP) in SWOT analysis: A hybrid method and its application to a forest-certification case. For Policy Econ 1 (1): 41-52. https://doi.org/10.1016/S1389-9341(99)00004-0.

Makarennu, Sabar A, Yumeina D, Nipi GE, Magfira W, Nurhidayah R, Pasau T. 2023. Rantai nilai (value chain) usaha gula aren di Kecamatan Cenrana Kabupaten Maros. Jurnal Hutan dan Masyarakat 15 (2): 107-117. https://doi.org/10.24259/jhm.v12i2.32048. [Indonesian]

Manaf S, Azisah A, Demmallino EB, Syamsuddin S. 2025. Strategic management and mapping of corn farming for sustainable animal feed in Maros District, South Sulawesi, Indonesia. Asian J Agric 9: 542-553. https://doi.org/10.13057/asianjagric/g090221.

Mogea J, Seibert B, Smits W. 1991. Multipurpose palms: The sugar palm (*Arenga pinnata* (Wurmb) Merr.). Agrofor Syst 13 (2): 111-129. https://doi.org/10.1007/BF00140236.

Mujetahid A, Muin AVF, Wulan S. 2023. Potential of Aren (*Arenga pinnata*) in KHDTK Hasanuddin University Educational Forest, Rompegading Village, Cenrana District, Maros Regency. IOP Conf Ser Earth Environ Sci 1277 (1): 012013. https://doi.org/10.1088/1755-1315/1277/1/012013.

Orejudos RD, Duka JU, Baladjay AA. 2022. Factors influencing smallholder cardava banana farmers' participation in collective marketing in Southern Philippines. Asian J Agric 6 (2): 87-96. https://doi.org/10.13057/asianjagric/g060205.

Pasaribu G, Winarni I, Gusti REP, Maharani R, Fernandes A, Harianja AH, Saragih GS, Turjaman M, Tampubolon AP, Kuspradini H, Lukmandaru G, Njurumana GN, Sukito A, Aswandi A, Kholibrina CR. 2021. Current challenges and prospects of Indonesian Non-Timber Forest Products (NTFPs): A review. Forests 12 (12): 1743. https://doi.org/10.3390/f12121743.

Pratiwi MSA, Sugihardjo S, Anantanyu S. 2024. Analisis faktor-faktor yang mempengaruhi minat pemuda untuk berwirausaha pertanian Kecamatan Wonogiri, Kabupaten Wonogiri. Jurnal Triton 15 (2): 400-408. https://doi.org/10.47687/jtv15i2.825. [Indonesian]

Rahman A, Sheikh B, Rahman M. 2020. IFAS and EFAS analysis of maritime region, Bangladesh: Entwining strategical approach. J Bangladesh Inst Plan 13: 29-45. https://doi.org/10.3329/jbip.v13i1.76800.

Robson JP, Wilson SJ, Sanchez CM, Bhatt A. 2020. Youth and the future of community forestry. Land 9 (11): 406. https://doi.org/10.3390/land9110406.

Rozaki Z, Vionanda R, Rahmawati N, Triyono. 2025. Stakeholders' roles and policy effectiveness in organic rice farming development in Central Java and Yogyakarta, Indonesia. Asian J Agric 9 (2): 513-521. https://doi.org/10.13057/asianjagric/g090218.

Saaty TL. 1977. A scaling method for priorities in hierarchical structures. J Math Psychol 15 (3): 234-281. https://doi.org/10.1016/0022-2496(77)90033-5.

Saaty TL. 2008. Decision making with the analytic hierarchy process. Intl J Serv Sci 1 (1): 83-98. https://doi.org/10.1108/JMTM-03-2014-0020.

Shrestha RK, Alavalapati JRR, Kalmbacher RS. 2004. Exploring the potential for silvopasture adoption in south-central Florida: An application of SWOT-AHP method. Agric Syst 81 (3): 185-199. https://doi.org/10.1016/j.agsy.2003.09.004.

Widiono S, Wahyuni ES, Kolopaking LM, Satria A. 2024. Livelihood diversity of rural communities without legal access to forest resources: The case of Kerinci Seblat National Park in Bengkulu Province. For Soc 8 (1): 249-270. https://doi.org/10.24259/fs.v8i1.30947.