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DEVELOPMENT OF A PENTAHELIXIC AQUACULTURE MODEL: A STUDY OF STUDENTS' PARENTS' BUSINESS UNITS

Pengembangan Akuakultur Model Pentaheliks: Studi pada Unit Usaha Orangtua Mahasiswa

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ABSTRACT

The development of small-scale aquaculture enterprises continues to face various challenges in technical, managerial, institutional, and marketing aspects. The Pentahelix model, which involves collaboration among academia, industry, government and financial institutions, associations, and media, has the potential to enhance the sustainability and competitiveness of this sector. This study analyzes the conditions of aquaculture enterprises owned by students' parents and formulates development strategies based on the Pentahelix model. The research employs a descriptive survey method involving 41 aquaculture enterprises, Focus Group Discussions (FGDs) with Pentahelix actors, and SWOT analysis to identify strengths, weaknesses, opportunities, threats, and strategic directions for development. The results show that most enterprises operate on a small scale with limited production and income, are members of fish farmer groups, rely on traditional technologies, and market their products through intermediaries and traditional markets. Technical, managerial, institutional, and marketing challenges require collaborative interventions through the Pentahelix approach. The Pentahelix actors assess that these enterprises possess considerable development potential. The SWOT analysis identifies strengths in farmers' experience and land availability, weaknesses in management and technology, opportunities in inter-actor synergy and market access expansion, and threats from price fluctuations and limited capital. The proposed development strategies emphasize improving technological innovation, business management, institutional strengthening, and optimizing Pentahelix networks to expand market and financial access. Therefore, the integrated implementation of the Pentahelix model can enhance technical, managerial, and marketing capacities, thereby strengthening the competitiveness, sustainability, and generational continuity of small-scale aquaculture enterprises owned by students' parents.

Keywords: Pentahelix, SWOT, Development Strategy, Aquaculture Unit, Student Parents' Business

ABSTRAK

Pengembangan usaha akuakultur skala kecil masih menghadapi berbagai kendala pada aspek teknis, manajerial, kelembagaan, dan pemasaran. Model Pentaheliks yang melibatkan akademisi, pelaku usaha, pemerintah dan lembaga keuangan, asosiasi, serta media, berpotensi memperkuat keberlanjutan dan daya saing sektor ini. Penelitian ini menganalisis kondisi unit usaha akuakultur milik orangtua mahasiswa serta merumuskan strategi pengembangannya berbasis model Pentaheliks. Peneliti menggunakan metode survei deskriptif terhadap 41 unit usaha, Focus Group Discussion (FGD) dengan aktor Pentaheliks, dan analisis SWOT untuk menentukan kekuatan, kelemahan, peluang, ancaman, serta arah strategi pengembangan. Hasil penelitian menunjukkan bahwa sebagian besar unit usaha beroperasi dalam skala kecil dengan produksi dan pendapatan terbatas, tergabung dalam kelompok pembudidaya, masih menggunakan teknologi tradisional, dan memasarkan hasil melalui pengepul dan pasar tradisional. Permasalahan teknis, manajerial, kelembagaan, dan pemasaran memerlukan intervensi kolaboratif melalui pendekatan Pentaheliks. Para aktor Pentaheliks menilai bahwa unit usaha tersebut memiliki potensi pengembangan ke depan. Analisis SWOT menunjukkan bahwa kekuatan utama terletak pada pengalaman pembudidaya dan dukungan lahan, sementara kelemahan mencakup aspek manajemen dan teknologi, peluang muncul dari sinergi antaraktor dan perluasan akses pasar, sedangkan ancaman berasal dari fluktuasi harga serta keterbatasan modal. Strategi pengembangan difokuskan pada peningkatan inovasi teknologi, perbaikan manajemen usaha, penguatan kelembagaan, dan optimalisasi jejaring Pentaheliks untuk memperluas akses pasar dan modal. Dengan demikian, implementasi terintegrasi model Pentaheliks berpotensi meningkatkan kapasitas teknis, manajerial, dan pemasaran, sehingga memperkuat daya saing dan keberlanjutan regenerasi usaha akuakultur orangtua mahasiswa.

Kata kunci: Pentaheliks, SWOT, Strategi Pengembangan, Unit Akuakultur, Usaha Orangtua Mahasiswa

INTRODUCTION

The world population is estimated to exceed 9 billion by 2050, so aquaculture is relied upon to maintain food security (*FAO, 2022*) and provide economic contributions (Boyd *et al*., 2020). However, aquaculture waste and climate change pose challenges that affect production systems and the environment (Heriansah *et al*., 2022, 2024). Amid threats of environmental degradation, small-scale aquaculture is gaining attention (Hossain *et al*., 2023) due to its considerable potential, such as in Indonesia where most ponds are managed traditionally (Wati, 2018). Traditional systems excel in producing organic food, maintaining ecosystem sustainability, and being supported by local knowledge (Jumiati *et al*., 2023). Therefore, the capacity development of small enterprises needs to be carried out so that traditional aquaculture remains competitive and sustainable.

The urgency of this study is based on the phenomenon of low student interest in continuing their parents' traditional businesses. Previous studies revealed that many graduates whose parents work in fisheries prefer to work as employees in institutions, even in fields that are not aligned with their educational background (Ikramullah *et al*., 2020). The study found that traditional family business units are perceived as not guaranteeing welfare, resulting in low interest in continuing them. This lack of human resource regeneration becomes a major challenge that threatens the continuity of agricultural enterprises in Indonesia, especially amid the dominance of the older generation today (Sukayat *et al*., 2023). In addition to supporting the regeneration process, strengthening the capacity of family enterprises is also expected to contribute to sustainable organic food production and facilitate employment opportunities in the face of the demographic bonus.

Systematic and comprehensive mapping of each business unit's capacity is important to understand the problems and needs of each unit, which vary (Fajarwati *et al*., 2023). If systematic and comprehensive understanding in socio-economic and biophysical contexts at the micro scale underlies the design of small-scale (traditional) aquaculture, it can contribute positively to its development and sustainability (Diedrich *et al*., 2019). Capacity profile mapping activities should, in principle, be carried out collaboratively by all stakeholders as an initial step in the intervention plan for enterprise development strategies/programs (Sugiharto *et al*., 2021).

Pentahelix is a model of socio-economic development toward innovation through the collaboration of 5 helices. These five helices interact synergistically according to their roles, namely academia (human resources, technology, higher education tridharma), business sector (business cooperation, networks, capital, CSR), government (policies, incentives, grants, infrastructure), community (source of ideas, interaction platforms), and media (source and disseminator of information, marketing) (Awaluddin & Sule, 2016; Sudiana *et al*., 2020). The pentahelix model is now widely used as a strategic framework for enterprise development. However, its implementation still encounters several obstacles, including in small and medium enterprise units.

The pentahelix model in the development of Manggarsari MSMEs in Surabaya reportedly faces obstacles related to mindset, capital, and the limited social media skills of MSME actors (Beatrice & Hertati, 2023). The development of MSMEs in Wonosari District found that the actors had not optimally carried out their respective roles, particularly due to low coordination among stakeholders and the low active role and readiness of MSMEs (Ishak & Sholehah, 2021). These previous studies indicate that the condition of business units appears to be a common constraint in implementing the pentahelix model, possibly because the involvement of business units at the early planning stage is not optimal.

In implementing the pentahelix model in small and medium enterprises, understanding the profile of business units, including their capacity and needs, becomes an essential foundation so that development strategies align with real conditions and can be implemented effectively. The five-helix approach is considered strategic because each helix has interconnected roles and interests in developing aquaculture enterprise capacity (Fajarwati *et al*., 2023). Development strategies will be less optimal if not based on local conditions (Diedrich *et al*., 2019), especially in aquaculture enterprises that have specific characteristics and high vulnerability. The success and sustainability of programs highly depend on the suitability of strategies with the local context. This study aims to map the capacity profiles and needs of students' parents' business units and formulate strategies for their development and sustainability using the pentahelix model.

METHODS

This study applies a qualitative approach that aims to provide an in-depth understanding of the data or facts collected. This approach was chosen because this study aims to map the actual conditions and analyze strategies to achieve the desired future conditions (Supriati *et al*., 2022). The data used come from two types of sources, namely primary data and secondary data. Primary data were obtained directly from respondents and other related parties through in-depth interviews, questionnaires, and focus group discussions (FGD). Meanwhile, secondary data were collected through literature reviews sourced from reliable references.

The unit of analysis or population in this study is the parents of students at the Institut Teknologi dan Bisnis Maritim (ITBM) Balik Diwa, particularly from the Aquaculture Study Program, which is relevant to aquaculture activities. The family environment of students must become the object of study activities to support enterprise development (Ikramullah *et al*., 2020). The number of active students in this study program recorded at the time the study was

conducted was 126 students. The sample was determined through purposive sampling with the following criteria:

a. The regency where the parent's business unit is located in South Sulawesi Province represents the largest number of students.
b. The village location in each regency is within the administrative area that directly overlaps.
c. The student's parent's business unit is fish, shrimp, and/or seaweed aquaculture.
d. The ownership status of the aquaculture business unit is self-owned (not a tenant or tenant).

The identification of the fulfillment of criteria has been carried out through interviews with students, and the results show that there are 71 business units of students' parents that meet the requirements. Furthermore, by using the Slovin formula n=N/1+N(e2)n = N / 1 + N (e^2)n=N/1+N(e2) at a confidence interval of 99%, 41 respondents were obtained as samples distributed across 7 (seven) regencies, including Maros Regency, Pangkep, Gowa, Takalar, Bulukumba, Sinjai, and Bone (Figure 1). The number of samples in each regency was determined proportionally based on the distribution of students in each regency.

The fieldwork design was supported by a structured questionnaire as an interview guide. The questionnaire was designed with a typology of open and closed questions and a Likert scale (values 4, 3, 2, and 1) with aspects referring to several previous studies (Diedrich *et al*., 2019; Fajarwati *et al*., 2023; Hossain *et al*., 2023; Rimmer *et al*., 2013; Sugiharto *et al*., 2021; Sukayat *et al*., 2023). These aspects include socio-economic aspects, aquaculture practices, institutional aspects, problems, and support needs.

Figure 1. Research location

Data collection was carried out offline to allow direct observation of the respondents' locations and activities. Students accompanied their parents during the interviews, while separate interviews were also conducted with the Village Head, BUMDes, extension officers, local entrepreneurs, and the head of Pokdakan to obtain information regarding village conditions as well as potentials and problems, aquaculture activities. The data obtained were analyzed descriptively to illustrate the capacity profiles and needs of the business units of students' parents. The results of the business unit profile analysis served as the basis for the Focus Group Discussion (FGD) involving the five pentahelix actors, namely academia, the business sector, government and banking, associations (community), and media (influencers). The FGD material began with a presentation on the business unit profiles of students' parents. Subsequently, active and in-depth brainstorming was carried out with all FGD participants regarding:

1. Perceptions of each pentahelix actor toward the business unit profiles of students' parents
2. Main concerns of each pentahelix actor for the next 1–5 years in their relevance to the development and sustainability of the business units of students' parents

3. Potential problems faced by each pentahelix actor in their relevance to the development and sustainability of the business units of students' parents
4. Support that can be provided by each pentahelix actor in their relevance to the development and sustainability of the business units of students' parents

The FGD data were then analyzed using SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) to identify the strengths and weaknesses (internal factors) as well as opportunities and threats (external factors) of the business units of students' parents. Internal factors were included in the IFAS (Internal Factors Strategic Analysis) matrix and external factors were included in the EFAS (External Strategic Analysis Factors) matrix. Subsequently, the analysis was incorporated into the qualitative SWOT Matrix model to formulate business development strategies (Rimmer *et al*., 2013; Supriati *et al*., 2022).

RESULTS

The profile of the aquaculture business unit of the students' parents provides an overview of the socioeconomic characteristics, aquaculture practices, institutions, major obstacles faced, and actual needs in the field. Figure 2 presents social characteristics, including age, formal education, business experience, business unit size, number of family members, empty yard area, and type of aquaculture business. Figure 3 presents the economic characteristics of the students' parents' business unit, including aspects of production volume, revenue, profits, and the marketing system implemented. Meanwhile, Figure 4 illustrates the aquaculture system used, including the application of production technology and utilization of land carrying capacity, as well as institutional characteristics related to the form and organizational structure of the aquaculture business unit.

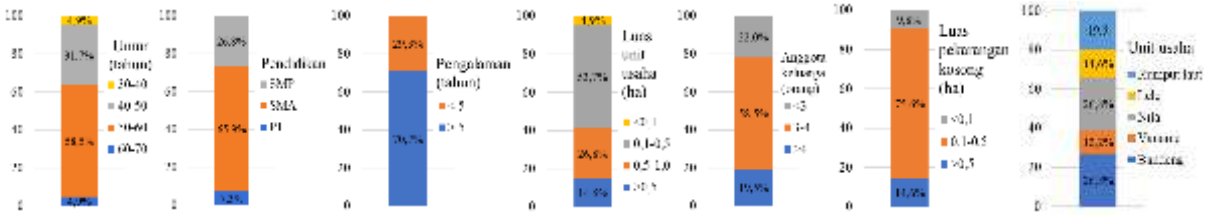

Figure 2. Social characteristics

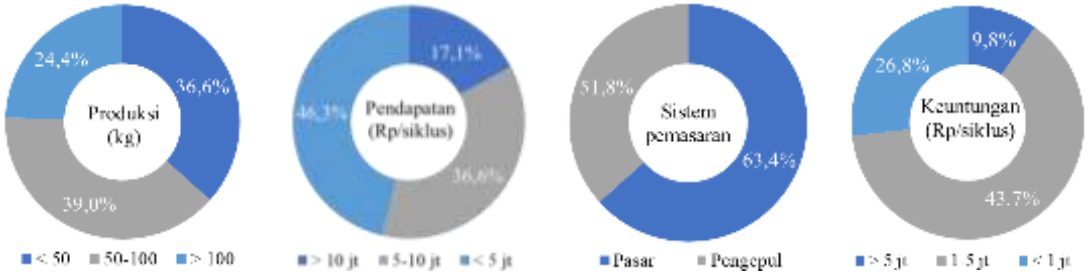

Figure 3. Economic characteristics

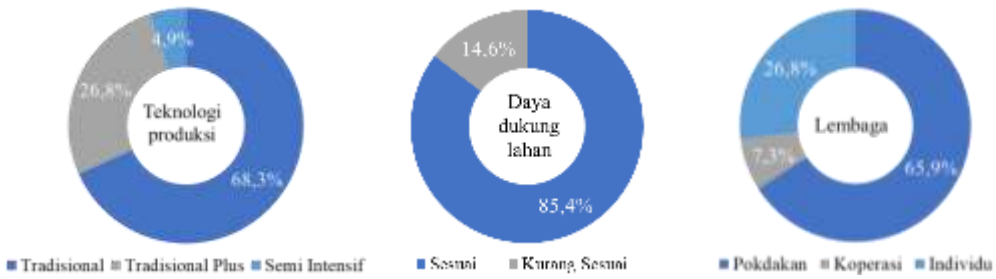

Figure 4. Aquaculture systems and institutions

Identification of problems faced by the student parents' business units, including technical aspects, business management, institutional, and marketing as well as the need for business development support is presented in Table 1. The profile data of the student parents' business units was then used as brainstorming material in Focus Group Discussion (FGD) activities involving 5 main elements of the pentahelix, including academics, entrepreneurs, local governments and banks, farmer associations, and media/influencers. Table 2 presents the perceptions, concerns, potential problems, and forms of support from each pentahelix actor.

Table 1. Business support problems and needs

Aspect	Problem	Support needs
Technical	1. Poor seed quality and difficulty in obtaining it consistently. 2. Use of simple/traditional aquaculture technology. 3. Limited knowledge of water quality management, feed, and disease control. 4. Inadequate infrastructure and production facilities.	1. Access to superior and certified seeds 2. Training in the application of appropriate aquaculture technology 3. Technical aquaculture training covering water quality management, feed, and disease control 4. Assistance with production facilities and infrastructure
Business management	1. Unstructured production planning 2. Unsystematic financial recording 3. Limited working capital for purchasing feed and seeds 4. Low access to formal financial institutions	1. Business management and entrepreneurship training, including business planning, financial record-keeping, and cost-profit analysis. 2. Access to capital and business credit with low interest rates and simple procedures.
Institutional	1. The weak role of fish farming groups (pokdakan) in strengthening their bargaining position and market access. 2. Suboptimal partnerships between farmers and large businesses. 3. Lack of coordination between group members in managing production and marketing activities. 4. Limited support from government or private institutions.	1. Strengthening the capacity of small-scale farmers through organizational, leadership, and group collaboration training. 2. Facilitating business partnerships between farmers and cooperatives, processing industry players, and marketing institutions. 3. Enhancing the role of extension institutions and technical assistance. 4. Supporting local government policies that favor small-scale farmers.
Marketing	1. Dependence on collectors as the primary marketing channel, resulting in low selling prices. 2. High and unpredictable product price fluctuations. 3. Limited market information and marketing networks.	1. Facilitating market access through partnerships with large collectors, restaurants, hotels, and fishery processing industries. 2. An easily accessible price and market information system so farmers can determine competitive

	4. Lack of promotional capabilities and use of digital media for product sales. 5. Lack of post-harvest facilities that can extend product shelf life.	selling prices. 3. Training in digital marketing and the use of social media or marketplaces to expand consumer reach. 4. Provision of simple post-harvest and processing facilities.

Table 2. Results of the Pentahelix Model FGD

Actor	Perception	Main Concern	Potential Problem	Support
Academics	Business units have potential but are weak in terms of technology and management	Appropriate and sustainable technological innovation	Low technology adoption and limited synergy with universities	Research, technical training, community service programs (KKN), and mentoring
Entrepreneurs	Market potential is adequate, but supply and quality are limited	Sustainability of supply and assurance of product quality	Quality variation and absence of business contracts	Supply partnerships and purchase contracts
Local government and banking institutions	Business units are not formally recorded and receive minimal intervention; high credit risk	Integration with regional development; strengthening community-based microcredit	Overlapping policies; weak financial record-keeping	Equipment assistance, training, capital, and licensing; microcredit schemes and financial literacy
Associations	Participation in associations is still low and networking is limited	Consolidation and advocacy for small-scale farmers	Low group activity and weak representation of stakeholders	Organizational facilitation and business networking training
Media	Lack of exposure for business units	Increasing visibility and positive image of aquaculture	Lack of engaging content from business actors	Digital promotion and branding training

Table 3 below presents a SWOT matrix that summarizes the results of identifying the profiles of student parents' business units and input from pentahelix actors..

Table 3. SWOT Matrix

Internal Factors		Weight	Rating	Score
Strength (S)	1. Long-standing business experience	0,15	4	0,60
	2. Adequate land and adequate carrying capacity	0,15	4	0,60
	3. Presence of a Farming Group (Pokdakan)	0,10	3	0,30
	4. Diversity of commodities	0,10	3	0,30
	Total (S)	0,50	-	1,80
Weakness (W)	1. Limited seed technology and quality	0,15	2	0,30
	2. Minimal business management	0,10	2	0,20
	3. Limited working capital	0,10	2	0,20
	4. Limited infrastructure and marketing	0,10	2	0,20
	5. Limited promotion	0,05	2	0,10
	Total (W)	0,50	-	1,00
External Factors				
Opportunity (O)	1. Support from pentahelix actors	0,15	4	0,60
	2. Business partnerships and contracts	0,10	3	0,30
	3. Government programs and microcredit	0,10	3	0,30
	4. Digital media and influencers	0,10	3	0,30
	5. Aquaculture market growth	0,05	4	0,20
	Total (O)	0,05	-	1,70
Threat (T)	1. Product price fluctuations	0,10	2	0,20
	2. Market competition	0,10	2	0,20
	3. Biological risks	0,10	2	0,20
	4. Policies and bureaucracy	0,05	2	0,10
	5. Lack of networks and associations	0,05	2	0,10
	Total (T)	0,40	-	0,80

DISCUSSION

Business unit profile

The profile of the aquaculture business units of students' parents shows social diversity that reflects the dynamics of small-scale fisheries. The majority of actors are aged 50–60 years with limited adoption of digital technology, while the younger age group (30–40) is low, indicating minimal regeneration of business actors (Anwarudin *et al*., 2020). Most have a secondary education with moderate adaptive capacity to production technology, yet require enhanced digital skills and business analysis (Setiawan, 2024). Long-standing business experience becomes an important social capital in management and innovation (Fajarwati *et al*., 2023; Ikramullah *et al*., 2022). Business units are managed on small land areas (<0.5 ha) with family labor, dominated by milkfish and tilapia, and some develop shrimp Litopenaeus vannamei and seaweed as adaptive strategies to market demand and local ecological conditions. The economic profile of the aquaculture business units of students' parents shows diversity with small to medium production scales and varying efficiency. Most produce <100 kg per cycle for household needs and are not yet integrated into supply chains, while a small portion applies semi-intensive systems >100 kg per cycle with commercial orientation. Income is dominated by the low–middle group (<Rp5 million per cycle) due to limited capital, skills, market access, and traditional technology. Dependence on collectors reduces margins, while direct marketing increases added value. Profits for the majority <Rp5 million per cycle indicate low economic efficiency. These findings emphasize the importance of innovation and efficient management in improving the performance of small enterprises in the capital-intensive aquaculture sector (Rimmer *et al*., 2013).

The profile of aquaculture systems and institutional structures of the business units of students' parents shows diversity in technology application, land suitability, and institutional participation. The majority use traditional systems with low productivity, while a small portion adopts semi-intensive systems that increase output through water quality management, measured feeding, aeration, and disease control. Land carrying capacity determines production efficiency and business resilience, while involvement in farmer groups or cooperatives strengthens access to information, capital, and markets. The findings underscore that strengthening local institutions and implementing ecosystem-based technology are key strategies for enhancing competitiveness and sustainability of small-scale aquaculture (Diedrich *et al*., 2019; Rimmer *et al*., 2013).

Based on the social, economic, aquaculture system, and institutional profiles, the application of the Pentahelix approach becomes a comprehensive strategy for developing competitive and sustainable aquaculture businesses. The diversity of actor characteristics, such as older productive age, secondary education, and small-scale operations, demands cross-sectoral collaboration to enhance human resource capacity and technology adoption (Hossain *et al*., 2023). The government provides regulations and facilities, academics disseminate innovations, business actors strengthen supply chains, communities build social networks, and media support publication. This synergy promotes modernization of production and institutions, forming a local innovation ecosystem that is adaptive to market dynamics and environmental challenges, making the Pentahelix model a strategic foundation for inclusive and innovative aquaculture development (Diedrich *et al*., 2019; Kiak & Ratu, 2023).

Problems and support needs

The aquaculture business units of students' parents face technical, managerial, institutional, and marketing constraints that reduce production efficiency. Major problems include low seed quality, limited cultivation technology, weak operational management, and minimal infrastructure. The use of traditional technology and limited knowledge of water, feed, and disease management increase fish mortality and reduce productivity. To overcome these issues, cross-sectoral collaboration through the Pentahelix model needs to be strengthened by involving academics, government, financial institutions, business actors, communities, and media. This synergy can enhance technical capacity, expand access to superior seeds and appropriate technology, and strengthen production facilities to achieve efficient and sustainable aquaculture (Kiak & Ratu, 2023; Rimmer *et al*., 2021).

The aquaculture business units of students' parents face managerial constraints that limit productivity and business sustainability. Major obstacles include unsystematic production planning, weak financial recording, limited working capital, and low access to formal financial institutions. Irregular planning and the absence of financial records hinder cost analysis, profitability evaluation, and resource efficiency (Nurafifah *et al*., 2025). Limited working capital slows technology adoption and business expansion, while procedural barriers and lack of information reduce access to banking. These conditions highlight the need for the Pentahelix model involving academics, business actors, government and banking, communities, and media to strengthen managerial capacity and promote sustainability of household aquaculture. The aquaculture business units of students' parents face institutional problems related to weak roles of farmer groups (pokdakan), partnerships, and external institutional support. Although most are members of farmer groups, their institutional structure remains weak, resulting in low bargaining power, coordination, and market access. Partnerships with cooperatives, processing industries, and modern markets are not optimal, causing dependence on local markets with low profit margins. Limited technical support, extension services, and government policies further hinder institutional strengthening (Chamidah *et al*., 2021). These issues underline the need for

Pentahelix collaboration to strengthen farmer institutions, expand business partnerships, and promote supportive policies for small-scale aquaculture.

The aquaculture business units of students' parents face marketing problems that limit profits and business sustainability. Major constraints include dependence on collectors, price fluctuations, limited market information, minimal promotional capability, and limited post-harvest facilities. Product prices are often below market value and experience seasonal instability, complicating production planning. Limited information and lack of digital promotion restrict market reach, while the absence of cooling or simple processing facilities limits access to wider markets (Fauzan & Susilo, 2025). Pentahelix collaboration is needed to strengthen partnerships, provide market information, enhance digital marketing capacity, and support post-harvest facilities for farmers.

FGD of Pentahelix actors

Academic perceptions indicate that the business units of students' parents have basic capacity, yet technology remains simple and management is suboptimal, aligning with the findings of Diedrich *et al*., 2019 and Rimmer *et al*., (2021) that household-scale farming is limited in technological and managerial innovation. Low technology adoption results from limited knowledge, implementation costs, and ineffective academic partnerships. Academics can support through applied research, technical training, student involvement, and technology adoption assistance. This continuous support increases productivity, efficiency, and competitiveness while implementing a synergistic Pentahelix model for small-scale aquaculture development.

Business actors perceive that the aquaculture market is substantial, yet inconsistent supply and variable product quality hinder sustainable business (Tran *et al*., 2022). They emphasize the need for improved production management and quality standardization, including size, freshness, and product safety, so that business units meet market demand and enhance competitiveness. Variation in fish size and feed quality are major challenges, while the absence of formal purchase contracts creates risks of price and supply uncertainty. Partnerships between business actors and business units can ensure stable supply, set prices, quality, and purchase volumes, and foster effective Pentahelix development. Local government perceptions indicate that many business units of students' parents are not officially registered, limiting policy intervention and development programs (Rahmawati *et al*., 2025). Banks assess credit risk as high due to limited collateral, business legality, and unsystematic financial records, reducing access to capital and microcredit (Nurafifah *et al*., 2025). Government and banking emphasize the need for integration of business units into regional programs to obtain technical assistance, grants, production facilities, and credit schemes suited to group capacity. This support can enhance production capacity, business formalization, financial management, and access to financing while strengthening Pentahelix development in local economic growth.

Farmer association perceptions indicate that low involvement of business units in organizations weakens networks and representation at regional and national levels (Rimmer *et al*., 2021). Associations emphasize member consolidation and advocacy for small farmers to increase participation in business networks. Main issues include weak group coordination and low representation, limiting access to government programs, industrial partnerships, and markets. Associations can support through assistance in forming formal groups, business networking training, advocacy strategies, and strengthening bargaining power. Strong institutions facilitate technology transfer and market information, reinforcing Pentahelix synergy.

Media (influencers) perceive that aquaculture business units of students' parents lack public exposure, so product potential and innovation remain less known (Fauzan & Susilo,

2025). Media emphasize the importance of branding and digital promotion to attract consumers, investors, and industry. Main issues include limited knowledge of digital marketing strategies, reducing product visibility. Media can support through branding training, content creation, social media utilization, online marketing strategies, and publication facilitation via influencers or local/national media. Increased visibility expands markets, enhances added value, and strengthens the positive image of aquaculture within the Pentahelix framework.

Development strategy

Based on the SWOT matrix in Table 3, four main strategy groups (SO–WO–ST–WT) can be implemented by each Pentahelix actor for developing the business units of students' parents, as shown in Table 4. The total scores for strengths (S), weaknesses (W), opportunities (O), and threats (T) are 1.80, 1.00, 1.70, and 0.80, respectively. The difference between positive and negative factors in the internal aspect (S–W) is 0.80 (strong internal) and in the external aspect (O–T) is 0.90 (supportive external environment). Since both values are positive, the strategy position is in Quadrant I (SO strategy). This position indicates that the aquaculture business units of students' parents are in an aggressive (growth-oriented) position with strong internal strengths and substantial external opportunities. Therefore, the main development strategy should utilize strengths and opportunities while minimizing weaknesses and threats through the support of Pentahelix actors (academics, business actors, government and banking, associations, and media).

Table 4. Development strategy for student parents' business units and implementing helix actors

Internal / External Factors	Opportunities (O): Support from pentahelix actors, business partnerships and contracts, government programs and microcredit, digital media and influencers, and the growth of the aquaculture market	Threats (T): Product price fluctuations, market competition, biological risks, policies and bureaucracy, and limited networks and associations
Strengths (S): Long business experience, adequate land and carrying capacity, existence of farmer groups (Pokdakan), and commodity diversity	SO (Aggressive) Strategy a. Optimizing experienced human resources for the adoption of new technologies (academia) b. Utilizing large areas of land for the expansion of high-value commodities in line with market growth (academia) c. Strengthening partnerships with industry and government through community groups (pokdakan) for access to microcredit and sales contracts (entrepreneurs, government, and banks) d. Product promotion through digital media to expand the market and strengthen local branding (media)	ST Strategy (Diversification/Protective) a. Implement biosecurity and disease control (academics and government) b. Utilize land and commodity diversity to reduce the risk of price fluctuations and market competition (academics, government, and entrepreneurs) c. Strengthen the group's bargaining position against collectors through coordination and networking between farmer groups (entrepreneurs, associations, and entrepreneurs)

Weaknesses (W): Limited seed technology and quality, minimal business management, limited working capital, limited infrastructure and marketing, and limited promotion.	Capacity Building Strategy (WO) a. Training in business management and modern technology b. Access to government microcredit programs to increase capital and production infrastructure (government) c. Establishing business partnerships for more efficient and sustainable marketing (entrepreneurs and associations) d. Increasing promotion and market reach (media and entrepreneurs)	WT (Defensive) Strategy a. Improve business management and record-keeping systems to address price and regulatory uncertainty (banking) b. Form associations or networks among fish farmers to strengthen advocacy on market policies and risks (associations and entrepreneurs) c. Increase production cost efficiency with simple technological innovations to remain competitive (academics)

CONCLUSION

The aquaculture business unit owned by the students' parents has considerable potential in terms of land area, commodity diversification, and farmer experience. However, it still faces limitations in technology, business management, post-harvest facilities, and market access. These challenges can be addressed through technical and management training, institutional strengthening, facilitating access to capital, and utilizing the Pentahelix network involving academics, entrepreneurs, government and banking institutions, associations, and the media. A SWOT analysis-based development strategy demonstrates the need to leverage strengths and opportunities to improve innovation, product quality, and marketing, while mitigating weaknesses and threats through internal capacity building and risk management. This will ensure sustainable farmer regeneration and the competitiveness of the aquaculture business unit.

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