



Sustainable Derivative Product Innovation as a Strategy to Strengthen Capacity and Independence of Duck Farmers in Suak Sigadeng Village, Aceh Province

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Abstract: This community service program aims to strengthen the institutional capacity of duck farmer groups and promote local economic independence through knowledge transfer and the application of appropriate technology to produce value-added livestock products within a zero-waste farming system. The program was implemented in four stages: counseling, training, technology implementation, and mentoring and evaluation, involving the Beujroh Women Farmers' Group (KWT), the Baro Tabina Farmers' Group, and the surrounding community. A total of 40 participants from the Beujroh Women Farmers' Group (KWT) and the Baro Tabina Farmers' Group in Suak Sigadeng Village, West Aceh Regency, Aceh Province, participated in the program. Program effectiveness was evaluated using a pre-test–post-test design involving all participants. Data were analyzed using the Normalized Gain (N-Gain) index, paired *t*-test, Wilcoxon signed-rank test, and Cohen's *d* effect size. The results showed that the average empowerment score increased from 1.43 to 3.51, representing a 146.2% improvement, with an average N-Gain score of 0.81 (high category). All seven empowerment indicators achieved high N-Gain values (0.75–0.85), with the highest gain observed in pellet machine operation (0.85) and the lowest in biosecurity practices (0.75). Both the paired *t*-test and Wilcoxon signed-rank test indicated statistically significant improvements across all indicators ($p < 0.001$), supported by very large Cohen's *d* effect sizes (4.03–10.91). These findings suggest that the mentoring program effectively enhanced participants' empowerment in a consistent and practically meaningful manner, supported the adoption of circular economy principles, and contributed to strengthening local economic independence through sustainable duck farming.

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Introduction

Sustainable national development requires strengthening economic independence at the rural level by optimizing the potential of natural and human resources. One sector with strategic value is duck farming, which contributes to food security, animal protein supply, job creation, and increased income for rural communities (Izwar et al., 2024). Duck farming also has good economic prospects because it produces meat and eggs, which have stable market demand (Rahman et al., 2019; Elly et al., 2015; Matitaputty & Bansi, 2018). Livestock development is generally carried out in rice paddy agroecosystems, especially after the rice harvest when natural forage is abundant. Business productivity is influenced by the husbandry system implemented, namely extensive, semi-intensive, or intensive, each of



which has different management characteristics (Gandia et al., 2023; Melinda & Alatas, 2024).

Despite its significant potential, duck farming still faces various obstacles, particularly the high risk of infectious diseases such as duck plague and duck cholera. The disease can cause high levels of discomfort and mortality, with infection prevalence reaching 52% in some areas and mortality rates as high as 29.71%, particularly on farms with poor biosecurity (Khan et al., 2018; Rahman et al., 2009; Hoque et al., 2011; Chakraborty et al., 2024; Islam et al., 2016). Furthermore, feed costs are a major challenge, contributing approximately 72–87% of total production costs (Uddin et al., 2020).

These problems are generally driven by weak business management, including biosecurity implementation, vaccination, waste management, and limited access to animal health services (Agbolosu & Aawona, 2021). Therefore, increasing the capacity of livestock farmers through training and mentoring on biosecurity, disease control, vaccination, waste management, carcass handling, and the application of livestock technology is an important step to increase productivity, business cessation, and livestock farmer welfare (Islam et al., 2025).

Despite its promising economic potential, the reality on the ground shows that most duck farms in rural areas are still managed traditionally and subsistence-based. This situation also occurs in Suak Sigadeng Village. Farmers in this region generally rely on conventional farming methods with a heavy reliance on the sale of primary products, namely fresh eggs and live ducks. This reliance on raw products places farmers in a weak bargaining position in the supply chain, where selling prices are largely determined by middlemen. When production is abundant, the price of fresh eggs often drops sharply, while the cost of commercial feed continues to rise year after year. This price fluctuation narrows farmers' profit margins and hinders the achievement of sustainable financial independence at the household level. Therefore, a comprehensive business analysis is essential to determine profitability, efficiency, and the various challenges faced by farmers (Handayani, 2022). Furthermore, the results of this analysis can serve as a basis for developing more effective and targeted mentoring programs (Prasetyo & Ningsih, 2021).

Furthermore, most duck farms in rural areas are currently managed using traditional, conventional systems, primarily to meet daily needs or for subsistence purposes. This stagnant situation is also evident in Suak Sigadeng Village. Farmers in this region generally still rely on rudimentary husbandry methods passed down through generations, lacking the touch of modern management practices. This phenomenon is exacerbated by the farmers' heavy reliance on the sale of primary or raw products, namely fresh eggs and live ducks.

Suak Sigadeng Village, a suburban area (the boundary between urban and rural areas), is a developing area. The development of Meulaboh City has influenced the development of Suak Sigadeng Village, both positively and negatively. The distribution of jobs in Suak Sigadeng is largely focused on the agricultural and livestock sectors (Izwar et al. 2025). Another fundamental problem faced by livestock farmers in Suak Sigadeng Village is limited knowledge and skills in downstream product processing. Innovation in post-harvest technology and the processing of derivative products has not yet reached the livestock farming community evenly. Yet, diversification of duck-based derivative products, such as processed salted eggs in various flavors, preserved meat, and the utilization of byproducts, offers significant added value potential. Without product innovation, livestock farmers lack alternative income sources during sluggish fresh produce markets. Innovation in the



formulation of alternative feed using local raw materials is crucial to support the efficiency and sustainability of livestock businesses (Hidayah & Ramdani, 2020).

Farmers' reliance on fresh egg sales without processing positions reduces their bargaining power in the marketing chain. Product prices are generally determined by middlemen, so that during times of abundant production, egg prices often fall to the point where they cannot cover production costs. This situation is exacerbated by the continued rise in commercial feed prices, narrowing profit margins and hindering farmers' economic independence.

Beyond economic challenges, livestock farming also poses environmental challenges due to suboptimal waste management. Improperly managed manure and feed residues have the potential to cause pollution, odor, and the spread of disease. Therefore, the application of a circular economy concept through the utilization of waste into economically valuable products, such as organic fertilizer and alternative energy sources, needs to be developed. Waste management can be achieved by adding lime to reduce odor and processing manure mixed with humus and plant residues into organic material (Erliyanti et al., 2023).

These issues highlight the need for planned, participatory, and sustainable community service programs. Capacity building for farmers is aimed at empowering them not only as raw material producers but also as agro-industrial players through improved business management, product processing, digital marketing, and integrated waste management. On the other hand, the success of a laying duck business is greatly influenced by sound financial management, livestock health, and marketing strategies (Sutrisno & Lestari, 2021). Improving farmer knowledge and skills can be achieved through ongoing extension and technical training (Izwar et al., 2024).

This community service program develops innovative egg-based derivative products and sustainable livestock farming, including the production of high-quality salted eggs, hygienic salted egg crackers, the production of azolla-based pellets, and empowering the provision of seed. Through knowledge transfer, the application of appropriate technology, and the implementation of a low-waste livestock system, this activity aims to increase group capacity, farmer technical skills, and community economic independence. This program is expected to become a model for sustainable village empowerment and can be replicated in other regions in Indonesia.

Method

This community service activity was conducted at the Community Service Partner Location, Suak Sigadeng Village, Johan Pahlawan District, West Aceh Regency, Aceh Province, Indonesia. This activity involved 40 residents as participants, who were members of the Beujroh KWT and the Baro Tabina Farmers Group. The community service activity was implemented through four stages: outreach, training, technology implementation, and mentoring and evaluation for the Beujroh and Baro Tabina KWT partner groups and the surrounding community.

- a) The outreach was conducted to increase partners' understanding of duck farming business development, utilization of local resources, and diversification of salted egg products.
- b) The training included duck disease prevention, online shop-based product marketing, market expansion analysis, and the production of salted egg derivative products such as salted egg crackers and steamed eggs.



- c) Technology implementation is carried out through the use of duck egg incubators, pellet production machines based on local materials, and processing technology for salted egg derivative products.
- d) Mentoring and evaluation are conducted periodically on the implementation of the agroforestry-silvopasture duck farming system, disease prevention, egg incubator use, pellet production, and processing of salted egg derivative products. Evaluation is based on the achievement of program indicators, including increased knowledge, skills, and technology application by partners.

Quantitative analysis was conducted by calculating the score difference, percentage increase, and N-Gain using the Hake (1998) formula, with high ($g \geq 0.7$), medium ($0.3 \leq g < 0.7$), and low ($g < 0.3$) categories. The assessment included business development, azolla feed utilization, biosecurity, digital marketing, product diversification, and the operation of hatching and pellet machines. Significant increases in 40 respondents were tested using paired t-tests and Wilcoxon signed-rank tests, while practical significance was measured using Cohen's d. Qualitative analysis was conducted descriptively to interpret changes based on field conditions and the empowerment and circular economy framework.

Result and Discussion

The Community Service Program was implemented at the Beujroh Women's Farmers Group (KWT) and the Baro Tabina Farmers Group in Suak Sigadeng Village. The program was designed to increase the capacity of farmers in duck farming, production efficiency, product diversification, and digital-based marketing. The program was implemented in stages through outreach, training, mentoring, and the introduction of appropriate technology, ensuring that participants not only gained knowledge but also implemented the technology in their daily business activities. Prior to the program, field observations and discussions with partners were conducted. The results indicated that most farmers still used traditional farming systems. Feed use was still dependent on commercial feed, resulting in relatively high production costs. Furthermore, disease control was carried out simply based on experience, thus not implementing sound biosecurity principles. Marketing still relied on regular customers and local markets, thus limiting market reach. Products produced were also dominated by fresh eggs and salted eggs, with no diversification into processed products with higher added value.

Duck management by farmers remains suboptimal, characterized by minimal supervision, reliance on natural feed and household waste, and the provision of commercial feed only at the beginning of the farm. This situation makes farmer competence a critical factor influencing duck egg productivity (Rahmi et al., 2025). Based on these conditions, the community service program focused on improving human resource capacity and implementing appropriate technology. This approach is expected to increase business productivity, production cost efficiency, and the competitiveness of duck farming products.

Quantitative Analysis per Indicator

The effectiveness of a mentoring program in improving partner empowerment cannot be measured solely by the difference in scores before and after the intervention, as the magnitude of the increase is strongly influenced by the initial scores of each indicator. Therefore, N-Gain analysis was used to more accurately measure the effectiveness of improving partner knowledge and skills, as this method normalizes the difference in scores against the theoretically achievable maximum improvement range. The analysis was conducted on seven empowerment indicators: understanding business development,



utilization of local feed, disease prevention (biosecurity), digital marketing, product diversification, incubator operation, and pellet machine operation. The results of the N-Gain calculation for each indicator, along with their categorization, are presented in Table 1.

Table 1. Before- jAfter Scores, Differences, Percentage Improvement, and N-Gain per Indicator

No	Empowerment Aspects/Indicators	Score Before	Score After	Difference (Δ)	Improvement (%)	N-Gain	Category N-Gain
1	Understanding Business Development	1,43	3,55	2,13	149,1%	0.83	high
2	Utilization of Local Feed	1,47	3,52	2,06	140,6%	0.81	high
3	Disease Prevention (Biosecurity)	1,46	3,38	1,92	131,2%	0.75	high
4	Digital Marketing	1,52	3,46	1,94	127,3%	0.78	high
5	Product Diversification	1,38	3,50	2,13	154,0%	0.81	high
6	Operation of the Incubator	1,38	3,55	2,17	157,2%	0.83	high
7	Pellet Machine Operation	1,34	3,60	2,25	167,7%	0.85	high
	Average	1,43	3,51	2,08	146,2%	0.81	high

The data in Table 1 show that all seven indicators are in the high N-Gain category ($g \geq 0.7$), with a range of 0.75-0.85. The indicator with the highest relative increase is pellet machine operation (N-Gain 0.85), followed by incubator operation (0.83) and understanding of business development (0.83). Conversely, the disease prevention/biosecurity indicator recorded the lowest N-Gain (0.75), although it remains in the high category, indicating that changing biosecurity-related behavior is relatively more demanding in terms of time and consistency than mastering technical-mechanical skills such as machine operation. The consistency of all indicators in the high category strengthens the validity of the conclusion that the mentoring program has an even impact on all dimensions of empowerment measured, rather than just being concentrated in certain aspects.

Inferential Statistical Analysis (Paired Difference Test)

To test the statistical significance of the increase in empowerment scores, a paired t-test was conducted, confirmed with a Wilcoxon signed-rank test, and Cohen's d effect size was calculated to assess the practical impact of the mentoring program. The results of the test on the seven empowerment indicators and the overall average are presented in Table 2.

Table 2. Paired t-Test and Wilcoxon Signed-Rank Test Results per Indicator (N = 40)

Aspects/Indicators	N	Mean $\pm$ SD Before	Mean $\pm$ SD After	t (df)	p (uji-t)	P (Wilcoxon)	Cohen's d
Understanding Business Development	40	1,42 $\pm$ 0,32	3,55 $\pm$ 0,22	37.78 (39)	<0,001	<0,001	5.97
Utilization of Local Feed	40	1,46 $\pm$ 0,39	3,52 $\pm$ 0,27	27.16 (39)	<0,001	<0,001	4.29



Aspects/ Indicators	N	Mean±SD Before	Mean±SD After	t (df)	p (uji-t)	P (Wilcoxon)	Cohen's d
Disease Prevention (Biosecurity)	40	1,46 ± 0,30	3,38 ± 0,21	30.30 (39)	<0,001	<0,001	4.79
Digital Marketing	40	1,52 ± 0,35	3,46 ± 0,29	25.49 (39)	<0,001	<0,001	4.03
Product Diversification	40	1,38 ± 0,26	3,50 ± 0,23	39.76 (39)	<0,001	<0,001	6.29
Operation of the Incubator	40	1,38 ± 0,35	3,55 ± 0,34	35.82 (39)	<0,001	<0,001	5.66
Pellet Machine Operation	40	1,35 ± 0,23	3,60 ± 0,28	37.11 (39)	<0,001	<0,001	5.87
Rata-rata Keseluruhan	40	1,42 ± 0,15	3,51 ± 0,14	68.99 (39)	<0,001	<0,001	10.91

Table 2 presents the results of statistical significance testing based on the individual scores of 40 respondents. The paired t-test results indicate that the increase in scores on all seven indicators and the overall average is statistically significant at the 99.9% confidence level ($p < 0.001$). This result is confirmed by the Wilcoxon signed-rank test, which also shows significance at the same level ($p < 0.001$) for all indicators, so the conclusions do not rely on the assumption of normality of data distribution. Cohen's d values ranged from 4.03 to 6.29 for each indicator, reaching 10.91 for the overall average score, far exceeding the conventional threshold for a “very large effect” ($d \geq 0.8$), indicating that the difference in pre- and post-activity scores was not only statistically significant but also practically meaningful. The large Cohen's d is also supported by the relatively small standard deviation (SD) of scores at each measurement stage, indicating a relatively uniform improvement response among the 40 respondents, rather than being driven by a handful of respondents with extreme changes. Overall, this combination of parametric and non-parametric test results provides strong empirical evidence that the mentoring program resulted in real changes in empowerment levels and not simply random fluctuations in the measurements.

Qualitative Analysis per Indicator

The following qualitative analysis was conducted to deepen the meaning behind the quantitative figures presented in the previous subchapter. The seven empowerment indicators do not stand alone but are interconnected within a single duck farming value chain, from business planning and feed provision, disease prevention, seed production, to processing and marketing of the final product. The discussion per indicator below examines the partners' initial conditions, the intervention process provided, and the substantive meaning of the observed score changes, rather than simply reporting N-Gain figures.

Understanding Business Development

Before the activity, partners had a very low level of understanding (score 1.43) regarding the concept of planned duck farming business development. Partners' insights in the initial stages were generally traditional, subsistence-oriented, and did not yet address aspects of business planning, production cost calculations, or profit projections. This mindset



is common in rural household-scale livestock businesses, where livestock are raised as savings or as a side activity without adequate financial records, making it difficult for partners to measure real profits or devise future business development strategies.



Figure 1. a) Tools and Materials for the Production of Duck Derivative Products. b) Salted Egg Cracker Production Process. c) Salted egg crackers are one of the duck derivative products.

After the mentoring program, the score increased sharply to 3.55 (high category, N-Gain 0.83), indicating that partners were able to develop more systematic business plans, understand cost-benefit components, and begin to focus on long-term business sustainability. The mentoring process included training on developing simple business plans, an introduction to the concepts of fixed and variable costs, and profit projection simulations based on the partners' production scale. This change reflects a shift in mindset from viewing livestock as a side activity to a professionally managed, productive economic unit. It also serves as a cognitive foundation for successful mastery of other technical indicators.

Utilization of Local Feed

This indicator increased from 1.47 to 3.53 with an N-Gain of 0.81 (high category). Initial conditions indicated partners' dependence on expensive, unstable manufactured feed, a common weakness in the cost structure of household poultry farming businesses, as commercial feed prices tend to fluctuate with the price of imported raw materials. Through training on utilizing local raw materials (agricultural waste, fishery byproducts, and organic materials found in the village) as partial substitutes for commercial feed, partners gained new competencies in independent feed formulation. These competencies included an understanding of the nutritional content of local raw materials, feed mixing techniques tailored to the ducks' growth phases, and storage methods to prevent spoilage. This improved score directly supports the principles of a circular economy, as previously unused waste is now an economically valuable production input, simultaneously reducing duck farm operational costs and reducing partners' dependence on feed suppliers from outside the village.

Disease Prevention (Biosecurity)

The biosecurity score increased from 1.46 to 3.38 (N-Gain 0.75, high category), the second-highest increase in absolute difference. However, the relative N-Gain was slightly lower than other indicators due to the complexity of biosecurity practices, which require consistent daily behaviors, such as pen sanitation, segregation of sick livestock, and livestock waste management. Unlike other technical indicators, which can be mastered through one or two intensive training sessions, biosecurity requires repeated and consistent habit formation, so the rate of improvement is understandably slower. Nevertheless, the improvement in this indicator remains significant and important to observe, as good biosecurity practices reduce the risk of disease outbreaks, lower duck mortality, and ultimately maintain stable production and sustainable partner incomes. Without an adequate biosecurity foundation, achievements



in other indicators, such as the efficiency of chick production through incubators, have the potential to be suboptimal due to the high risk of livestock mortality.

Digital Marketing

Partners' digital marketing capacity increased from 1.52 to 3.46 (N-Gain 0.78, high category). This relatively higher initial score compared to other indicators indicates that some partners already had initial exposure to gadgets and social media, but had not yet utilized them for product marketing purposes, but rather for personal communication and daily entertainment. Mentoring in the form of promotional content training, online transaction recording, and introduction to marketplaces successfully encouraged partners to expand their market reach beyond their villages, shortening the distribution chain, and potentially increasing profit margins for duck products and their derivatives. With the ability to market products online, partners are no longer entirely dependent on local middlemen or collectors who have been suppressing selling prices at the farmer level, thus strengthening their bargaining position in the supply chain.

Product Diversification

Product diversification increased from 1.38 to 3.51 with an N-Gain of 0.81 (high category). Initially, partners sold only live ducks or raw eggs as single products with minimal added value, making their income highly vulnerable to fluctuations in primary commodity prices. After the intervention, partners began processing derivative products such as salted eggs, duck floss, and organic fertilizer from livestock waste. This improvement represents a concrete manifestation of strengthening the circular economy, as the entire value chain, from feed input to waste, is directed toward producing products with market value, while simultaneously strengthening the economic resilience of partner households against fluctuations in primary commodity prices. This diversification also opens up opportunities for partners to target a broader market segment, given that processed products such as salted eggs and duck floss have a longer shelf life and a more flexible distribution reach than raw products.

Incubator Operation

The competency score for operating an egg incubator increased from 1.38 to 3.55, with an N-Gain of 0.83 (high category), the second-highest achievement across all indicators. This demonstrates the successful transfer of appropriate technology from the implementation team to partners, who previously relied entirely on natural hatching with mother ducks, which had low efficiency and uncontrolled hatchability due to its high dependence on mother ducks and weather conditions. Efforts to increase duck productivity can be achieved by selecting superior breeds, providing adequate feed in both quantity and quality, and providing feed additives. Optimal productivity can be achieved if the feed nutrients provided meet the ducks' standard requirements (Anahamu et al., 2018).

The ability to operate the incubator independently increases the efficiency of day-old duck production, accelerates the production cycle, and opens up opportunities for partners to become suppliers of ducklings to other farmers in their surrounding villages. With more controlled temperature and humidity control using the machine, partners can more accurately predict the harvest time for the ducklings, allowing for more thorough and sustainable planning of day-old duck production and marketing

Pellet Machine Operation

This indicator recorded the highest increase among all measured aspects, from 1.35 to 3.60, with an N-Gain of 0.85 (high category). Prior to the activity, partners lacked the skills or access to technology to independently produce pellet feed, making it difficult to process

locally sourced raw materials into practical, shelf-stable feed. After mentoring, partners mastered the operation of a pellet machine, which processes local feed ingredients into pellet feed that has a longer shelf life and is easier to distribute. This achievement serves as a key leverage point for the program's sustainability, as independence in pellet feed production directly reduces feed costs, which have historically been the highest cost component in duck farming. The high N-Gain for this indicator also confirms that partners acquire hands-on skills relatively more quickly than conceptual or behavioral competencies, in line with a similar pattern observed in the incubator operation indicator.

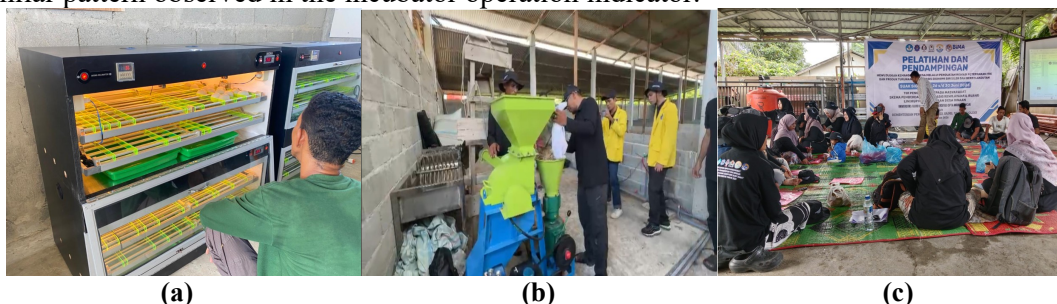


Figure 2. a) Operation of the salted egg incubator machine by partners. b) Duck pellet production process by partners. c) Partner Training and Mentoring Activities
Linkages between Empowerment Improvement and Circular and Sustainable Economy Principles

The pattern of improvement across the seven indicators demonstrates a coherent linkage with the principles of a circular economy (Ellen MacArthur Foundation, 2013), namely closing the loop of materials and energy and maximizing the value of each production input. This principle is not only relevant as a theoretical framework but is also concretely reflected in changes in partner practices in the field, as outlined in the previous section.

Improvements in the indicators for local feed utilization and pellet machine operation indicate that previously underutilized agricultural waste and local materials are now becoming feed raw materials, reducing dependence on external inputs (manufactured feed) and minimizing leakage of economic value outside the village. Improvements in the product diversification indicator demonstrate the strengthening of downstreaming of derivative products such as salted duck eggs, shredded duck meat, and organic fertilizer, extending the value chain and increasing income without requiring proportionally additional primary inputs.

Meanwhile, improvements in the operation of incubators support the efficiency of livestock regeneration, and improvements in digital marketing expand market access for derivative products, enabling the added value generated through these circular practices to be economically realized. Thus, these four indicators local feed, pellet machines, product diversification, and digital marketing form a mutually reinforcing cycle: local inputs are processed into self-sufficient feed, livestock production is optimized through hatching technology, livestock products are processed into value-added products, and these products are marketed more widely through digital channels. Rahman, Suryana, and Fadhilah (2021) stated that the development of smallholder duck farming businesses in Kalimantan still faces various obstacles, including limited access to capital sources, low quality feed made from local raw materials, and the lack of effective marketing systems and networks.

Therefore, the observed increase in empowerment levels is not simply an increase in technical knowledge, but rather a strengthening of the capacity of partner groups to



implement more efficient, low-waste, and long term sustainability oriented production models. This model emphasizes that circular economy-based community empowerment cannot be understood as a single package of interventions, but rather as a series of interrelated competencies that need to be developed simultaneously.

Supporting and Inhibiting Factors

Several supporting factors were noted to have contributed to the successful increase in empowerment levels. First, the high motivation of partner groups to adopt appropriate technology with direct economic benefits, particularly incubators and pellet machines, both of which recorded the highest N-Gain across all indicators. Second, hands-on mentoring resulted in more effective skills transfer than a lecture-only approach, as partners could directly practice and repeat the skills taught under the guidance of the implementation team. Third, the availability of local raw materials supported the practical application of circular economy concepts in the field, ensuring that training materials were not merely theoretical but could be directly applied using resources locally available to partners.

Another inhibiting factor that needs to be considered for program sustainability is limited internet access, which can impact the consistency of digital marketing practices, given that online promotional activities and transactions are highly dependent on stable connectivity. According to Sundari & Lestari (2022), the implementation of digital marketing strategies contributes to disrupted market access for laying duck farmers, while simultaneously supporting the growth of product branding, thereby sustainably increasing business capacity.

Furthermore, further mentoring is needed regarding biosecurity aspects, which require behavioral changes rather than simply one-time technical skills, in line with the relatively lower N-Gain for this indicator compared to machine-based indicators. These two inhibiting factors are crucial for program sustainability, as long-term success is determined not only by knowledge transfer during the mentoring period, but also by ongoing infrastructure support and post-program mentoring.

Implications for Village Independence

Consistently increasing the empowerment level of partner groups to a high level has strategic implications for the independence agenda of Suak Sigadeng Village. Strengthening capacity throughout the duck farming value chain, from upstream (feed and breeding) to downstream (product processing and marketing), has the potential to reduce economic leakage from the village to outside areas, strengthen the income base of farming households, and open up opportunities for replicating the business model to other community groups in the village.

The circular economy model internalized through this program also aligns with the Sustainable Development Goals (SDGs), particularly in terms of poverty alleviation, food security, and responsible consumption and production. The partners' independence in managing the entire production chain, from feed formulation and hatching independently, to processing and marketing of derivative products, reduces the vulnerability of the duck farming business to fluctuations in input prices from outside the village, while increasing the village's capacity to generate added economic value independently.

With these achievements, the program can serve as a reference model for local potential-based empowerment interventions in other rural areas with similar characteristics, particularly villages with a home-based livestock business that has potential for local raw materials but lacks performance in business management, appropriate technology, or product marketing. Egg-laying duck farming is a promising poultry business due to its ability to



generate significant economic returns, leading to increasing interest in the implementation of intensive husbandry systems as a means of increasing production (Hasrin et al., 2023). The program's sustainability needs to be directed at strengthening regular mentoring, particularly in the areas of biosecurity and digital marketing, so that achievements do not stop at the stage of increasing knowledge but continue to develop into established and sustainable habits and business systems.

Conclusion

The analysis results show that the community service program significantly increased the empowerment level of partner groups in Suak Sigadeng Village, from a very low category (average score of 1.43) to a high/independent category (3.51), with an average N-Gain value of 0.81 (high category). Based on data from 40 respondents, the increase was statistically significant across all indicators ($p < 0.001$) with a very large effect size (Cohen's $d = 4.03-10.91$), indicating real and meaningful change. All indicators, including business development, utilization of local feed, disease prevention, digital marketing, product diversification, and operation of incubators and pellet machines, experienced an increase in the high category. The greatest increase occurred in the ability to operate pellet machines and incubators, demonstrating the effectiveness of technology transfer in supporting business continuity. Overall, the program successfully strengthened the capacity of partner groups in implementing a circular economy-based production system and encouraging village economic independence.

Recommendation

To support the sustainability of the program, the Beujroh Farmers Group (KWT) and the Tabina New Farmers Group need to integrate the development of agro-silvopasture-based livestock businesses with partner businesses, with full support from the Suak Sigadeng village government. This will result in increased income for the local community. Support for the implementation of this community service program requires commitment from all relevant communities in Suak Sigadeng.

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