Journal of Social Sciences and Technology for Community Service (JSSTCS)
https://ejurnal.teknokrat.ac.id/index.php/JSSTCS
Vol 7, No 2, September 2026, Hal 100-107
E-ISSN 2723-2026 (Media Online)
P-ISSN 2723-455X (Media Cetak)
DOI: **10.33365/jsstcs.v7i2.2798**

Smart Solar Incubator for Strengthening Village Poultry Production and Food Independence

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Received	Accepted	Publish
11-Agustus-2026	10-September-2026	15-September-2026

Abstract—This community service program addressed low productivity in native-chicken seed production at Pemuda Libureng Farm, Mattirowalie Village, Libureng District, Bone Regency. Prior to the intervention, the partner utilized a conventional wooden incubator with a capacity of 50 eggs, manual egg turning, unstable lamp-based heating, and complete reliance on grid electricity. Consequently, hatchability was limited to 30–40%. The program implemented a Smart Solar Incubator that integrated solar photovoltaic power, battery storage, grid backup, automatic temperature control, and an automatic egg-turning mechanism. The technology transfer was complemented by training in hatching management, biosecurity, basic cash-flow recording, cost-of-production calculation, standardized chick-box packaging, and digital marketing. The core field implementation was completed in June 2026. Program documentation indicated hatchability exceeding 85% and operational energy efficiency reaching up to 70%. Furthermore, egg turning transitioned from three manual turns per day to automatic operation every three hours. The partner also adopted basic business bookkeeping and digital marketing through Facebook Marketplace and WhatsApp Business. Revenue growth exceeding the baseline is considered a program projection, as longitudinal post-program financial records were not available in the provided evidence. The intervention demonstrates the effectiveness of integrating appropriate renewable-energy technology and community education in jointly enhancing rural poultry production and local food resilience.

Keywords: community empowerment; native chicken; solar incubator; renewable energy; digital marketing

1. INTRODUCTION

Native-chicken production has an important role in rural livelihood systems because it connects small-scale breeding, local feed resources, household enterprise, and local food supply. Community-based poultry development can improve productive skills and help rural groups strengthen their economic activities when technical interventions are paired with practical management support (Asminaya et al., 2021; Dalimunthe et al., 2021). The market for day-old chicks (DOC) also depends on reliable hatching performance and marketing strategies that connect breeders with potential buyers beyond their immediate village (Harifuddin et al., 2024; Nurmayasari et al., 2024).

Pemuda Libureng Farm is a productive youth group in Mattirowalie Village, Libureng District, Bone Regency, South Sulawesi. The group consists of nine young villagers and operates a pioneering native-chicken breeding business. The initial assessment identified strong local demand for DOC, estimated at 500–700 chicks per month, but the partner could

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not meet this demand because its hatching technology was limited. The group used two conventional wooden incubators with a combined capacity of approximately 50 eggs per cycle. Heating relied on incandescent lamps without precise digital temperature control, and eggs were turned manually three times per day.

These conditions created several connected problems. First, temperature fluctuations reduced hatchability to only 30–40%, meaning that most fertile eggs failed to produce viable chicks. Second, grid electricity and continuously operating heating lamps created a significant operational burden; the proposal estimated that electricity represented about 25% of operating costs. Third, power interruptions increased the risk of embryonic mortality. Fourth, business management was weak because the partner did not yet maintain systematic cash-flow records or calculate the cost of production. Marketing was predominantly local and passive, with limited use of digital platforms. These conditions are consistent with the wider need to improve technical efficiency, product consistency, and market organization in small-scale DOC businesses (Harifuddin et al., 2024; Sugiarti et al., 2024).

The community service team therefore designed an integrated intervention combining appropriate technology with community education. The technological solution was a Smart Solar Incubator using a hybrid energy configuration: solar photovoltaic power as the primary renewable source, battery storage for continuity, and grid electricity as backup. The incubator incorporated automatic temperature control and automatic egg turning. Hybrid electricity systems have been applied in poultry settings to reduce dependence on a single energy source and improve operational reliability (Yuhendri et al., 2020). The technical intervention was complemented by training in hatching practice, biosecurity, business bookkeeping, cost-of-production calculation, standardized DOC packaging, branding, and digital marketing. In community-service settings, simple financial recording, packaging design, and digital marketing have also been used to strengthen small-enterprise capacity and market readiness (Maryana et al., 2022; Moeljono, 2023; A. Putri & Andi Achmad, 2024; Y. A. Putri & Handayaningrum, 2022).

The objective of this article is to describe the implementation and verified early outcomes of the Smart Solar Incubator community service program. The article focuses on three questions: how the technology was transferred and operated by the partner, what technical performance changes were documented after implementation, and how business-management and marketing support were integrated to strengthen the sustainability of the intervention. The program is relevant to food self-reliance, clean-energy use, youth economic participation, and village-based development.

2. IMPLEMENTATION METHOD

2.1 Program Setting and Community Education Approach

The program was implemented with Pemuda Libureng Farm in Mattirowalie Village, Libureng District, Bone Regency. The broader PKM program was designed as an eight-month community partnership process, while the core field implementation reported in the accompanying program documentation took place in June 2026. The partner group contributed the installation site, fertile hatching eggs, daily labor, and participation in all training and mentoring activities.

The implementation approach was based on community education and adult-learning principles. Partner members were positioned as active learners rather than passive recipients of equipment. Training was organized as hands-on practice and mentoring, consistent with community-service approaches that build usable skills through direct application, participation, and continued assistance (Dalimunthe et al., 2021; Moeljono, 2023).

2.2 Stages of Implementation

a. Preparation and socialization. The team coordinated roles, conducted discussions with the partner, aligned the activity schedule, prepared the installation area, and confirmed responsibilities for equipment operation and maintenance.

b. Technology installation and testing. The hybrid incubator system was assembled and installed at the partner site. Solar panels, battery storage, control components, and

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the automatic egg-turning mechanism were integrated. Functional testing covered temperature stability, energy continuity, and operation of the turning mechanism.

c. Technical training. Partner members received practical training in fertile-egg selection, grading, modern incubation, biosecurity, incubator operation, candling, and post-hatch DOC handling. Semi-intensive poultry development programs similarly emphasize practical husbandry knowledge and structured maintenance to improve productivity (Dalimunthe et al., 2021).

d. Business and marketing training. The team trained the partner to prepare simple cash-flow records, calculate the cost of production per chick, use standardized chick boxes, develop product branding, take product photographs, and use Facebook Marketplace and WhatsApp Business for marketing.

e. Mentoring, evaluation, and sustainability. Mentoring used a learning-by-doing model. Technical assistance included daily operating checks and observation of incubation milestones, while business mentoring focused on operational-cost recording and basic profitability analysis. Sustainability activities included preparation of operating procedures, a management guide, and an internal arrangement for equipment maintenance.

2.3 Evaluation and Data Reporting

Evaluation compared documented baseline conditions with early endline evidence from implementation records and the attached July 2026 activity report. The principal technical indicators were hatchability, energy performance, and egg-turning practice. Business indicators were the availability of basic bookkeeping practices, cost-of-production calculation, standardized packaging, and use of digital marketing channels. Because the supplied evidence did not include a multi-month audited income series after the intervention, the proposed increase in monthly revenue was not classified as an achieved outcome in this article.

3. RESULTS AND DISCUSSION

3.1 Baseline Conditions and Priority Problems

The baseline assessment showed that the partner's production bottleneck was not a lack of market demand but a mismatch between demand and hatchery capacity. Demand for DOC in the Libureng area was estimated at 500–700 chicks per month, whereas the partner relied on a small conventional incubator system with approximately 50 eggs per cycle. Temperature instability resulted in only 30–40% hatchability, and power failures created additional risk. Manual egg turning three times per day also consumed productive time that could otherwise be used for flock management, record keeping, and marketing. The low and variable technical performance weakened product consistency and the partner's bargaining position.

The business side showed a similar need for structured support. Cash-flow records and standardized cost calculations were not yet routinely used, and marketing depended mainly on local buyers and word of mouth. Research on DOC enterprises highlights the importance of business-model clarity, market segmentation, and stronger distribution strategies for maintaining competitiveness (Nurmayasari et al., 2024; Sugiarti et al., 2024). The intervention therefore treated production technology, business management, and market access as interdependent components rather than separate problems.

Table 1. Baseline conditions and program responses

Priority issue	Baseline condition	Program response
Hatchability	30–40% with unstable lamp-based heating	Automatic temperature control and hybrid incubator operation
Energy reliability	Full dependence on grid electricity; outage risk	Solar PV + battery + grid backup
Egg turning	Manual, 3 times/day	Automatic turning every 3 hours
Financial management	No systematic cash-flow/HPP record	Simple bookkeeping and cost-of-production training
Marketing	Local word of mouth	Facebook Marketplace and WhatsApp Business

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Packaging	Conventional/limited packaging	Standardized branded chick box

3.2 Smart Solar Incubator Implementation and Technical Outcomes

The central intervention was the installation of a hybrid solar-powered incubator. During daytime operation, solar energy could be used as the primary source; battery storage maintained continuity when solar input was unavailable, and grid electricity functioned as a backup source. This configuration was designed to reduce vulnerability to outages and to lower the operational energy burden. Automatic temperature control stabilized the incubation environment, while the egg-turning mechanism operated every three hours. Maintaining stable incubation conditions is important because hatchability is sensitive to egg quality, temperature, and other reproductive-management factors (Harifuddin et al., 2024; Moulizar et al., 2017).

Figure 1. Installation of the solar photovoltaic system and hybrid incubator at the partner site (June 2026).

Early implementation evidence showed a substantial technical improvement. Hatchability, which had been only 30–40% under the conventional system, was reported to exceed 85% after the Smart Solar Incubator was applied. Operational energy efficiency was reported at up to 70%. These two outcomes are the strongest quantitative indicators available in the supplied implementation evidence. They suggest that the combination of renewable-energy integration and automatic process control addressed the two most critical baseline constraints: unstable incubation conditions and dependence on continuously supplied grid electricity.

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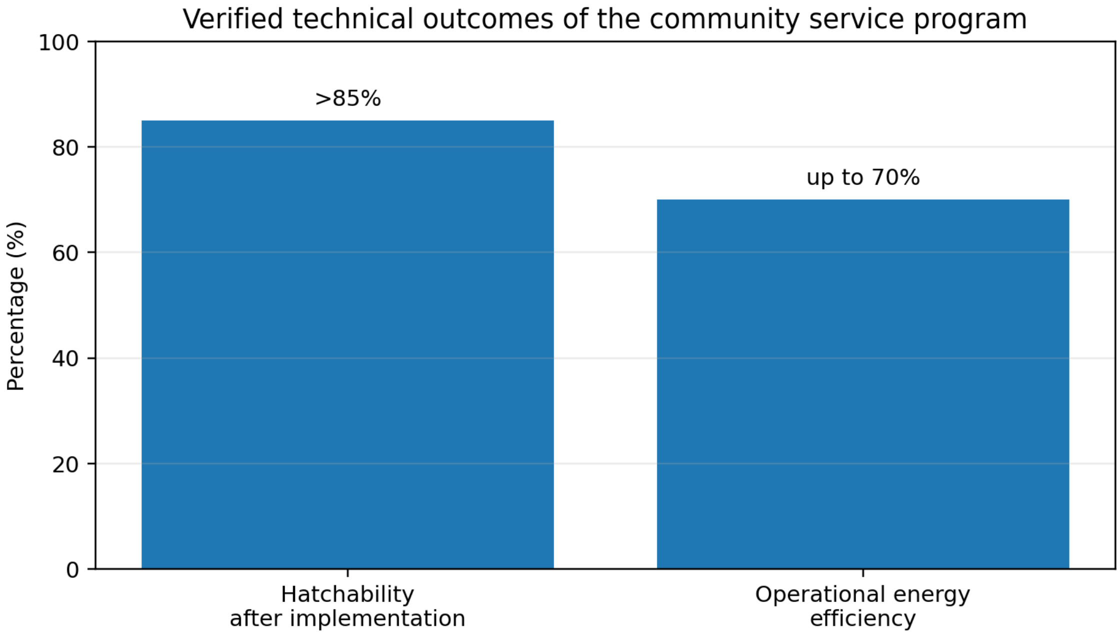

Figure 2. Verified technical outcomes reported after implementation. The chart uses 85% as the conservative plotted value for the reported result of >85%.

Table 2. Early outcome indicators after implementation

Indicator	Baseline	After implementation	Evidence status
Hatchability	30–40%	>85%	Verified in activity report
Operational energy performance	Grid-dependent; electricity ≈25% of operating cost	Efficiency up to 70%	Verified in activity report
Egg turning	Manual, 3 times/day	Automatic, every 3 hours	Implemented
Temperature control	Unstable, manual lamp heating	Automatic control	Implemented
Revenue	Rp400,000–Rp500,000/month	>Rp3,000,000/month	Projection; not treated as achieved

The hatchability result is also consistent with the program's emphasis on egg selection, candling, biosecurity, and post-hatch handling. Broader native-chicken development programs emphasize that technology, feed, husbandry, and practical training need to be treated as an integrated production system rather than as isolated inputs (Asminaya et al., 2021; Dalimunthe et al., 2021). The automatic system also reduced repetitive manual handling. In practical terms, this can free partner members to allocate more time to brooding, record keeping, marketing, and routine equipment monitoring.

3.3 Business Management, Packaging, and Digital Marketing

Technology adoption was accompanied by business-management support so that increased production capacity would not create a new bottleneck at the marketing stage. The partner was introduced to simple cash-flow recording and calculation of the cost of production. This is important because a small producer can increase output but still face weak profitability when costs, pricing, and cash movements are not recorded systematically. Community-service evidence shows that simple financial records can help small producers understand expenses, income, and business progress, while digital-marketing training can strengthen promotion and market access (Hamidy, 2023; Maryana et al., 2022; Moeljono, 2023).

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Packaging was improved through the use of standardized chick boxes with ventilation and product identity. This provided a more suitable container for DOC distribution and supported branding. Product-packaging design is relevant to increasing the selling value and market presentation of small-enterprise products (A. Putri & Andi Achmad, 2024). The program also introduced Facebook Marketplace and WhatsApp Business to broaden market reach beyond nearby buyers. Digital marketing can expand promotional channels for small enterprises, while web- and mobile-based systems can also support DOC cultivation and management processes (Hamidy, 2023; Maryana et al., 2022; Setiawan & Eko, 2022).

Figure 3. Handover and use of standardized chick boxes as part of product handling and branding support.

3.4 Participation, Sustainability, and Community Value

Partner participation was a central feature of implementation. Pemuda Libureng Farm provided the installation location, fertile eggs, daily labor, and member participation during training and mentoring. This in-kind contribution increased partner ownership of the intervention and reduced the risk that the incubator would become an externally managed asset. The team also emphasized an internal maintenance arrangement, operating procedures, and routine records to support continued use after the intensive assistance period ended.

From a community-development perspective, the program combined renewable-energy technology, poultry-production knowledge, and small-enterprise skills within one learning process. This integration is relevant for youth groups because technical competence alone does not ensure enterprise sustainability. Community education can help translate new equipment into routines, responsibilities, and collective decision-making. Participatory native-chicken development programs likewise combine training, practical application, and local involvement to strengthen productive capabilities (Asminaya et al., 2021; Dalimunthe et al., 2021).

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Figure 4. Community service team, partner members, and local stakeholders during the implementation activities in Mattirowalie Village.

3.5 Limitations of the Available Evidence

The available data support strong conclusions about early technical performance but more limited conclusions about longer-term economic impact. Hatchability above 85%, automatic operation, and energy efficiency up to 70% were documented during implementation. By contrast, the projected increase in monthly revenue from approximately Rp400,000–Rp500,000 to more than Rp3,000,000 requires follow-up financial records across several production cycles before it can be reported as an achieved impact. Future monitoring should therefore record the number of eggs set, fertile eggs, chicks hatched, chick mortality, electricity consumption, operating costs, selling price, sales volume, and net income for each cycle. This would allow technical efficiency and economic sustainability to be evaluated with the same level of evidence.

4. CONCLUSION

The Smart Solar Incubator program provided an integrated response to the production and business constraints faced by Pemuda Libureng Farm in Mattirowalie Village, Bone Regency. The hybrid solar-battery-grid system, automatic temperature control, and automatic egg turning directly addressed unstable incubation conditions, outage risk, and labor-intensive manual operation. Early implementation evidence showed hatchability increasing from 30–40% to above 85% and operational energy efficiency reaching up to 70%. The intervention also introduced simple business bookkeeping, cost-of-production calculation, standardized chick-box packaging, and digital marketing through Facebook Marketplace and WhatsApp Business. These results indicate that appropriate renewable-energy technology can generate stronger community benefits when it is embedded in adult learning, mentoring, and enterprise management. Long-term economic outcomes, particularly the projected increase in monthly revenue, should be verified through multi-cycle financial monitoring before being treated as realized impact.

ACKNOWLEDGEMENTS

The authors acknowledge the Directorate of Research and Community Service (DPPM), Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, for supporting the PKM Partnership Grant. Appreciation is also extended to Pemuda Libureng Farm, the Head of Mattirowalie Village, the Head of Nusae Hamlet, participating students, and community members who supported the installation, training, mentoring, and documentation activities.

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E-ISSN 2723-2026 (Media Online)
P-ISSN 2723-455X (Media Cetak)
DOI: **10.33365/jsstcs.v7i2.2798**

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