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INNOVATIVE COOLING SYSTEM: SOLAR-POWERED WATER SPRAYERS FOR CATTLE SHEDS IN TULUNGAGUNG REGENCY

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Abstract

The Community Service (CS) project was implemented in Sumberingin Kidul Village, Ngunut District, Tulungagung Regency, East Java. The target beneficiary was UD. Arta Lumintu, a local SME engaged in beef cattle farming. The farm, established in 2017, was temporarily closed due to the Covid pandemic and resumed operation after a year. Key challenges included high temperatures (24-31°C) and humidity (74-77%), which negatively impacted cattle productivity and excessive electricity consumption for cattle shed operations. The project aimed to address these issues by installing a water spray system with a high-pressure pump and an off-grid solar power system. The system effectively reduces temperature and humidity in the sheds while minimizing electricity costs. The installation consists of a 540 Wp solar panel, a 1500 VA Smart inverter, a 100 Ah VRLA battery, and six pressurized water sprinkler points positioned in various areas of the cattle sheds, powered by a 350 W booster pump. This initiative improves farm efficiency, supports energy independence, and introduces smart farming technology to benefit local farmers.

Keyword: Cattle Sheds, Cooling System, Solar Energy, Smart Farming, Water Spray

INTRODUCTION

Sumberingin Kidul Village is one of the villages in Tulungagung Regency with a significant livestock population. The village boasts a diverse range of livestock, including laying hens, broiler chickens, Arab chickens, quail, cows, Etawa goats, and fish (gourami, catfish, and ornamental fish). According to the East Java Provincial Central Statistics Agency, Tulungagung's beef cattle population reached over 120,000 by 2023, making it the largest livestock population in the regency (BPS Kabupaten Tulungagung, 2023). This robust cattle ecosystem is supported by an active artificial insemination program, contributing to Tulungagung's recognition as having the second-highest number of cow and buffalo births through artificial insemination in East Java (Yohanes, 2024).

Livestock ownership is not confined to large-scale farms but is widespread among Tulungagung residents. Beef cattle farming, in particular, offers a promising business opportunity due to its relatively low maintenance requirements and disease resistance compared to poultry. As highlighted in Table 1, the population of large livestock (cows,

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buffaloes, and horses) is distributed across various sub-districts of Tulungagung Regency, demonstrating its widespread presence in the region (Trihatmaja, 2017).

Table 1. Livestock distribution in Tulungagung Regency in 2022

District	Beef Cattle	Dairy Cattle	Buffalo	Horse
Besuki	1 490	-	3	4
Bandung	2 527	-	13	2
Pakel	4 250	-	-	-
Campurdarat	7 859	-	-	-
Tanggunggunung	5 254	-	-	-
Kalidawir	9 732	32	-	1
Pucanglaban	3 714	-	-	-
Rejotangan	11 245	1 620	5	10
Ngunut	7 139	51	1	2
Sumbergempol	9 791	112	-	3
Boyolangu	6 154	-	-	-
Tulungagung	1 004	-	-	2
Kedungwaru	5 979	71	-	2
Ngantru	11 175	7	-	2
Karangrejo	5 498	8	54	1
Kauman	3 249	29	60	6
Gondang	5 271	62	26	12
Pagerwojo	5 739	9 971	94	1
Sendang	10 005	13 017	16	-
Total	**117. 075**	**24. 980**	**272**	**48**

Source: BPS Kabupaten Tulungagung, 2023

Table 1 shows that the beef cattle population in Ngunut district reached 7,139 in 2022. This population has remained relatively stable, fluctuating between 7,000 and 8,000 head. Nearly all of Ngunut's 18 villages have livestock breeders, with over 100 breeders in most villages. Sumberingin Kidul Village, in particular, has a substantial number of livestock breeders, with approximately 150 breeders and 400 cattle. However, based on local surveys and interviews, both the number of livestock breeders and the cattle population are expected to increase in the current year.

The main beneficiaries of this community service programme were SMEs involved in cattle fattening, such as UD. Artha Lumintu, a five-year-old business owned by Mr Suwanto. The farm covers an area of about 2,000m², 30% of which is used for cattle sheds and the rest for growing elephant grass (Pennisetum purpureum).

Based on field observations, the layout and design of the cattle enclosure meet the criteria for a well-constructed facility (Utama, 2022). The partner's expertise in technical management and cattle farming is sufficient to ensure that key aspects - such as site selection, building placement, shed construction, flooring and frame and roof design, were carefully planned from the outset. Figures 1 provide photographs documenting the condition of the enclosure at UD. Arta Lumintu.

Figure 1. The condition of the cattle shed at UD. Artha Lumintu's beef cattle farm

Based on interviews and field observations, this partner demonstrates significant potential for growth into a larger industrial or business-oriented livestock SMEs through the adoption of modern smart farming technologies. To achieve this goal, collaboration with various stakeholders, particularly academic institutions, is essential. The survey identified at least two key challenges that require solutions.

The main problems faced by the partners are related to weather conditions and ambient temperature, as well as the use of electricity to support the equipment in the cattle sheds. Some specific examples of these problems faced by farmers include: (i) High temperature and humidity, Tulungagung's annual temperature typically ranges from 24°C to 31°C, with humidity levels between 74% and 77%. The ideal environmental temperature for cattle is approximately 17°C to 25°C. Temperatures below 17°C can lead to weight loss as cattle expend energy to maintain body warmth. Conversely, temperatures exceeding 25°C can cause heat stress, resulting in various health problems such as slow weight gain, decreased appetite, and increased susceptibility to diseases (Chen et al., 2016). The ideal air humidity for cattle is around 50% to 70%. Air humidity above 72% can make cattle uncomfortable and hinder their breathing. (ii) High electricity consumption, the use of electricity in the barn is significant, particularly for water pumps, lighting, heating equipment for cow feed supplements and grass choppers. This significant electricity consumption can lead to increased costs for farmers.

In response to the problems outlined above, this community service programme proposes the following solutions: (i) the installation of a cow shed cooling system to create a comfortable environment for the cattle that is easy for farmers to operate, and (ii) the development of an independent energy source to power shed equipment (e.g. lights, water pumps) through the installation of a small solar power system. This initiative aims to strengthen the use of science and technology and renewable energy to support the concept of smart farming. The results of the programme are expected to serve as a model for local farmers, ultimately contributing to a livestock industry that can compete in national and global markets.

IMPLEMENTATION METHOD

A. Flowchart of Community Service Implementation

The community service partnership activities were carried out at the UD. Artha Lumintu's cattle shed location was carried out in the form of installing a solar power plant and a cattle shed cooling system. The installation was done on 3 August 2024. The success of CS implementation is closely linked to the use of appropriate, effective, efficient and sustainable methods. Therefore, a deeper focus on CS implementation methods is needed, especially on the solutions developed by the implementation team. In addition, this methodology needs to be supported by technical descriptions to ensure the smooth implementation of the CS project.

The following steps are necessary to support the implementation method of this community service partnership:

1. Internal team coordination: Strengthen the program structure by coordinating among lecturers, education staff, and students to ensure organized and focused activities. This includes technical, managerial, and scheduling aspects of the partnership implementation.
2. Partner coordination: Coordinate with partners regarding the installation of solar-powered sprinkler/nozzle systems.
3. Location assessment: Review the cattle shed location and identify strategic points for equipment placement.
4. Work plan development: Create a clear and structured work plan, including detailed specifications and design requirements for the installation. At this stage, the team collects detailed data, including pump capacity, flow rate and pressure, availability of electrical power in the shed area, existing electrical equipment, ambient temperature and humidity, solar radiation and location of equipment. The solar-powered sprinkler system for cooling the pen has limited capacity. Due to the large number of cattle and the large shed area, several alternative capacity options need to be considered.
5. Material procurement: Purchase necessary tools and materials for the solar-powered sprinkler systems, including solar panels, battery controllers, inverters, batteries, high-pressure pumps, sprinklers, and supporting materials.
6. Coordinate local labour: Coordinate with workshop personnel or local labour to assist with installation.
7. Assembly and installation process: The assembly integrated the solar-powered system with the shed cooling technology. The solar power generation system comprises solar panels, an inverter/controller, and a battery. This system powered the water spraying pumps and supporting electronic equipment, with potential applications for lighting cattle shed lamps.

8. Evaluation and testing of installation performance: The solar-powered sprinkler system requires a performance test in the cowshed. A 24-hour 'ON' test will assess the functionality and performance of the installed equipment. Monitoring and minor repairs will be carried out during this period to ensure the long-term sustainability of the system and provide confidence to partners.

In general, the process of community service implementation has several stages, which are shown in the flow chart in Figure 2.

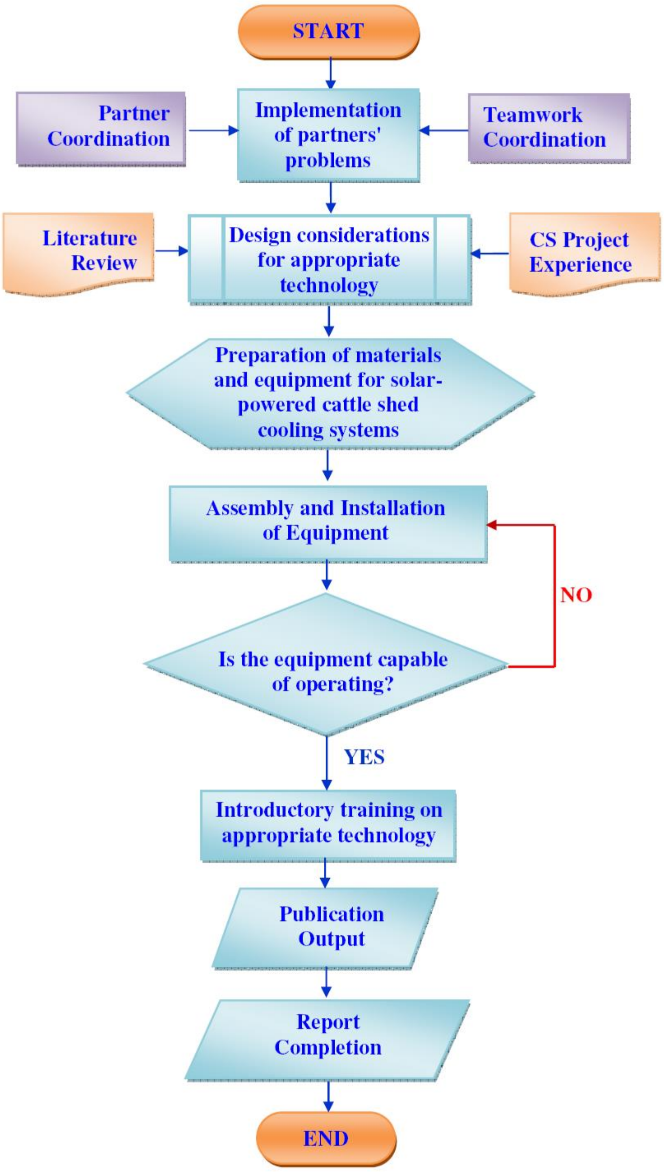

Figure 2. Flow chart for the implementation of community service

B. An Overview of the Implementation of Appropriate Technology

Farmers using smart farming technology often use environmental cooling systems that incorporate sprinkler systems to alleviate heat stress in cattle sheds. This approach involves spraying water on livestock and their environment to achieve evaporative cooling. Research suggests that the combination of sprinklers and fans is effective in mitigating the adverse effects of heat stress in dairy cows (Paolo et al., 2023). In addition, spraying water on dairy cows can reduce their body temperature and respiratory rate, resulting in increased feed intake and milk production (Bah et al., 2022).

Additionally, using water sprinklers to spray the cattle shed environment has been proven to significantly reduce pen temperature, humidity, temperature-humidity index (THI), rectal temperature, respiratory rate, and heart rate in beef cattle (Koekoeh, 2023). The humidification and cooling system in cattle sheds has also been studied to offset the heat generated by the livestock, with adjustments based on THI to optimize electricity and water usage (Rolandas et al., 2023). Sprinkler systems applied at different temperature thresholds have been shown to influence changes in body temperature in steers at feeding areas, with lower thresholds leading to smaller increases in body temperature (Augenstein et al., 2020).

On the other hand, research into the use of solar panel technology has been widely applied in community service (CS) initiatives (Asrori et al., 2021; Hidayat et al., 2023). One of the key benefits of solar energy is its ability to provide a reliable power supply for essential equipment such as pumps, aerators, and lighting in agricultural and aquaculture settings. As a result, adopting solar panel technology as a standalone energy source offers a practical solution for farmers, livestock keepers, and small to medium enterprises (SMEs).

For this reason, Asrori et al. (2022) installed solar panels on water filtration systems in Koi fish farms in Tulungagung. This micro-scale solar system serves as a power source for filter pumps and pond aerators. The 600 Wp solar panel system consists of 4 x 150 Wp panels, an 850 VA hybrid inverter and a 100 Ah VRLA battery. This setup can power a 75W pump with a flow capacity of 26,000 litres per hour. The installation has resulted in a monthly saving of IDR 108,352.5 in PLN electricity costs.

The implementation of CS activities will continue until 2023 when this small-scale solar power generation technology will also provide electricity for heating equipment in chicken farms in Blitar (Asrori et al., 2023). The solar panels installed for this purpose have a capacity of 600 Wp and include a 100 Ah energy storage system, enabling the production of 3.6 kWh of electrical energy per day.

Therefore, according to the references mentioned earlier, the appropriate technology implemented at this partner location comprises two primary components: the solar power generation system and the sprinkler installation system. The sprinkler system, which includes pipework, electronic controls, and water pumps, has been designed to mitigate the heat load in the beef cattle shed.

RESULTS AND DISCUSSION

The community service programme achieved its main objective of installing a cooling system for the cowshed and a solar power source. The results of these activities are detailed below.

A. Installation of Solar Power Systems

Smart farming often utilizes renewable energy, such as solar power, to meet various operational needs. In cattle sheds, this includes lighting, ventilation systems, water pumps, and cooling systems. Solar power can provide electricity for these essential functions, ensuring optimal conditions for livestock. This community service project focused on implementing a solar-powered sprinkler system to address cooling needs in the cattle shed.

Figure 3 illustrates the installation process of the solar panels at the cattle shed site. The installed solar panels have a capacity of 540 Wp, capable of generating electrical energy that varies based on weather conditions and sunlight intensity in the area. In tropical regions like Indonesia, solar panels typically produce around 4-5 kWh of electricity per day for every 1 kWp of installed capacity. With a 540 Wp capacity, the system is estimated to generate approximately 2.16 to 2.7 kWh per day, assuming 4-5 hours of effective sunlight. This output is sufficient to meet the electricity requirements of the cattle shed at the community service location.

Figure 3. Installation of 540 Wp solar panels on the cattle shed roofs

The next step involves assembling the smart solar inverter, panel box, and battery, as shown in Figures 4 and 5. Pre-prepared cables and supporting components, including switches and fuses, are then connected to the inverter and battery.

Figure 4. Installation of solar energy converters and their equipment

Figure 5. Installation of MCB panels & batteries

Figure 6 shows the completed installation of the solar power system. The solar power system in this cow shed consists of a 540 Wp monocrystalline solar panel, a 1.5 kVA PSW Smart inverter and a 12V/100 Ah battery installed to supply energy to the cow shed.

Figure 6. Results of the solar power system installation

B. Installation of Water Sprayer System

The cattle shed cooling system utilizes a water mist spraying method to cool the cattle. A booster pump facilitates (Figure 7) the creation of fine water droplets. As the water evaporates from the cattle's skin, it absorbs heat, effectively lowering their body temperature. The nozzles/sprinklers are strategically placed throughout the shed to ensure even water distribution.

Figure 7. Installation and positioning of booster pump equipment

A sprinkler nozzle is a device designed to spray water. In cattle (cow) sheds, it's essential for the spray to produce a fine mist, which necessitates a nozzle with a small hole diameter. The type of nozzle used affects several factors, including droplet size, flow rate, spray pattern, and width. The specific sprinkler used for this application is illustrated in Figure 8.

Figure 8. Placement of sprinkler nozzles in the cattle shed

Figure 9 illustrates the results of installing a pressurized water spray system for cooling cattle sheds. This solar-powered sprinkler system offers multiple benefits, including enhanced comfort for the cattle, improved productivity, better meat quality, efficient use of water and energy, and economic advantages. By reducing heat stress, the system encourages healthier natural behaviours, increases feed consumption, and contributes to a higher average daily weight gain (ADG) in beef cattle. Ultimately, this leads to improved meat quality and higher profits for farmers.

Figure 9. Pressurized water spray system for cattle cooling

C. The equipment handover to the cattle farmer (UD. Artha Lumintu)

Solar-powered water spraying systems installed in beef cattle sheds provide numerous benefits, particularly in hot climates. By reducing heat stress, these systems enhance livestock comfort and prevent heat-related illnesses, ultimately boosting productivity and improving farmer welfare. As part of a community service project, the State Polytechnic of Malang implemented this appropriate technology at UD. Artha Lumintu. Figure 10 depicts the symbolic handover of the equipment to farmer partners at UD. Artha Lumintu, marking the successful completion of the project.

Figure 10. The handover process of equipment in the cattle shed area of UD. Artha Lumintu

Diversification of appropriate technology through community service is critical. Beyond implementation, increasing partner knowledge and awareness of sprinkler water cooling systems and solar power generation is equally important. The scope of this community service project, focused on beef cattle, was limited by the capacity of the installed equipment. However, the row model technology is designed for replication and development by partners, potentially benefiting all cattle in the shed.

CONCLUSION

The community service project successfully demonstrated the effectiveness of solar-powered sprinkler systems in improving livestock productivity and welfare. By mitigating heat stress, the system promotes healthier cattle, increased feed consumption, and higher daily weight gain, leading to better meat quality. While the initial investment and maintenance costs are significant, the long-term economic and productivity benefits make solar-powered sprinklers a valuable option for beef farms in hot climates.

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