Research Article

Evaluation of Environmental Impact, Economic Viability, and Performance of Priangan Sheep Fed with Dried Water Spinach (*Ipomoea aquatica*)

Pramita Nindya Saraswati*, Anggita Fatmaningrum, Aan Andri Yano

Vocational Program of Animal Husbandry, Vocational School, Universitas Sebelas Maret, Surakarta, Indonesia.

Abstract | Indonesia's growing demand for meat, particularly from sheep, has increased the need for affordable and sustainable feed sources amid challenging tropical conditions. *Ipomoea aquatica (dried water spinach, DWS),* rich in crude protein, has shown potential but remains understudied in Priangan sheep under practical lowland farming systems. This study aimed to evaluate the economic viability and performance of Priangan sheep fed DWS, alongside the impact of environmental factors. Conducted from May to June 2024 at a commercial sheep farm in Sukoharjo, Indonesia, the exploratory research involved 275 male Priangan lambs with an initial body weight of 13.79±2.41 kg. The lambs were distributed unevenly among 38 pens within four different housing facilities (D, E, F, G), each pen being a colony pen of 1.9 × 1.25 × 1.0 m accommodating 6-8 lambs of similar size and weight and fed a diet of 40% self-made concentrate and 60% DWS, totaling 4% of body weight. Environmental conditions were monitored, and animal performances were recorded. Economic viability was assessed using the Benefit-Cost Ratio (BCR), Break-even Point (BEP), and Payback Period of Credit (PPC). Environmental and financial data were analyzed descriptively, while Pearson's correlation was used to assess relationships among performance variables. Results showed that although the lambs experienced suboptimal conditions, those in unit G performed best, with higher average daily gain (ADG), and lower feed conversion ratio (FCR) and feed cost per gain (FCG). The economic analyses yielded a BCR of 1.2, BEP of IDR 161,148,481 (80 lambs), and a PPC of 7.9 months. Thus, supplementing DWS could enhance sheep performance and ensure economic viability, although further studies are needed to investigate physiological responses and local farm comparisons.

Keywords | Animal feed, Cost-benefit analysis, *Ipomoea*, Sheep, Tropical climate, Weight gain

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***Correspondence** | Pramita Nindya Saraswati, Vocational Program of Animal Husbandry, Vocational School, Universitas Sebelas Maret; **Email:** pramitanindyas@staff.uns.ac.id
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INTRODUCTION

The growing population of Indonesia is improving living standards, which are driving increased demand for animal protein, particularly meat, which contains 20-25% protein (Saragih *et al*., 2023; Ruxton and Gordon, 2024). Among various protein sources, sheep are particularly important for human consumption (Furtado *et al*., 2020). To achieve high productivity, sheep require favorable conditions, including a suitable environment (Benoit *et al*., 2019). However, Indonesia's tropical climate, with elevated temperatures, can impede animal growth and limit water availability for both livestock and crops (Yano *et al*., 2018).

Indonesia has several local sheep breeds, such as Garut, Priangan, Batur, Wonosobo (Ibrahim *et al*., 2024). Batur and Wonosobo sheep are typically raised in highland areas (Tresia *et al*., 2021), while Garut and Priangan sheep are found in lowland regions (Alhuur *et al*., 2023), where higher temperatures may affect their performance. A study found that male Garut sheep raised in highlands exhibit superior growth characteristics compared to those raised in lowland areas (Agustina *et al*., 2023). This suggests that elevation and climate variations affect animal performance. However, the environmental impacts on Priangan sheep are less understood.

Priangan sheep, a local thin-tailed breed from West Java, resulted from crossbreeding Cape, Javanese, and Merino sheep (Gustaman, 2021). This breed is well adapted to tropical environments and widely valued for its meat quality and economic importance in smallholder farming systems. The average daily gain (ADG) of male Priangan sheep is reported to be 43.25 grams/head/day (Raihan *et al*., 2022). Furthermore, Priangan sheep have higher meat composition and lower fat content compared to fat-tailed sheep (Baihaqi and Herman, 2012). Their genetic diversity also provides potential for further selection and improvement programs.

To maximize their potential, one of the key factors affecting livestock growth is feed. Feed plays a crucial role in the productivity of sheep, including both growth rates and body composition (Sudarman *et al*., 2008). However, it represents 60-70% of production cost in sheep farming (Koestanti *et al*., 2014), highlighting the need for affordable and sustainable feed sources to reduce expenses.

Water spinach waste, consisting of stems, roots, and leaves not consumed by humans, is a potential alternative feed due to its nutritional value (Tistiana and Widodo, 2023). The leaves contain 28.3% dry matter (DM), 27.8% crude protein (CP), while the stems have 7.34% DM and 11.4% CP (Samkol, 2009). Thus, in addition to potential ecological benefits, such as reducing agricultural waste, water spinach waste represents a valuable feed resource due to its nutritional composition. When processed into dried water spinach (DWS), it offers a higher CP content (5-6%) compared to other common feeds like corn cobs (3.5-4.5%) and rice straw (4.5% CP) (Afroz *et al*., 2020; Maulana *et al*., 2021; Arwinsyah *et al*., 2019).

A study found that supplementing beef cattle rations with water spinach improved feed degradability (Sambo *et al*., 2023). Feeding Garut sheep with DWS significantly increased body weight by 2.04 kg in 14 days, with a daily weight gain of 142 g, and further productivity was enhanced when combined with high-energy and protein concentrates (Maulana and Baliarti, 2021). DWS is an affordable, widely available feed with good nutritional content (Hasanah *et al*., 2019). While the impact on Priangan sheep has not been well studied, positive results are expected given the genetic similarities between Garut and Priangan sheep (Ibrahim *et al*., 2024).

Despite dried water spinach's (DWS) potential for ruminants, its documented application in Priangan sheep remains limited. Existing research has focused on controlled, multi-treatment experiments in artificial settings, overlooking smallholders' reliance on uniform feeding due to economic constraints. Moreover, performance under practical DWS feeding in lowland tropical environments (where heat stress and water scarcity often limit productivity) remains unstudied, along with environmental interactions affecting DWS effectiveness. Therefore, the objective of this study was to evaluate the environmental impact, growth performance, and economic viability of Priangan sheep fed a uniform DWS-based diet under real-world smallholder conditions. To address this gap, a field-based assessment was conducted. Natural variation in growth, feed efficiency, and economics under ambient conditions was analyzed to provide realistic insights for sustainable smallholder systems and bridge the research–practice divide.

MATERIALS AND METHODS

Time and place of study

The study was conducted from May to June 2024 at a commercial sheep farm in Sukoharjo, Indonesia (latitude 7° 40′ 59.99′ S, longitude 110° 49′ 59.99′ E), situated at an elevation of 89-125 meters above sea level in a region characterized by lowland and hilly topography. The minimum air temperature recorded was 23°C, while the maximum reached 34°C. The average humidity was measured at 77%, with an annual rainfall of 2,790 mm. It was observed that nighttime temperatures tend to be lower than those during the day.

Animal and housing

This study adopted an exploratory, field-based design under a uniform feeding regime. No control or treatment groups were used, which limits the internal validity of the study as it precludes causal inference regarding the specific effect of dried water spinach compared to alternative feeds. This design choice was intentional to reflect real-world smallholder conditions and to assess practical performance variability and economic outcomes under consistent feeding reflective of commercial practice. The assessment of whether the outcomes were favorable or unfavorable was based on comparisons with established performance benchmarks and economic indicators reported in previous studies and industry standards, rather than against an experimental control group. All animal use protocols for the exploratory research were reviewed and approved by the Research

Ethics Committee of the Faculty of Animal Husbandry, Universitas Sebelas Maret, Surakarta, Indonesia, which approved all procedures conducted in this study under the assigned code 128/UN27.14/TA.00.03/2024.

A total of 275 male Priangan lambs (as per the decree of the Indonesian Agricultural Minister No. 300/Kpts/SR.120/5/2017), aged 4 to 6 months, with an initial body weight (BW) of 13.79±2.41 kg, were allocated unevenly across 38 pens in four lamb housing facilities; house D, E, F, and G, which had similar management practices, diet, and feeding schedule but differed slightly in structural orientation, natural ventilation, and stocking density. Each lamb was housed in a colony pen measuring 1.9 meters in length, 1.25 meters in width and 1 meter in height. The total area of the colony pen on the farm was 2,375 m^2. Lambs were raised for 40 days using a feedlot system, with intensive management in separate colony pens, accommodating 6-8 lambs per pen, allocated based on similar body size and weight.

Diet and feeding programs

All animals were provided with the same diet to reflect uniform feeding practices commonly adopted in commercial smallholder operations. Each lamb was fed a diet comprising dried water spinach and a self-made concentrate mix. The dried water spinach, sourced as agricultural waste from East Java, served as a primary component. The concentrate consisted of the following ingredients: rice bran (10%), pollard (6%), coffee husks (11%), palm kernel meal (6.5%), copra meal (13%), corn gluten feed (14.5%), corn (13%), distiller's dried grains with soluble (7%), biscuit meal (5%), soybean meal (13%), and a premix feed (1%). The chemical compositions of the feed materials were analyzed and are presented in Table 1, where Crude Ash and Carbohydrates in DWS are reported as not determined because these parameters were not measured in this study.

Table 1: Nutrient content of concentrate and dried water spinach.

Content of nutrient (%)	Concentrate[a]	Dried water Spinach[b]
Dry matter	89.35-89.39	84.7
Crude ash	8.28-8.35	Not Determined
Crude protein	18.45-18.67	11.13
Crude fiber	12.32-12.60	27.64
Crude fat	6.06-6.09	3.24
Carbohydrates	56.31-56.53	Not Determined
Total digestible nutrients (TDN)	80.46-80.71	57.76

Note: [a]Results of Laboratory of Food and Nutrition, Center for Food and Nutrition Studies, Universitas Gadjah Mada; [b]Purnamasari *et al.* (2018).

During the study, each lamb was provided with a diet consisting of 40% concentrate and 60% dried water spinach, with a total feed amounting to 4% of body weight. All lambs were fed twice daily. Each lamb was offered 0.50 kg/day of concentrate, provided at 7:00 AM and 3:30 PM, and 1.30 kg/day of dried water spinach (DWS), provided at 9:00 AM and 4:30 PM. Actual feed intake was determined by subtracting the amount of feed refused from the amount offered for each feed type. Dried Spinach Intake (DSI) refers specifically to the actual intake of dried water spinach after accounting for refusals. Clean drinking water was made available *ad libitum* throughout the study period.

Data collection

Due to strict movement controls safeguarding livestock health, environmental data could not be collected daily throughout the 40-day trial. Consequently, temperature (T) and relative humidity (RH) were recorded daily for five consecutive days to characterize housing conditions. Measurements occurred three times daily (8:00 AM, 12:00 PM, 4:00 PM) inside lamb pens using an automatic hygrothermograph (Xuzhou Sanhe Automatic Control Equipment Co., Ltd., China) fixed 0.8 m above ground. Despite this limitation, all calculated THI values indicated severe heat stress (Gopar *et al.*, 2020), suggesting a challenging environment for the lambs. Previous studies also report minimal day-to-day THI fluctuation during the dry season in this region (Yano *et al.*, 2018), supporting the representativeness of our measurements.

T and RH values were first averaged by measurement time across the five days, and then overall averages were calculated to analyze diurnal variation and compute the Temperature-Humidity Index (THI) using the formula proposed by the National Research Council (NRC, 1971): $THI = (1.8 \times T + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)]$, where T is the air temperature (°C) and RH is the relative humidity (%). The THI categories followed Gopar *et al.* (2020).

This approach minimized the influence of short-term fluctuations, ensuring that the calculated THI accurately reflected housing conditions throughout the observation period. The resulting THI values were then classified according to heat stress categories described by Gopar *et al.* (2020) to facilitate interpretation in relation to animal comfort.

Feed intake (dried water spinach, DSI) was measured daily using a 1-g precision digital scale (CV. Avodamitra Indotech, Indonesia). Dry matter intake (DMI; g/head/day) was calculated the next morning from offered and refused feed. Individual lamb weights were recorded before morning feeding using a 0.05-kg sensitivity digital livestock scale (3A DLE-200; PT. Alexindo Putra Mandiri, Indonesia). Average daily gain (ADG) was derived from weight change over the study period. Feed conversion ratio (FCR) was calculated from intake and weight gain, while feed cost per gain (FCG) was calculated from daily feed expenses divided by ADG.

Economic viability was assessed through field observation and farm-owner interviews. The benefit-cost ratio (BCR) was computed using a modified formula from Merida *et al.* (2024), and the break-even point (BEP) with payback period of credit (PPC), followed by adjusted methods Siregar and Aulia (2023).

Table 2: Environmental conditions of the Priangan sheep farm.

Day	8.00 AM			12.00 PM			4.00 PM		
	T (°C)	RH (%)	THI	T (°C)	RH (%)	THI	T (°C)	RH (%)	THI
1	29.2	76	81.05	31.9	64	83.20	31.0	68	82.56
2	28.5	81	80.66	33.3	62	84.85	30.9	70	82.73
3	28.9	77	80.73	31.7	59	82.06	32.0	55	81.78
4	28.0	86	77.20	32.3	60	83.07	31.9	62	82.85
5	28.6	82	80.96	31.8	66	83.40	32.1	58	82.44
Mean	28.24	80.4	80.12	32.2	62.2	83.31	31.58	62.6	82.47
SEM	1.07	1.90	1.21	0.77	1.60	0.95	0.72	2.39	0.61

Data analysis

Relative environmental measures were expressed as mean ± standard error of the mean. Ecological and financial variables were analyzed descriptively. Differences in animal performance among houses (D, E, F, and G) were evaluated using a one-way analysis of variance (ANOVA) in IBM® SPSS Statistics 25.0 for Windows. When significant effects were detected ($p < 0.05$), post hoc comparisons were conducted to identify differences between groups.

RESULTS AND DISCUSSION

Environmental condition

Temperature and humidity are crucial factors in managing livestock in tropical regions (Palulungan *et al.*, 2013). For 5 consecutive days, we monitored ambient temperature (T), relative humidity (RH) daily (Table 2). During this period, the average daily temperatures and RH in the animal pen were 30.67°C (ranging from 26 to 33.3°C) and 68.4% (ranging from 55 to 86%), respectively. The trend in the T and RH of the current study is in line with previous studies (Panjono *et al.*, 2024; Yani and Purwanro, 2006). In contrast, Yano *et al.* (2018) found lower T and higher RH in a mountainous region of the same country (1060 meters above sea level), with ranges of 19-20°C and 83-93%, respectively. This discrepancy may be attributed to geographical differences, such as varying altitudes. According to Dolák *et al.* (2023), temperatures tend to be lower in mountainous areas. As warm air rises, it expands and cools due to decreasing pressure. Consequently, high-altitude regions are considered more sensitive and responsive to climate change (Pepin *et al.*, 2022).

Furthermore, the measurement of temperature and RH aims to assess the environmental suitability for sheep rearing. Piirsalu *et al.* (2020) identified a lower critical temperature of 24°C and a humidity level below 71% for sheep. In accordance, the maximum critical point of environmental temperature in sheep is around 26°C (Silanikove, 2000). This implies that the lambs were not exposed to ideal conditions in the morning due to the elevated RH and temperature experienced during the day.

To further evaluate the stress experienced by the lambs, the THI value was calculated. This index, which combines ambient temperature and humidity, serves as a reliable indicator of stress resulting from microclimate conditions (Aslimah and Astuti, 2014). According to the THI level assessment by Gopar *et al.* (2020), the lambs in this study experienced severe heat stress during the day. Poor environmental conditions during daylight hours can lead to increased physiological stress and behavioral changes in livestock (Kandemir *et al.*, 2013). Unfortunately, this study did not observe physiological responses or behavioral changes, leaving the impact of these environmental factors still uncertain.

Table 3: Productivity traits of Priangan sheep fed with dried water spinach. Dried Spinach Intake (DSI) represents actual intake calculated as feed offered minus refusals.

Variable	D	E	F	G	P-value
Dried Spinach Intake (DSI), g/head/day	261.08±4.53[a]	349.80±6.91[b]	350.34±7.13[b]	370.70±5.09[b]	0.000
Final BW, kg	13.62+1.03[a]	18.17±1.59[b]	18.32±1.60[b]	19.33±1.17[b]	0.000
Dry Matter Intake (DMI), g/head/day	435.11±5.84[a]	582.16±8.94[b]	584.04±9.22[b]	617.84±6.56[b]	0.000
Average Daily Gain (ADG), g/day	68.61±2.32[a]	90.49±3.65[b]	92.92±3.32[b]	97.13±2.68[b]	0.000
Feed Conversion Ratio (FCR)	6.34±0.13	6.45±0.51	6.27±0.59	6.36±0.19	0.428
Feed Cost per Gain (FCG), Rp/kg	34,626.98±9.85	35,196.12±37.38	34,227.86±43.95	34,744.98±14.36	0.431

Note: means in the same column with different superscripts showed a significantly different (P<0.05)

Notably, environmental data were collected only during five days, despite the total fattening phase spanning 40 days. While this sampling duration was intended to provide a representative snapshot of typical dry-season conditions, it may not fully capture short-term fluctuations. In tropical lowland regions, daily and weekly climate variability can significantly impact thermal comfort and physiological stress in livestock (Yano *et al*., 2018). Therefore, the limited environmental monitoring could lead to an underestimation or overestimation of the actual heat stress levels experienced by the lambs. Unrecorded microclimatic variations, such as ventilation differences or temperature shifts, may also have been influenced by performance between houses. The observed THI values indicate that severe heat stress was present during the monitored period, although conditions may have varied outside the measurement window. Future studies should employ continuous environmental monitoring to better link performance outcomes to thermal stress.

Animal performance

This study evaluated the effects of feeding Priangan sheep with dried water spinach (DWS) on animal performances (Table 3). Sheep supplemented with DWS (group E, F, G) showed significantly ($P < 0.05$) higher DWS intake (DSI), consuming around 350-370 g/head/day of DWS compared to 261 g/head/day in group D. The high feed intake suggests high palatability, indicating that the feed has a desirable smell and texture (Sudarmman *et al*., 2008). This is consistent with the findings of Maulana *et al.* (2021), who reported good palatability for water spinach straw. Unfortunately, this study did not directly evaluate the physical characteristics of the feed. Moreover, as all lambs received the same diet, the superior performance in house D cannot be attributed solely to feed effects and may also reflect uncontrolled housing factors such as ventilation, heat load, or stocking density. Furthermore, since all lambs received identical feed and environmental conditions, the specific factors affecting feed intake in this study remain unclear.

Lambs in house E, F, and G exhibited significantly higher DMI ($P < 0.05$) compared to those in house D, which may reflect relatively low feed utilization in house D. Environmental factors, including temperature, relative humidity, and THI, may have also contributed to variation in DMI, as all lambs experienced considerable heat stress. Previous studies have reported contrasting effects of heat stress on feed intake, ranging from negligible impact in lambs (Mahjoubi *et al*., 2015) to reductions in dairy ewes Mehaba *et al*. (2021). Appetite decline under heat stress is mainly attributed to elevated body temperature (Mehaba *et al*., 2021; Yano *et al*., 2018) and may also relate to increased gut fill from water consumption (Silanikove, 2000).

This increased DSI translated into greater dry matter intake (DMI) significantly ($P < 0.05$), which supported improved growth performance, as evidenced by significantly higher final body weight ($P < 0.05$) and average daily gain (ADG) ($P < 0.05$). In this study, feed intake (DSI) and DMI appears to influence body weight gain, consistent with Ponnampalam *et al*. (2022) and Panjono *et al*. (2024). To our knowledge, no previous study has specifically reported similar findings for Priangan sheep at 5 months of age, but the results are reasonably comparable to Garut sheep given their close genetic relationship (Prajoga and Permana, 2009).

Several studies indicate varying body weights for Garut sheep aged 4-5 months, with females reaching 10-11 kg (Faisal *et al*., 2017) and males reaching 12-14 kg (Sunando *et al*., 2016). In summary, Garut sheep generally have lower body weights compared to Priangan sheep. Furthermore, despite the lower body weight in house D, it remains within the acceptable standard range. Apart from that, although all lambs experienced severe stress, the lambs showed different responses expressed in different body weights. It indicates that lambs in house E show poor body heat management. In line, studies reported that heat stress conditions decreased the live weight of sheep (Ponnampalam *et al*., 2022).

Continuously, ADG also varies across different animal houses, with lambs in house E, F, and G achieving the relatively similar ADG, which is up to 29.36% greater than the lowest ADG observed in house D. These findings imply that increases in DSI and DMI are associated with higher ADG (Table 3). These findings are consistent with previous studies (Panjono *et al*., 2024; Obeidat and Obeidat, 2022; Aprilliza *et al*., 2014). However, despite these results, house D has the lowest ADG among all the lambs, indicating that these lambs might be struggling with environmental heat stress. Heat stress can reduce feed intake in lambs, leading to slower growth rates (Bernabucci *et al*., 2009). In addition, lambs in house D were likely using more energy to regulate their body temperature. This energy used for body heat regulation can result in reduced energy available for growth, leading to lower body weight when high temperatures create uncomfortable conditions for the sheep (Sunando *et al*., 2016).

This study found that Priangan sheep aged 5 months have an ADG ranging from 68 to 97 g/d. Astuti and Sastradipradja (2000) reported a relatively higher ADG for male Priangan sheep, approximately 109-114 grams per day when kept intensively cages with a diet of concentrate and native grass, whereas those on a grazing system achieved an ADG of 48 to 51 grams per day, fed solely with native mixed grass. Another study by Kurnia (2022) found that female Priangan sheep aged 4 months had an ADG of 64 to 112 grams per day when fed dried water spinach. This implies that the sex of the lamb impacts its ADG. This finding aligns with Gaafar *et al.* (2012) and Bansal *et al.* (2022), who reported that sex of birth significantly affects ADG, with males exhibiting higher growth rates compared to females. The observed differences between sexes are likely attributable to hormonal variations in their endocrine and physiological systems. Specifically, estrogen in females may inhibit the growth of long bones, whereas testosterone in males tends to enhance the growth rate (Bansal *et al.*, 2022).

Despite these improvements in growth and intake, FCR values remained relatively similar across all groups ($P > 0.05$), indicating that it did not adversely affect feed efficiency. This unexpected result could be attributed to uncontrolled on-farm factors inherent to the exploratory design, such as uneven distribution of lambs across pens with varying stocking densities, which could influence social hierarchy, feed access, and thermoregulatory behavior. These uncontrolled factors likely drove the observed inter-house differences, indicating that the results reflect field-based smallholder conditions rather than a controlled dietary trial.

Moreover, all lambs were exposed to severe heat stress (THI category), potentially altering maintenance energy requirements and nutrient partitioning, thereby weakening expected associations between feed intake, growth, and feed efficiency. FCR is defined as the amount of dry matter intake (DMI) required to achieve a 1 kg increase in BW, whereas feed cost per gain (FCG) represents the total cost incurred to achieve the same weight gain. Consequently, these environmental and management factors may account for the divergence from established literature and warrant further investigation.

The FCG values were similar across all lambs ($P > 0.05$), suggesting that these lambs required similar financial investment for maintenance. This finding aligns with a study by Gunawan (2010), who reported that sheep supplemented with 6% earthworm meal had a daily DMI of approximately 850 g, similar to the current study. In contrast, Muqorrobin (2018) found a significantly lower FCG when supplementing with 0.5-1.5% java turmeric meal, corresponding to a daily DMI of 500-600 g. Gaafar *et al.* (2012) examined environmental factors affected the feed cost of weight gain in lambs, reporting that sheep experienced lower feed cost in winter, suggesting improved economic efficiency despite a 7.28% increase in DMI compared to summer. This phenomenon was probably attributed to the greater availability of feed during winter.

As Indonesia is located in the subtropical region (Yano *et al.*, 2018), the rainy season is analogous to winter. During this period, the water availability is abundant. Abundant water availability significantly promotes plant growth, enhancing the vitality of forage crops (Xue *et al.*, 2018). Consequently, this leads to an increase in feed supply for farmers. Mmanda (2020) suggested that an increase in the supply of feed ingredients, along with stable demand, could lead to a decrease in the feed prices, implying that lower temperatures may contribute to the cost efficiency. However, direct comparisons with the current findings are limited due to the lack of available feed cost data. Moreover, based on the result of the current findings, which implies the lambs are exposed to an unideal environment leading to heat stress, may probably explain the higher FCG in the current study compared to the findings of (Gaafar *et al.*, 2012).

Table 4: Annual variable cost of Priangan sheep farming.

Component	Unit	Quantity	Price (IDR)	Total cost (IDR)
Male Priangan lamb	head	335	1,200,000	402,000,000
Feed				
Concentrate	kg	13,044.34	6,000	78,266,040
Dried water spinach	kg	8,441.86	5,100	43,053,486
Medicines				
Diarex	bottle	3	20,000	60,000
Albenol	bottle	2	280,000	560,000
Metoxy blue	bottle	3	30,000	90,000
Total Cost				524,029,526

Table 5: Fixed cost of Priangan sheep farming.

Component	Yearly expense (IDR)
Depreciation cost	62,337,000
Electricity	13,200,000
Gasoline	8,400,000
Labor wages	75,600,000
Total Cost	159,537,000

Beyond physiological and performance outcomes, it is also important to consider potential cofounding factors related to the experimental setup. The uneven distribution of lambs across the pens may have introduced variation in stocking densities, which could influence individual feed access, social hierarchy, and thermoregulatory comfort. Higher stocking density can increase competition and stress levels, potentially affecting intake behavior and performance outcomes. While this uncontrolled variability reduces internal validity, it stems from the exploratory design intentionally chosen to reflect real-world smallholder conditions rather than a controlled experimental setting. Importantly, all pens were provided with the same diet, feeding schedule, and management practices, which minimizes systematic bias and allows meaningful interpretation of overall trends. The findings, while not experimentally isolated, offer practical insights that are directly applicable to small-scale livestock systems. Nevertheless, the absence of a conventional forage control group and the limited scope of environmental monitoring represent important constraints. Future controlled studies incorporating alternative diets and stricter environmental assessments are recommended to provide a more robust evaluation of feed strategies under tropical conditions.

Economic viability

To assess the economic viability, we begin by calculating the total production expenses, including both fixed and variable costs (Raineri *et al*., 2015), for one year of lamb rearing. The annual variable costs and fixed costs are detailed in Tables 4 and 5, respectively. Depreciation cost, a component of fixed cost, reflects the decline in utility of the asset over time (Goni and Budiarso, 2018). However, this concept does not apply to land, as its value generally appreciates annually (Wang and Levinson, 2023).

Table 6: Total revenues of Priangan sheep farming.

Component	Unit	Quan-tity	Price (IDR)	Total price (IDR)
Sheep sales	Head	335	2,000,000	670,000,000
Fertilizer sales	Sack	665	5,000	3,325,000
Total Revenues				673,325,000

Table 7: Investment cost of Priangan sheep farming.

Compononet	Unit	Quantity	Cost (Rp)	Total cost (Rp)
Lamb housing	Pen	1	200,000,000	200,000,000
A set of housing tools	Set	1	14,612,000	14,612,000
Concentrate	kg	13,044.34	6,000	78,266,040
Dried water spinach	kg	8,441.86	5,100	43,053,486
Total Investment				335,931,526

In addition to cost analysis, total annual revenues from sheep farming are presented in Table 6, and the initial investment costs are shown in Table 7. In this study, we examined three indicators to assess the feasibility: benefit-cost ratio (BCR), break-even point (BEP), and payback period of credit (PPC) (Table 8). The BCR is a measurement tool used to determine the feasibility of an investment in a business. It is calculated by comparing the total value of revenues to the total expenses (Uzunoz and Akcay, 2009). The Priangan lamb fattening business has a BCR of 1.2, indicating that the venture is feasible and profitable, as it exceeds 1. This aligns with Hanum *et al*. (2021) the assertion that a BCR greater than 1 signifies profitability and feasibility, while a BCR less than 1 indicates a loss and renders the business unviable. A higher BCR value suggests greater potential profits from the venture. Given the dynamic nature of business, the BCR should be tailored to each individual farm. To date, to our best knowledge, no studies have reported the BCR specifically for Priangan sheep farming. In contrast, Mufidah (2023) documented BCR values ranging from 0.6 to 1.2 for Indonesian local sheep, which varied based on the annual income of the operation. The study further suggests that a timeframe of over three years is required for the business to be deemed feasible. Notably, the farm in the current study was established in 2020 and is operationally viable.

Table 8: Financial analysis result of Priangan sheep farming.

Component	Value
Benefit-cost ratio (BCR)	1.2
Break-even point (BEP)	
Rupiah	IDR 161,148,481
Quantity	80 lambs
Payback period of credit (PPC)	236 days ≈ 7.87 months

Furthermore, given that the BEP plays a vital role in management decision-making (Siregar and Aulia, 2023), BEP is then calculated. In this study, the calculated BEP was found to be significantly higher than that reported by Mufidah (2023). This suggests that the current study must achieve greater revenue, which translated to an increased need for sheep sales. Additionally, the fattening sheep enterprise examined here is considered profitable, as its annual revenue exceeds the BEP. In contrast, Mufidah (2023) reported longer PPC than what was observed in the current study. This difference can be attributed to higher number of sheep sold in the current study, suggesting effective marketing strategies and strong buyer relationships. Wibow *et al*. (2016) identified key factors influencing sheep sales in Indonesia including the sex of the sheep. In this study, all the fattening sheep were male, which may enhance their appeal to buyers. Thus, it is plausible that the male sheep are preferred by the buyers. This finding aligns with Bansal *et al*. (2022), who noted that male sheep is favored due to their faster growth rates and greater body weight. Although Mufidah (2023) did not provide information on the sex of the sheep, the observed variation may be influenced by sex-related characteristics or other unreported variables within the study.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that Priangan sheep, as a local breed, exhibit a remarkable adaptability to tropical conditions, even under suboptimal environmental stress. Feeding dried water spinach (DWS), a cost-effective feed option, supported satisfactory growth performance under tropical lowland farming conditions, particularly in males. In addition, the economic prospects of rearing Priangan sheep appear promising. While the single-diet design in this study reflects practical realities and provides field-level insights, the absence of a conventional forage control group, together with limited environmental monitoring and variation in stocking density, highlights the need for further controlled studies. Future research should incorporate physiological assessments and treatment-based comparisons to optimize feed strategies and deepen the understanding of environmental interactions. Nevertheless, the current findings provide practical and applicable value for sustainable livestock development in tropical regions.

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NOVELTY STATEMENT

This study pioneers the field-based assessment of dried water spinach (DWS) for Priangan sheep under documented tropical heat stress, quantifying natural performance variation and economic viability under a uniform feeding regime to bridge experimental research and smallholder practice.

AUTHOR'S CONTRIBUTION

PNS contributed to methodology, validation, and investigation. AF played a role in conceptualization and data curation. Meanwhile, AAY contributed to software utilization and writing original draft. All authors have given their final approval for this manuscript.

Generative AI and AI-assisted technology statement

The authors confirm that the scientific content, data analysis, and conclusions in this manuscript were developed entirely without the use of generative AI. AI-based tools were applied solely to refine the clarity and grammar of the language, and all resulting edits were carefully reviewed and approved by the authors.

Conflict of interest

The authors have declared no conflict of interest.

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