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Smallholder Livestock Farming and Rural Livelihoods in the Enclave of Mount Merbabu National Park, Indonesia

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Abstract. *Smallholder livestock farming plays an important role in rural livelihoods, particularly in communities surrounding protected areas where agricultural activities interact with natural resource management. This study aimed to characterize the socioeconomic profiles, production practices, and livelihood functions of livestock farmers in the enclave landscape of Mount Merbabu National Park, Indonesia. A quantitative cross-sectional survey was conducted in October 2026 across five hamlets using a total sampling approach, in which all eligible livestock farmers in the selected hamlets were targeted for participation. Data from 167 respondents were collected through structured interviews, field observations, and documentation, and analyzed using descriptive statistics. The results showed that livestock farmers had an average age of 52.2 years, with crop farming constituting the primary occupation of 94.0% of respondents. Livestock enterprises included beef cattle, dairy cattle, goats, and sheep, with 50.9% of respondents identifying savings as a livestock production purpose. Crop–livestock integration was reported by 86.8% of respondents, indicating the importance of resource complementarity in farming systems. Major constraints included high feed prices (55.7%), animal diseases (53.3%), and unstable selling prices (37.7%), with variations across study sites. These findings highlight the multifunctional role of livestock as both a productive activity and a household financial asset. This study contributes empirical evidence on how livestock production, household asset functions, and crop–livestock integration intersect within rural livelihoods in enclave communities associated with protected-area landscapes. Strengthening livestock livelihoods requires location-specific interventions addressing feed management, animal health, and market access while considering natural resource management in protected-area landscapes.*

Keywords: *Smallholder livestock farming, Rural livelihoods, Household savings, Crop–livestock integration, Protected areas, Mount Merbabu National Park*

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INTRODUCTION

Smallholder livestock farming plays an important role in sustaining rural livelihoods, particularly in developing countries where agricultural households depend on multiple economic activities. Beyond providing animal-source food and income, livestock contributes to household asset accumulation, risk management, and agricultural resource utilization. In Indonesia, livestock production remains dominated by small-scale farming systems characterized by family labour, locally available resources, and traditional management practices (Agus & Widi, 2018). Livestock farming is frequently integrated with crop production, enabling households to utilize agricultural residues as feed and livestock manure as organic fertilizer (Herrero et al., 2010).

The economic significance of livestock extends beyond agricultural production. Rural households often maintain livestock as productive assets that can be converted into financial resources when necessary. Livelihood diversification enables households to manage economic uncertainty through the allocation of labour, assets, and productive resources (Ellis, 2000). Hänke & Barkmann (2017) demonstrated that livestock ownership provides a financial buffer against agricultural production failures. However, livestock-based savings remain vulnerable to biological and market risks, particularly when animals must be sold under unfavourable conditions (Zant, 2023). Understanding livestock farming therefore requires consideration of household economic objectives, production arrangements, and asset-management strategies. From a rural livelihood perspective, livestock production should be understood not only as an agricultural enterprise but also as part of a broader household strategy involving productive resouces, economic security, and livelihood diversification.

These relationships become particularly important in communities located within or adjacent to protected areas, where agricultural livelihoods interact with conservation objectives. Protected-area management requires balancing biodiversity conservation with local communities' access to natural resources (Alamanda et al., 2022; Aprylasari & Azizah, 2025). In this context, livestock farming represents an important component of the relationship between household livelihoods and natural resource management. Livestock production depends on access to feed, water, land, and other agricultural resources, while farming practices may also have implications for resource utilization in landscapes surrounding conservation areas. These interactions create a need to understand

how livestock farming is organized at the household level and how farmers manage productive resources under different local conditions. Importantly, examining these relationships does not necessarily require measuring direct ecological impacts; socioeconomic characteristics, production practices, and resource-use patterns provide an initial empirical basis for identifying livelihood-related considerations relevant to protected-area management.

Mount Merbabu National Park, Central Java, Indonesia, provides a relevant setting for examining these interactions. Communities in the enclave-associated settlements of Batur and Tajuk Villages, Getasan Subdistrict, Semarang Regency depend on agricultural and livestock activities supported by locally available resources. Aissiyah et al. (2019) documented grass and fuelwood utilization among communities surrounding Mount Merbabu National Park, highlighting the relationship between subsistence needs and conservation management. Their research provides important evidence concerning community dependence on natural resources; however, it does not comprehensively characterize livestock ownership, household production objectives, livestock-related financial functions, marketing arrangements, or the diversity of livestock farming constraints across settlements. Meanwhile, (Agus & Widi, 2018) highlighted production management and institutional challenges affecting smallholder livestock development in Indonesia, but their broader review does not specifically address the socioeconomic and livelihood characteristics of livestock farmers in the enclave-associated communities of Mount Merbabu National Park.

Despite these contributions, an important empirical gap remains in understanding how smallholder livestock farming supports rural livelihoods across the five selected hamlets of Ngaduman, Gedong, Nglelo, Thekelan, and Seloduwur. Specifically, the available studies cited above do not establish how farmers' socioeconomic characteristics, livestock ownership patterns, production objectives, household resource utilization, and marketing practices vary across these locations. Furthermore, the extent to which livestock functions as a productive enterprise, household financial asset, and component of integrated crop–livestock farming has not been systematically characterized in these communities. The variation in production constraints, including feed availability, animal health, water access, and market conditions, also requires closer examination. Addressing these knowledge gaps is important because differences in household livelihood strategies

and farming conditions may require different livestock development priorities rather than uniform interventions across the enclave landscape.

Accordingly, the present study primarily focuses on the socioeconomic characteristics, production practices, and livelihood functions of smallholder livestock farming, while considering the protected-area landscape as an important environmental and institutional context. It does not directly assess biodiversity outcomes, conservation effectiveness, or the ecological impacts of livestock production. Instead, the study provides a descriptive empirical foundation for understanding livestock-based livelihoods in communities whose agricultural activities are situated within a broader conservation landscape.

This study aimed to characterize the socioeconomic profiles, production practices, and livelihood functions of smallholder livestock farmers in five hamlets associated with Mount Merbabu National Park. Specifically, it examined farmers' demographic characteristics, livestock ownership, production objectives, household resource utilization, feeding practices, crop–livestock integration, marketing arrangements, and major production constraints. By examining variations across study sites, the study provides empirical insights into the multifunctional role of livestock and its implications for livelihood-oriented livestock development in protected-area landscapes. Its contribution lies in integrating household socioeconomic characteristics, livestock production arrangements, and livelihood functions within a single descriptive assessment, thereby providing locally grounded evidence to inform context-specific livestock development strategies in enclave-associated communities.

LITERATURE REVIEW

Smallholder livestock farming plays an important role in rural livelihoods, particularly in agricultural households that depend on multiple economic activities. Livestock contributes not only to household income but also to asset accumulation, financial security, and livelihood diversification. Ellis (2000) emphasized that rural livelihood diversification involves the combination of productive activities and assets to sustain household economic conditions. Similarly, Hänke & Barkmann (2017) demonstrated that livestock ownership provides an important financial buffer against agricultural production failures. However, Zant (2023) highlighted that livestock-based

savings may involve economic risks, particularly when animals are sold under unfavorable market conditions. These findings indicate that livestock farming should be understood as both a productive enterprise and a component of household livelihood strategies.

The socioeconomic characteristics of livestock farmers influence the organization and management of smallholder farming systems. Agus & Widi (2018) identified that livestock production in Indonesia is predominantly characterized by small-scale enterprises, traditional management practices, and challenges related to production resources and institutional development. Similarly, Kardaya et al. (2020) reported that smallholder livestock farmers commonly have relatively low formal education levels and substantial practical farming experience. These characteristics suggest that livestock production is closely associated with household resources, accumulated knowledge, and locally established management practices. Understanding farmers' socioeconomic profiles is therefore important for identifying the characteristics and development needs of smallholder livestock enterprises.

Crop–livestock integration represents another important component of smallholder agricultural systems. Herrero et al. (2010) emphasized that mixed farming systems create opportunities for resource complementarity through the utilization of agricultural residues as livestock feed and the recycling of animal manure as organic fertilizer. Such practices may improve resource utilization and strengthen the relationship between crop and livestock production. Titisari et al. (2022) also highlighted the potential of agricultural waste conversion in supporting integrated and environmentally oriented farming practices. Nevertheless, the effectiveness of crop–livestock integration depends on resource availability, production management, and local farming conditions.

Livestock farming in protected-area landscapes requires particular consideration because agricultural livelihoods interact with natural resource management and conservation objectives. Aissiyah et al. (2019) examined grass and fuelwood utilization among communities surrounding Mount Merbabu National Park, demonstrating the importance of natural resources in supporting local subsistence activities. Meanwhile, Alamanda et al. (2022) highlighted the relevance of farmers' readiness and institutional support for livestock development surrounding Baluran National Park. These studies indicate that livestock-related livelihoods in conservation landscapes need to be

understood within their socioeconomic and environmental contexts. However, resource utilization studies do not necessarily provide comprehensive information on livestock ownership, production objectives, household economic functions, and marketing arrangements.

Previous studies have highlighted the importance of livestock in rural livelihood diversification, household asset management, agricultural resource integration, and protected-area communities. However, the available studies provide limited integrated evidence on how these characteristics are manifested across the five selected hamlets of Ngaduman, Gedong, Nglelo, Thekelan, and Seloduwur around Mount Merbabu National Park. Therefore, this study focuses on characterizing the socioeconomic profiles, production practices, and livelihood functions of smallholder livestock farmers across these locations. By examining these dimensions together, the research seeks to provide a more comprehensive descriptive understanding of livestock-based rural livelihoods in enclave-associated communities and identify locally relevant priorities for livestock development.

RESEARCH METHODS

1. Study Area and Research Design

The study was conducted from October 1 to 30, 2026, in five hamlets located within the enclave landscape of Mount Merbabu National Park, Central Java, Indonesia. The research sites included Ngaduman and Gedong Hamlets in Tajuk Village, and Nglelo, Thekelan, and Seloduwur Hamlets in Batur Village. Both villages are administratively located in Getasan District, Semarang Regency. These locations were purposively selected because of their proximity to the national park, the presence of livestock farming communities supported by the Mount Merbabu National Park Authority, and the continued importance of traditional livestock production in local livelihoods.

A quantitative research approach employing a cross-sectional survey design was used to characterize livestock farmers, their production practices, and livelihood-related activities (Setia, 2016). The survey approach enabled standardized information to be collected from livestock farmers across different study sites. The research was descriptive in nature and aimed to identify patterns in socioeconomic characteristics, livestock management practices, and livelihood functions rather than establish causal relationships among variables.

2. Sampling and Data Collection

Respondents were selected using a total sampling approach, in which all livestock farmers within the designated study locations were targeted as research participants. This approach was adopted based on the population characteristics and the relatively limited number of livestock farmers in the selected hamlets. No additional inclusion or exclusion criteria were applied, as the study was intended to include all livestock farmers identified within the five selected hamlets, regardless of their livestock commodities, farming experience, or production orientation. The enumerated population consisted of 167 livestock farmers, distributed across Thekelan (62 farmers), Ngaduman (43 farmers), Gedong (32 farmers), Seloduwur (18 farmers), and Nglelo (12 farmers). All 167 identified livestock farmers were included in the survey, representing the complete enumerated livestock farming population across the selected study locations. The population distribution and survey coverage are presented in Table 1.

The primary unit of analysis was the individual livestock farmer. Information concerning household resources, livestock ownership, and farming activities was obtained through individual respondent interviews. Each respondent could report more than one livestock commodity; therefore, livestock ownership categories were not considered mutually exclusive, and different livestock commodities owned by the same respondent were not treated as separate observational units.

Primary data were collected through direct field observations, face-to-face interviews using structured questionnaires, and field documentation. The questionnaire covered farmers' demographic and socioeconomic characteristics, livestock ownership, farming experience, production objectives, labour utilization, capital access, feeding practices, livestock housing, waste management, marketing channels, and production constraints. The livestock enterprises examined included beef cattle, dairy cattle, goats, and sheep.

The questionnaire was structured to collect both single-response and multiple-response information. Single-response questions were used to record individual socioeconomic characteristics and selected farming attributes, while multiple-response questions allowed respondents to report more than one livestock commodity, production objective, marketing channel, or farming constraint. Interviews were conducted directly with livestock farmers involved in livestock management activities.

Field observations were conducted to document livestock management practices and farming conditions, while photographic documentation provided supplementary information on livestock housing, animals, feeding facilities, and farm infrastructure. Secondary data were obtained from relevant scientific literature, government publications, and supporting information related to Mount Merbabu National Park.

3. Data Analysis

Data were analyzed using descriptive quantitative methods to characterize the socioeconomic profiles, livestock production practices, and livelihood functions of the surveyed livestock farmers. Categorical variables were summarized using frequencies and percentages, while numerical variables, including farmers' age and livestock farming experience, were described using measures of central tendency and dispersion (Mishra et al., 2019).

Responses containing multiple categories, such as livestock types, production objectives, marketing channels, and farming constraints, were tabulated as multiple-response variables. Percentages for these categories were calculated relative to the relevant number of respondents, allowing individuals to be represented in more than one category. Consequently, the sum of percentages across multiple-response categories could exceed 100%. Missing observations were excluded from calculations involving the corresponding variables.

Descriptive comparisons across the five study sites were conducted to identify variations in livestock composition, production practices, and farming constraints. For comparisons between hamlets, percentages were calculated by dividing the number of respondents reporting a particular characteristic by the number of respondents with valid information for that variable within the corresponding hamlet and multiplying by 100. This approach accounted for differences in the number of respondents across the five locations. The analysis focused on identifying observable patterns rather than establishing causal relationships (Setia, 2016). No inferential statistical tests were performed; therefore, observed differences between hamlets were interpreted as descriptive variations rather than statistically significant differences. The findings were subsequently interpreted in relation to smallholder livelihood strategies, crop–livestock integration, and livestock development within a protected-area landscape.

RESULTS AND DISCUSSION

1. Socioeconomic Characteristics of Livestock Farmers

The study involved 167 livestock farmers from five hamlets surrounding Mount Merbabu National Park, Central Java, Indonesia. The largest proportion of respondents originated from Thekelan (37.1%), followed by Ngaduman (25.7%), Gedong (19.2%), Seloduwur (10.8%), and Nglelo (7.2%). The respondents were predominantly male (96.4%), with a mean age of 52.2 years. Among the 164 respondents with valid age information, 89 respondents (54.3%) were older than 50 years, while only 10 respondents (6.1%) were aged 35 years or younger.

Table 1. Socioeconomic characteristics of livestock farmers

Characteristics	Frequency (n)	Percentage (%)
Male	161	96.4
Female	6	3.6
Primary education	69	41.3
Junior secondary education	41	24.6
Senior secondary education	18	10.8
Higher education	7	4.2
Incomplete primary education	2	1.2
Education not recorded	30	18.0
Crop farming as primary occupation	157	94.0
Livestock farming as secondary occupation	163	97.6

The predominance of middle-aged and older respondents suggests that livestock farming is largely maintained by individuals with established farming experience. Comparable characteristics were reported by Kardaya et al. (2020), who found that smallholder beef cattle farming in southern West Java was commonly associated with primary-level education, substantial practical experience, and livestock keeping as a secondary occupation. Although the limited representation of younger respondents may raise concerns about future farming continuity, this cannot be interpreted as direct evidence of declining generational succession because the participation and occupational preferences of younger household members were not examined. Nevertheless, the age distribution raises relevant considerations regarding the future availability of agricultural labour, the transfer of livestock management knowledge, and the continuity of household livestock enterprises. Older farmers may possess substantial practical knowledge accumulated through long-term experience, but maintaining livestock production over

time may also require opportunities for younger household members to acquire and apply such knowledge. These implications remain tentative because the study did not directly assess intergenerational knowledge transfer, household labour succession, or younger family members' intentions to continue livestock farming.

Educational attainment was relatively low, with primary and junior secondary education representing the largest categories. Livestock farming experience averaged 17 years, indicating that respondents had accumulated substantial practical knowledge through long-term engagement in animal husbandry. This combination suggests that livestock management may depend considerably on experiential learning and locally established practices. Such experience may represent an important knowledge resource for livestock management and informal learning within farming households. However, accumulated experience alone does not demonstrate that knowledge is being transferred to younger generations or that livestock enterprises will continue across generations. Nevertheless, the relationship between experience, adoption of improved technologies, and production efficiency requires further investigation. Similarly, the predominance of male respondents reflects the composition of the survey rather than necessarily demonstrating that women have limited involvement in livestock care or household production decisions (Azizah et al., 2023).

Most respondents identified crop farming as their primary occupation (94.0%), while livestock keeping was predominantly reported as a secondary activity (97.6%). This indicates that livestock production is embedded within diversified agricultural livelihoods rather than functioning exclusively as an independent commercial enterprise. Ellis (2000) explained that rural households diversify their economic activities to manage uncertainty, allocate labour, and utilize available assets. Herrero et al. (2010) similarly highlighted the complementary functions of crops and livestock within smallholder agricultural systems.

These characteristics suggest that livestock farming around Mount Merbabu represents an integrated household livelihood strategy in which agricultural production, family resources, and accumulated farming experience are closely connected. However, the economic importance of livestock cannot be fully determined without quantifying its contribution to household income and expenditure.

2. Livestock Ownership, Production Orientation, and Livelihood Functions

Livestock production across the surveyed respondents was characterized by considerable diversity. Beef cattle were reported by 69 respondents (41.3%), dairy cattle by 57 (34.1%), goats by 31 (18.6%), and sheep by 27 (16.2%). Livestock ownership categories were not mutually exclusive, as individual respondents could maintain more than one livestock commodity. Therefore, the frequencies represent reported commodity ownership rather than separate livestock enterprises or independent observations.

Table 2. Livestock ownership and production purposes

Indicator	Frequency (n)	Percentage (%)
Beef cattle	69	41.3
Dairy cattle	57	34.1
Goats	31	18.6
Sheep	27	16.2
Savings as production purpose	85	50.9
Fattening	68	40.7
Milk production	36	21.6
Breeding	7	4.2

Production objectives included savings (50.9%), fattening (40.7%), milk production (21.6%), and breeding (4.2%). These objectives were not mutually exclusive, indicating that productive and financial functions may coexist within the same livestock enterprise. Such diversity is consistent with the multifunctional nature of smallholder livestock systems, in which animals provide marketable products, household assets, and other economic benefits. However, these percentages represent production objectives reported across the surveyed respondents and should not be interpreted as commodity-specific production patterns without cross-tabulation between livestock types and production purposes.

Savings was identified as a livestock production purpose by 85 respondents (50.9%), as presented in Table 2. This finding indicates that household asset accumulation represents one of the important motivations for livestock keeping among the surveyed farmers, alongside fattening, milk production, and breeding. The financial function of livestock is therefore relevant to understanding household livelihood strategies, although the study does not directly measure the amount of savings accumulated, livestock asset values, or the contribution of livestock ownership to household financial resilience.

Hänke & Barkmann (2017) demonstrated that livestock can serve as an informal insurance mechanism, enabling households to cope with agricultural production failures through animal sales. Similarly, Zant (2023) identified livestock as an important savings instrument in rural economies, although its financial effectiveness may decline when households are forced to sell animals under unfavourable market conditions.

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The different livestock commodities may also involve distinct production cycles, market arrangements, and household economic functions. Dairy cattle production can potentially generate relatively regular income through milk sales, whereas cattle fattening generally emphasizes animal weight gain and income realization through livestock sales. Breeding activities focus on producing offspring and maintaining or expanding livestock assets, while goat and sheep production may provide flexible opportunities for animal sales according to household needs and market demand. These distinctions provide a conceptual basis for interpreting the different economic roles of livestock commodities. However, the present descriptive data do not quantify commodity-specific income, sales frequency, production profitability, or the distribution of production objectives within each livestock category. Consequently, these differences should be regarded as potential characteristics of the production systems rather than demonstrated economic comparisons.

Overall, livestock ownership appears to fulfil a dual function in the study area: supporting agricultural production and maintaining household assets. However, the extent

to which these functions contribute to household financial security requires additional information on livestock sales, production costs, income allocation, and responses to economic shocks.

3. Household Labour, Capital Access, and Livestock Marketing

Livestock production was strongly supported by household-owned resources. Most respondents (98.2%) used privately owned livestock housing facilities, while 73.1% relied exclusively on family labour. These findings indicate that livestock enterprises were predominantly organized through household production arrangements rather than formal business structures employing substantial external labour. Family labour may provide flexibility in managing daily livestock activities alongside crop production. However, reliance on unpaid family labour does not necessarily imply lower economic costs because household members' time has alternative productive uses. In this context, family labour should be understood as an important productive resource that contributes to livestock management while also involving opportunity costs. Time allocated to feeding, animal care, and other livestock activities may reduce the availability of household labour for alternative agricultural or non-agricultural activities. Therefore, the economic contribution of livestock farming cannot be fully evaluated without considering the value of unpaid household labour.

Regarding access to financial resources, 126 of the 151 respondents with classifiable answers (83.4%) reported not using borrowed capital. This pattern may indicate a preference for financing livestock enterprises through household savings or existing assets. Nevertheless, limited borrowing should not automatically be interpreted as financial exclusion, as it may also reflect differences in investment requirements, attitudes toward indebtedness, and risk-management preferences. The low reported use of borrowed capital may reflect several possible circumstances, including reliance on internally available resources, relatively limited investment requirements, a preference for avoiding repayment obligations, or difficulties accessing formal finance. However, the questionnaire results presented in this study do not establish which of these explanations predominates. Additional information on credit demand, financing preferences, loan applications, and borrowing constraints would be necessary to distinguish voluntary non-borrowing from restricted financial access.

Livestock marketing was dominated by collectors or intermediaries, reported by 97 respondents (58.1%), followed by cooperatives or village cooperative units, reported by 40 respondents (24.0%), and direct consumer sales (10.2%). Cooperative-based marketing was strongly associated with dairy farming, as 39 of the 40 respondents reporting cooperative marketing also kept dairy cattle. This indicates that 97.5% of respondents reporting cooperative marketing were dairy cattle owners, suggesting a close correspondence between dairy farming and organized marketing arrangements within the surveyed population.

The observed marketing arrangements may reflect differences in the characteristics of livestock products and their distribution requirements. Fresh milk requires frequent collection and timely handling, making organized cooperative channels potentially advantageous for coordinating collection and distribution. In contrast, live-animal transactions may involve less frequent sales, for which collectors or intermediaries can provide access to buyers and facilitate transportation. Nevertheless, the available data do not establish the complete commodity-specific distribution of marketing channels, particularly for beef cattle, goats, and sheep.

In the Mount Merbabu landscape, intermediaries may potentially reduce the logistical burden associated with transporting and selling livestock. However, reliance on a limited number of buyers could also create information asymmetries and unequal negotiating conditions. These possibilities cannot be confirmed without investigating price formation, alternative buyer availability, and farmers' bargaining experiences. Accordingly, the predominance of intermediary-based marketing should not be interpreted as direct evidence of unequal bargaining power or unfavourable selling prices. Rather, it highlights the importance of examining farmers' access to market information, available marketing alternatives, and institutional support in future research.

Cooperative participation among dairy farmers reflects a different marketing arrangement. Because fresh milk requires frequent collection and timely distribution, organized marketing channels may offer operational benefits. (Ginting et al., 2018) demonstrated that transaction costs associated with feed procurement, information access, and milk marketing influence smallholder dairy enterprise performance. Communication networks linking farmers, brokers, and other stakeholders have also been documented in Indonesian cattle enterprises (Putritamara et al., 2020).

The coexistence of intermediary-based and cooperative-based marketing indicates that market organization varies across livestock commodities. This variation has implications for extension programs and institutional development. Improving market information and strengthening producer organizations may potentially enhance farmers' marketing options. Nevertheless, whether these interventions increase income or bargaining power would require comparative economic analysis.

Thus, the findings suggest that household resources and market relationships are important structural characteristics of livestock farming, while the economic effectiveness of different financing and marketing arrangements remains an empirical question.

4. Feeding Practices and Crop–Livestock Integration

Forage constituted a fundamental component of livestock feeding systems. Natural grass was reported by 116 respondents (69.5%), while cultivated grass was reported by 25 respondents (15.0%). Supplementary feeds included concentrates (60.5%), pellets (37.1%), and pollard (21.0%). These findings indicate that livestock feeding generally combines locally available forage with supplementary feed resources, reflecting the mixed feeding arrangements commonly observed in smallholder ruminant production.

Herrero et al. (2010) emphasized that crop–livestock systems depend on interactions between biomass production, livestock feeding, and agricultural resource management. In farming systems where livestock constitutes a complementary household activity, the availability of locally accessible forage may influence production costs, livestock ownership decisions, and the amount of labour required for daily animal care.

Forage utilization is particularly relevant in the Mount Merbabu landscape because agricultural livelihoods are situated around a protected natural areaAissiyah et al. (2019) documented the utilization of grass and fuelwood by communities surrounding Mount Merbabu National Park, demonstrating that access to natural resources is connected to local subsistence activities. Their study also highlighted the importance of understanding resource utilization within the institutional and social context of conservation management.

However, the present survey did not establish the precise origin of the forage used by respondents. Natural grass could originate from privately managed land, agricultural areas, communal resources, or locations where collection is permitted. Therefore, forage

utilization should not automatically be interpreted as direct dependence on resources within the national park. Distinguishing between these sources is important for accurately assessing the relationship between livestock farming and conservation-area resource use.

Crop–livestock integration was reported by 145 respondents (86.8%), with the same proportion indicating livestock waste utilization. The application of livestock manure to agricultural land represented one of the commonly identified integration practices. This suggests that crop and livestock production are connected through resource recycling, potentially enabling households to utilize agricultural residues as feed and return livestock manure to cultivated land. Herrero et al. (2010) identified nutrient recycling as an important characteristic of mixed farming systems.

Nevertheless, the sustainability of integration depends on more than the existence of resource-recycling practices. Nutrient losses, manure handling, feed availability, and labour requirements can influence actual environmental and economic performance. Without information on quantities of manure applied, feed obtained from agricultural residues, or input costs avoided, the efficiency of crop–livestock integration cannot be conclusively evaluated.

The findings therefore indicate that integrated agricultural practices are widely reported among surveyed households, providing a potential foundation for improved resource management (Titisari et al., 2022). In a protected-area landscape, strengthening cultivated forage production, feed preservation, and manure utilization may offer opportunities to improve livestock production while reducing unnecessary pressure on external resources. However, their conservation benefits require further empirical assessment.

5. Livestock Farming Constraints and Spatial Differences

Livestock farmers reported several production, economic, and resource-related constraints. High feed prices represented the most frequently reported challenge (55.7%), followed by animal diseases (53.3%) and livestock selling-price instability (37.7%). Other constraints included feed shortages (21.0%), water shortages (18.0%), limited capital (15.0%), and climate-related changes (8.4%).

Table 3. Major livestock farming constraints

Constraint	Frequency (n)	Percentage (%)
High feed prices	93	55.7
Animal diseases	89	53.3
Selling-price instability	63	37.7
Feed shortages	35	21.0
Water shortages	30	18.0
Limited capital	25	15.0
Climate-related changes	14	8.4

The prominence of high feed prices indicates that livestock production is vulnerable to increasing input costs, particularly among farmers using purchased supplementary feeds. Similarly, animal diseases potentially threaten livestock productivity and the economic value of household assets. Agus & Widi (2018) identified feeding management, animal health, and institutional support as important challenges affecting the development of Indonesian smallholder cattle production.

Selling-price instability represents an additional concern because livestock frequently functions as a household savings instrument. When animals are maintained as assets, their economic value depends partly on prevailing market prices at the time of sale. Zant (2023) demonstrated that livestock-based savings may become less effective when adverse market conditions reduce the real value of animals during periods of household financial stress.

These findings suggest that the interaction between production and market risks may be particularly important for livestock-dependent households. Increasing feed costs can reduce the economic benefits of maintaining animals, while disease outbreaks and unfavourable selling prices may simultaneously threaten the value of livestock assets. Consequently, improving livestock resilience requires attention to both production management and marketing conditions. Research on beef cattle farmers affected by flooding in Bima Regency similarly emphasizes the importance of sustainable livelihood strategies in response to external shocks (Kharismafullah et al., 2022).

Spatial differences were evident across the study sites. Water shortages were reported by 41.9% of respondents in Thekelan, while 72.2% of respondents in Seloduwur identified selling-price instability. In Gedong, 71.9% reported high feed prices. These variations suggest that livestock development challenges differ according to local conditions.

Livestock composition also varied. Dairy cattle were relatively common in Gedong and Thekelan, while beef cattle were prominent in Ngaduman. Goat and sheep keeping was frequently reported in Seloduwur. These differences may reflect variations in local production opportunities, household resources, and marketing arrangements. However, the descriptive data do not establish which factors explain the observed patterns.

Agus & Widi (2018) emphasized that improvements in smallholder livestock systems require approaches adapted to production conditions and farmers' capacities. Accordingly, the results suggest that geographically differentiated interventions may be more relevant than uniform livestock development programs. For example, improved water management may be particularly important in areas reporting water shortages, whereas better market information and collective marketing may be more relevant where selling-price instability is prominent. Nevertheless, such priorities should be considered preliminary because respondents' reported constraints do not necessarily measure their actual economic severity.

6. Implications for Livestock Development in Protected-Area Landscapes

The findings reveal three interconnected characteristics of livestock farming around Mount Merbabu National Park. First, livestock keeping is closely integrated with crop-based agricultural livelihoods. Second, livestock serves multiple economic functions, particularly as a productive enterprise and household savings asset. Third, livestock production is affected by heterogeneous resource constraints and marketing arrangements across the study sites. These characteristics indicate that livestock development strategies should consider broader household livelihood objectives rather than focusing exclusively on productivity. Herrero et al. (2010) highlighted the importance of resource complementarities and integrated production in strengthening smallholder agricultural systems.

In the Mount Merbabu area, livestock development may therefore benefit from integrating productive, economic, and environmental considerations. Improved forage cultivation, animal health services, livestock waste management, and marketing institutions represent potentially relevant intervention areas. Such initiatives could be developed through collaboration among farmers, agricultural extension services, local governments, and protected-area management authorities (Alamanda et al., 2022; Azizah & Firmansyah, 2025). Within this context, conservation-related institutions may have a

potential role in facilitating communication concerning permitted resource access, sustainable forage management, and coordination between livelihood development activities and conservation objectives. However, the present study did not directly evaluate existing resource-access arrangements, institutional coordination mechanisms, or the effectiveness of conservation-related interventions. Therefore, these institutional roles should be regarded as potential areas for future collaboration rather than established findings of the survey.

Aissiyah et al. (2019) demonstrated that natural resource utilization around Mount Merbabu National Park is closely associated with local livelihood needs. This underscores the importance of understanding how livestock farmers access and manage feed resources before designing conservation-related interventions. Although natural grass was commonly reported as a feed source, the absence of information on its precise origin prevents conclusions about direct dependence on resources inside the national park. Future research should therefore distinguish forage obtained from privately managed agricultural land, communal resources, and areas where collection may be regulated by conservation authorities. Such information would provide a stronger empirical basis for understanding the relationship between livestock-based livelihoods and protected-area management.

However, the present research did not directly measure biodiversity outcomes, environmental impacts, household economic resilience, or the effectiveness of conservation partnerships. Therefore, the implications identified here represent potential development directions rather than demonstrated causal outcomes.

The study also has methodological limitations. Its cross-sectional and primarily descriptive design does not establish causal relationships between farmers' socioeconomic characteristics, livestock management practices, and livelihood outcomes. Moreover, differences in respondent numbers across hamlets and incomplete information for selected variables constrain the interpretation of spatial patterns. Additional limitations include the absence of direct measurements of commodity-specific economic returns, unpaid household labour costs, quantitative resource flows within crop–livestock systems, and specific forage collection locations. These limitations should be considered when interpreting the financial, environmental, and institutional implications of the findings.

Despite these limitations, the research provides a useful empirical characterization of livestock farming within a protected-area landscape. Its main contribution lies in identifying the coexistence of agricultural livelihood integration, savings-oriented livestock ownership, differentiated market arrangements, and location-specific production constraints. By examining these characteristics within a single descriptive assessment, the study contributes locally grounded evidence on how livestock production and household livelihood functions are organized across enclave-associated communities.

CONCLUSION

Smallholder livestock farming around Mount Merbabu National Park plays an important role in rural livelihoods, functioning as both a productive activity and a household asset, with 85 respondents (50.9%) identifying savings as one of their livestock production purposes. Livestock farming is closely integrated with crop production, supported by family labour and local resources. Crop–livestock integration was reported by 86.8% of respondents, indicating the prevalence of integrated agricultural practices, although their economic and environmental performance was not directly measured. However, high feed costs, animal diseases, and unstable selling prices remain major challenges. Differences in production systems and constraints across study sites suggest the potential relevance of location-specific development strategies. Potential development priorities include improved forage cultivation, feed preservation, strengthened animal health services, better access to market information, and stronger producer organizations. Collaboration with protected-area management authorities may also support coordination between livestock development and natural resource management. However, these interventions should be considered potential priorities rather than proven solutions, as their effectiveness was not evaluated in this study. Given its cross-sectional descriptive design, the study does not establish causal relationships between livestock farming practices and livelihood outcomes. Furthermore, household economic resilience, environmental impacts, and conservation outcomes were not directly measured. Further research is needed to assess the relationships between livestock production, household economic resilience, and environmental sustainability in protected-area landscapes.

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