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Revolution or Disruption? Implications of Precision Livestock Farming (PLF) for Traditional Livestock Systems in Indonesia

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ABSTRACT

Precision Livestock Farming (PLF) is a modern approach to livestock management that leverages sensors, the Internet of Things (IoT), and artificial intelligence to enhance efficiency, productivity, and animal welfare. In developed countries, PLF is regarded as a revolution in the livestock sector; however, in the context of traditional livestock farming in Indonesia, particularly among small-scale beef cattle farmers, its implementation poses a dilemma between opportunities for transformation and risks of disruption. This systematic review, conducted in accordance with the PRISMA framework, critically examines the implications of PLF for traditional farmers by synthesizing literature from Scopus, Web of Science, ScienceDirect, and Google Scholar (2010-2024). Through thematic analysis of 40 selected studies, we find that PLF offers substantial benefits, including improved feed efficiency, early disease detection, and enhanced animal welfare, but also faces significant barriers, such as high investment costs, limited infrastructure, low digital literacy, and risks of smallholder marginalization. By integrating evidence from both technological and socio-economic perspectives, this review provides a holistic analysis of PLF's dual role as both a transformative tool and a potential disruptor in developing agricultural contexts. The findings underscore the necessity of context-sensitive adoption strategies, informed by incremental technology introduction, supportive policies, targeted subsidies, cooperative models, and capacity-building initiatives. This study contributes to the literature by offering a policy-relevant framework for aligning PLF with inclusive and sustainable livestock development in Indonesia and similar settings.

Keywords: Precision Livestock Farming, beef cattle, traditional farmers, agricultural technology

INTRODUCTION

Precision Livestock Farming (PLF) is a modern approach to livestock management that utilizes digital technologies, sensors, and artificial intelligence to monitor animal health, productivity, and welfare in real time. In developed countries, PLF is increasingly being adopted as a new standard in livestock farming, as it is believed to enhance production efficiency and sustainability. However, livestock systems in Indonesia, particularly among traditional beef cattle farmers, are still dominated by conventional practices characterized by limited capital, restricted access to technology, low levels of education, and limited digital literacy.

At the national level, the Indonesian government has launched several strategic initiatives to modernize the livestock sector, such as the *Sapi Kerbau Komoditas Andalan Negeri* (SIKOMANDAN) and *Upaya Khusus Percepatan Peningkatan Populasi Sapi dan Kerbau Bunting* (UPSUS SIWAB) programs. These policies aim to increase livestock productivity and population through improved breeding, feeding, and management practices. However, they have not yet fully integrated digital technologies such as PLF into their implementation frameworks. This omission represents a critical gap between national agricultural modernization goals and the technological realities on the ground, particularly for small-scale farmers.

Studies indicate that PLF not only optimizes resource use but also reduces the environmental impact of livestock production while addressing the growing global demand for animal-based products (Egon & Oloyede, 2023). The implementation of PLF has also been associated with long-term cost savings through early disease detection and more precise feed management. On the other hand, research on the impacts of PLF on small-scale farmers remains limited, particularly in developing countries such as Indonesia. While existing literature highlights the potential of PLF to improve productivity and sustainability, there is a conspicuous lack of studies examining its socioeconomic implications within the framework of Indonesia's national livestock policies and local farming contexts. Some literature highlights the risk of marginalizing traditional farmers due to unequal access to technology. Still, few studies provide actionable insights into how PLF can be harmonized with existing policy instruments and local wisdom.

Despite its promising benefits, the application of PLF among traditional farmers raises a critical question: can this technology truly be accessed and utilized by smallholders within Indonesia's current policy and infrastructural landscape, or will it instead widen the gap between modern and traditional livestock systems? Local conditions, such as those in West Nusa Tenggara (NTB), one of Indonesia's main beef cattle production centers, require closer examination to fully understand the potential and challenges of PLF adoption in relation to national development agendas.

This article reviews the literature on the application of PLF in beef cattle farming, with particular focus on its implications for traditional farmers in the context of Indonesia's agricultural and digitalization policies. It seeks to examine whether PLF can serve as a revolutionary solution to improve productivity in alignment with national goals, or whether it poses a risk of disruption that threatens the sustainability of small-scale farmers. By addressing the gap between policy intent and practical implementation, this review contributes to a more nuanced understanding of how PLF can be adapted to support inclusive and policy-coherent livestock development in Indonesia.

This review is significant because it offers a critical perspective on the introduction of advanced technologies into traditional livestock systems, situating the discussion within Indonesia's policy environment. By identifying both the opportunities and challenges of PLF, the findings are expected to serve as a reference for academics, policymakers, and livestock practitioners in formulating strategies for inclusive, sustainable, and policy-responsive technology adoption.

MATERIALS AND METHODS

Research Design and Methodological Framework

This study employs a systematic literature review (SLR) guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework.(Page et al., 2021). The PRISMA approach ensures transparency, reproducibility, and rigor in the identification, selection, and synthesis of relevant literature. The review process is structured into four main phases: identification, screening, eligibility assessment, and inclusion.

Data Sources and Search Strategy

A comprehensive literature search was conducted across four electronic databases:

1. Scopus
2. Web of Science
3. ScienceDirect (Elsevier)
4. Google Scholar (used complementarily to capture local Indonesian publications and grey literature relevant to the context)

The search strategy combined keywords and Boolean operators to maximize coverage:

- ("Precision Livestock Farming" OR "PLF")
- AND ("beef cattle" OR "cattle farming")
- AND ("smallholder farmers" OR "traditional farmers")
- AND ("developing countries" OR "Indonesia" OR "NTB" OR "West Nusa Tenggara")

Search filters were applied to restrict results to articles published between January 2010 and December 2024, in English or Indonesian.

Literature Screening and Selection Process

The screening process followed the PRISMA flow diagram (Figure 1) and consisted of three stages:

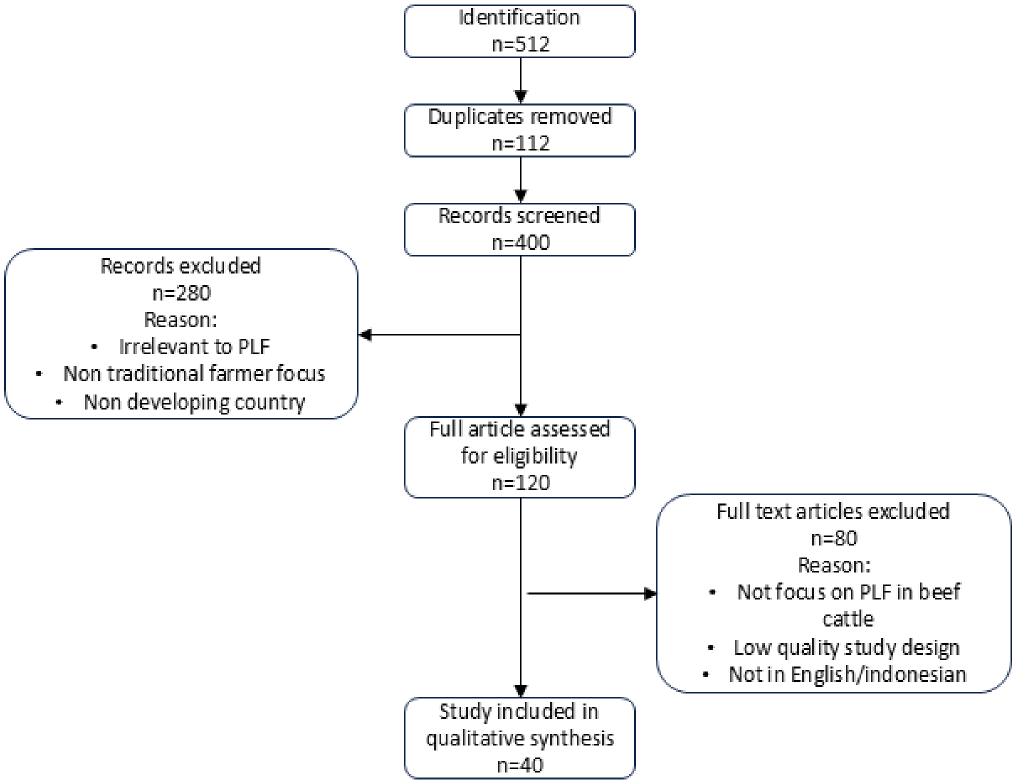
1. Identification: Initial search results from all databases were pooled, and duplicates were removed using reference management software (Zotero 6.0).
2. Screening: Titles and abstracts were screened independently by two researchers based on the inclusion and exclusion criteria. Discrepancies were resolved through discussion or consultation with a third reviewer.
3. Eligibility: Full texts of potentially relevant articles were retrieved and assessed for final inclusion. Articles that did not meet the eligibility criteria were excluded, with reasons documented.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Peer-reviewed journal articles, conference proceedings, or research reports.
- Studies focused on PLF technologies in beef cattle production.
- Research involving smallholder or traditional farmers in developing countries, especially Indonesia.
- Publications between 2010 and 2024 in English or Indonesian.

Figure 1. PRISMA 2020 Flow Diagram of the Literature Selection Process



Exclusion Criteria:

- Grey literature without peer review.
- Studies exclusively on non-ruminants (e.g., poultry, swine) without relevance to PLF in cattle.
- Articles lacking empirical data or conceptual relevance to traditional farming systems.

Quality Assessment of Selected Studies

To ensure the reliability and validity of the included literature, a quality assessment checklist was adapted from the Mixed Methods Appraisal Tool (MMAT) and the CASP guidelines. Each article was evaluated based on:

1. Clarity of research objectives and methodology
2. Appropriateness of study design and data collection
3. Relevance to PLF and traditional farming contexts
4. Strength of findings and implications

Studies were scored as high, medium, or low quality. Only studies rated medium or high were included in the final synthesis. The quality assessment was conducted independently by two reviewers, with inter-rater reliability calculated (Cohen's $\kappa = 0.85$), indicating strong agreement.

Data Extraction and Synthesis

Data from selected studies were extracted using a standardized template covering:

- Authors, year, country of study
- Research objectives and methodology
- Key findings related to PLF benefits, challenges, socio-economic impacts, and policy recommendations

Thematic analysis was employed to synthesize findings into coherent categories:

1. Potential and benefits of PLF
2. Implementation challenges among traditional farmers
3. Socio-economic and policy implications
4. Strategies for inclusive adoption

Validity and Reliability

To enhance validity, the entire selection and analysis process was documented and cross-verified. Regular team discussions were held to ensure consistency in interpretation and minimize bias. The use of PRISMA and quality assessment tools further strengthens the methodological rigor of this review.

RESULTS AND DISCUSSION

Concept and Benefits of Precision Livestock Farming (PLF)

Precision Livestock Farming (PLF) is a modern approach to livestock management that utilizes digital technologies, sensors, and artificial intelligence to monitor animal health, productivity, and welfare in real time. The core principle of PLF is to assist farmers in disease detection, improve feed efficiency, and ultimately reduce long-term production costs. According to Tzanidakis et al., (2023)PLF systems have the potential to enhance grazing efficiency and enable early detection of health issues; however, their implementation remains constrained by economic, cultural, and technological factors.

Key technologies include automated livestock weighing systems, Radio Frequency Identification (RFID) for animal identification and behavioral monitoring, body temperature tracking, Geographic Information Systems (GIS) for pasture evaluation and optimization, Unmanned Aerial Vehicles (UAVs) for herd management, and virtual fencing for livestock and grazing control (Tzanidakis et al., 2023). The collected data are analyzed using advanced algorithms to detect problems early and support data-driven decision-making.

When integrated with Industry 4.0 technologies, PLF holds considerable potential to improve animal welfare and increase the accuracy of health assessments. These innovations not only enhance livestock management practices but also create opportunities to develop more sustainable food production systems within the agro-industrial sector. (Morrone et al., 2022).

Table 1. Benefits of Precision Livestock Farming (PLF)

No	Benefit	Source
1	Improved Animal Welfare and Health: PLF enables early detection of diseases, stress, and behavioral changes, allowing timely interventions to be implemented more effectively.	1. (Tzanidakis et al., 2023) 2. (Kaur et al., 2023) 3. (Monteiro et al., 2021) 4. (Aquilani et al., 2022) 5. (Rowe et al., 2019)
2	Production and Management Efficiency: The automation of feed, water, and environmental monitoring enhances resource utilization efficiency and reduces operational costs.	1. (Tzanidakis et al., 2023) 2. (Tedeschi & Mendes, 2021) 3. (Niloofar et al., 2021) 4. (Zhang et al., 2021)
3	Sustainability: PLF contributes to reducing greenhouse gas emissions and waste through feed optimization, waste management, and environmental monitoring.	1. (Tedeschi & Mendes, 2021) 2. (Niloofar et al., 2021) 3. (Papakonstantinou et al., 2024)
4	Transparency and Auditability: The digitalization of livestock data facilitates supply chain traceability and supports compliance with consumer demands and regulatory requirements.	1. (Kaur et al., 2023) 2. (Morrone et al., 2022) 3. (Krampe et al., 2024)

Based on Table 1, PLF provides four main benefits that can positively impact farmers, while also generate environmental advantages and foster sustainability through continuous ecological monitoring. However, the adoption of new technologies is not without challenges, and the uptake of PLF remains limited due to economic constraints, gaps in technological infrastructure, and the need for farmer training. Additional challenges include ethical concerns, data privacy issues, and the potential reduction of human–animal interactions. (Tuyttens et al., 2022).

The Condition of Traditional Beef Cattle Farming in NTB: Challenges, Opportunities, and Prospects

Most of the Indonesia's population earns its primary income from agriculture, including in the province of West Nusa Tenggara (NTB). Although agriculture remains the backbone of NTB's economy, livestock farming is often regarded as a supplementary source of income or as a form of savings. Traditional beef cattle farming in NTB is largely dominated by smallholder farmers who own 5-10 cattle and practice traditional husbandry systems. Productivity levels remain low due to limitations in feed, reproductive management, and access to innovation. Most farmers in NTB raise cattle as a secondary activity or for family subsistence rather than as their primary business venture.

The prevailing cut-and-carry system, in which animals are mainly fed on agricultural residues and low-quality pastures, results in low growth and reproductive performance (calving rate ~65%, calf mortality 10-20%, daily weight gain 0.15-0.25 kg/day) (Irawan et al., 2022) (Adnyana et al., 2021) (Amam et al., 2024) (Warman et al., 2023). Farmers in NTB generally have low levels of formal education, which reduces their ability to adopt innovations. Similar challenges are observed across Indonesia, a developing country, where the majority of livestock keepers face difficulties adapting to new technologies due to low levels of education. This issue is further exacerbated by the demographic profile of Indonesian farmers, many of whom are elderly, which further constrains their capacity to implement new technologies.

For example, a study by Huda et al., (2021) Cattle farmers in Madura revealed that the majority were within the age range of 46-50 years, with more than three-quarters being male (76.67%). Moreover, nearly half of the respondents (46.67% of 30 farmers) had only completed primary school. Both age and education level were found to have significant effects on the likelihood of adopting new technologies.

Table 2. Demographics of Farmers in West Nusa Tenggara (NTB)

No.	Regency	Age %		Education (%)				Source
		<50	>50	NS	ES	JHS	SHS	
1	Lombok Barat	-	-	38.51	35.92	19.63	5.92	(Lukman et al., 2023)
2	Kabupaten Bima	54	46	8	16	26	28	(Warman et al., 2023)
3	Sumbawa	45	55	-	10	10	80	(Dimeng et al., 2024)

Note: NS; no education, ES; elementary school. JHS; junior high school, SHS; senior high school

Table 2 shows that the majority of farmers/livestock keepers in NTB have low levels of education and are predominantly older than 50 years. This demographic condition is one of the factors contributing to the persistence of traditional livestock management practices and to limited adoption of modern technologies. Nevertheless, NTB has considerable potential and opportunities for development as a beef cattle production region. The availability of extensive land and abundant agricultural residues, particularly on Sumbawa Island, indicates a strategic potential to support feed supply. However, their utilization has not been optimized, and thus, these resources have yet to make a significant contribution to livestock production systems. (Adnyana et al., 2021).

In addition to natural resources, several strategic government programs such as Sapi Kerbau Komoditas Andalan Negeri (SIKOMANDAN) and Upaya Khusus Percepatan Peningkatan Populasi Sapi dan Kerbau Bunting (UPSUS SIWAB) have been initiated to stimulate the growth of livestock populations and productivity. However, their effectiveness in practice remains limited, and their tangible impacts on sustainable production have not been fully realized.

Table 3. Challenges and Opportunities of Traditional Beef Cattle Farming in NTB

No	Aspect	Challanges	Opportunities	Source
1	Farm Scale	Predominantly small-scale, subsistence-oriented	Predominantly small-scale, subsistence-oriented	1. (Irawan et al., 2022) 2. (Amam et al., 2024) 3. (Warman et al., 2023)
2	Feed	Low quality and limited access	Optimization of agricultural residues & *Leucaena*	1. (Irawan et al., 2022) 2. (Adnyana et al., 2021)
3	Reproduction	Low calving rate and high calf mortality	Training in reproductive management	1. (Warman et al., 2023) 2. (Amam et al., 2024)
4	Gender	Limited women’s empowerment	Gender-focused capacity building strategies	1. (Villano et al., 2025)

Moving forward, a comprehensive evaluation of program implementation mechanisms, capacity building for farmers, and integration with local resource potentials is required to more effectively achieve the intended objectives of improving livestock populations and productivity.

Traditional beef cattle farming in West Nusa Tenggara (NTB) plays a vital role in supporting food security and the regional economy. However, the sector continues to face challenges, including low productivity, limited access to technological innovations, and limited farmer empowerment. Sustainable development strategies need to focus on strengthening farmer organizations, developing feed innovations based on local resources, enhancing capacity through training, and integrating women's empowerment into the livestock value chain. Such approaches are expected to improve both productivity and farmer welfare sustainably.

Challenges in Implementing PLF among Traditional Farmers

PLF technologies offer substantial advantages and convenience for farmers who adopt them effectively, with sustainability being one of the most attractive features. Nevertheless, traditional farmers face significant barriers in adopting this technology. From an economic perspective, the costs associated with PLF, such as equipment, hardware, and software, are prohibitively high. Concerns about significant initial investments, the need for specialized operational knowledge, and the demand for continuous technical support remain widespread. Adoption tends to benefit large-scale farms with greater resources. (Papakonstantinou et al., 2024). Similarly, Taer, (2025) Emphasizes that high costs and limited access to IoT instruments and systems are the primary obstacles to PLF adoption. PLF requires substantial upfront investment in hardware, sensors, and digital infrastructure, which is often beyond the reach of small-scale traditional farmers (Tejada Gimenez & Cifuentes Ortiz, 2022).

Infrastructure limitations further constrain PLF implementation. Many rural areas in NTB still experience unreliable electricity and inadequate internet access, making it challenging to operate PLF systems consistently. Limited infrastructure, particularly electricity, internet connectivity, and technical support in rural regions, poses a fundamental challenge to PLF adoption. These limitations not only reduce implementation effectiveness but also exacerbate the technology adoption gap between smallholder farmers and modern commercial operations. (Taer, 2025);(Nery et al., 2024).

Human resources also play a critical role in the adoption of PLF. Farmers need adequate knowledge and skills to operate and maintain digital technologies. Studies by Molieleng et al., (2021) and Nery et al., (2024) The report states that limited digital literacy among traditional farmers remains a crucial barrier. Insufficient competence prevents farmers from maximizing the benefits of PLF. To address this, empowerment strategies such as technical training, field mentoring, and the establishment of digital service centers are required. These measures would not only accelerate PLF adoption but also strengthen farmers' capacity to transition to more modern and sustainable production systems. Low educational attainment, as shown in Table 2, directly contributes to low digital literacy. This condition also explains why many conventional farmers remain resistant to change, showing little interest in adapting to technological advancements and being content with traditional practices. Resistance to change is still strong among some farmers, reflected in their reluctance to abandon long-standing methods and their skepticism toward new technologies (Álvarez García et al., 2024).

Another critical factor is social support. The lack of social support networks and the absence of effective communities of practice among farmers constitute major barriers to the adoption of innovation. Limited knowledge exchange and the sharing of practical experience not only slow the diffusion of technology but also reduce opportunities for collaboration in addressing common challenges. Therefore, strengthening social networks, learning groups, and farmer forums is essential to building a more inclusive and sustainable innovation ecosystem (Hayden et al., 2018). Nevertheless, it must be acknowledged that PLF has the potential to widen inequalities between farmers who can adopt the technology and those who cannot (Neethirajan, 2023).

Precision Livestock Farming: Solution or Disruption?

As a form of revolution in modern livestock systems, Precision Livestock Farming (PLF) plays a strategic role in enhancing farmers' productivity and competitiveness. Moreover, the integration of this technology aligns with the sustainable development agenda by promoting resource efficiency, ensuring animal welfare, and strengthening the long-term sustainability of national livestock production. Therefore, the adoption of PLF should be regarded as a key pillar in transforming the livestock sector toward the industry 4.0 era.

PLF emerges as a strategic approach to address the challenges of modern livestock production, including the growing demand for animal protein, the need for efficient resource utilization, and the imperative of sustainability. By integrating technologies that enable monitoring of animal health, behavior, and the environment at the individual level, PLF significantly improves productivity, reduces operational costs, and raises animal welfare standards. Accordingly, PLF adoption is not only relevant for enhancing the competitiveness of the livestock sector but also consistent with the broader global sustainability agenda.

From a critical perspective, however, PLF also has the potential to generate disruption by widening socio-economic disparities between smallholders and large-scale farmers, particularly due to high investment costs and operational complexity. Another crucial risk lies in the erosion of traditional practices and local wisdom, which often hold adaptive and ecologically sustainable values. For this reason, the development of PLF should be accompanied by mitigation mechanisms, including subsidies, training, and the integration of local knowledge, to ensure that its adoption does not exacerbate inequalities or undermine the socio-cultural resilience of farming communities.

The adoption of PLF faces not only technical and economic barriers, such as high capital investment and limited infrastructure, but also social and institutional obstacles, including cultural resistance and insufficient cross-disciplinary collaboration. Broader implications include shifts in human–animal relationships, increased dependence on technology, and ethical concerns related to farmer identity and animal welfare. Issues of data privacy and complex system integration further underscore that successful PLF implementation requires a holistic approach that integrates technological, social, economic, and ethical dimensions.

Table 4. Benefits and Challenges of Precision Livestock Farming (PLF) Across Livestock Farming Aspects

No	Aspect	Solution	Disruption	Sources
1	Productivity & Efficiency	Enhances production efficiency, enables early disease detection, improves feed management, and reduces operational costs	High initial investment, limited infrastructure, data integration challenges, and slow adoption	1. (Papakonstantinou et al., 2024) 2. (Lovarelli et al., 2020) 3. (Vranken & Berckmans, 2017) 4. (Niloofar et al., 2021) 5. (Aquilani et al., 2022) 6. (Kopler et al., 2023) 7. (Kaur et al., 2023) 8. (Zhang et al., 2021) 9. (Bianchi et al., 2022) 10. (Tzanidakis et al., 2023)
2	Animal Welfare	Real-time monitoring, stress/disease detection, improved animal welfare standards	Risk of technological dependence, reduced human–animal interaction, and ethical concerns	1. (Papakonstantinou et al., 2024) 2. (Lovarelli et al., 2020) 3. (Vranken & Berckmans, 2017) 4. (Aquilani et al., 2022) 5. (Kleen & Guatteo, 2023) 6. (Tuyttens et al., 2022)
3	Environment	Reduction of greenhouse gas emissions, efficient resource utilization, and land conservation	Difficulty in quantitatively measuring environmental impacts, need for long-term data	1. (Papakonstantinou et al., 2024) 2. (Marchegiani et al., 2025) 3. (Lovarelli et al., 2020) 4. (Niloofar et al., 2021) 5. (Aquilani et al., 2022) 6. (Menendez et al., 2022) 7. (Lovarelli et al., 2024)
4	Economy	Potential profitability gains, reduced labor costs, optimized supply chain	High investment costs, uncertain return on investment, and farmer resistance to change	1. (Papakonstantinou et al., 2024) 2. (Lovarelli et al., 2020) 3. (Kopler et al., 2023) 4. (Zhang et al., 2021) 5. (Bianchi et al., 2022)

No	Aspect	Solution	Disruption	Sources
5	Social & Cultural	Supply chain transparency, product traceability, and improved consumer trust	Changing farmer roles, erosion of local wisdom, and cultural adoption challenges	1. (Lovarelli et al., 2020) 2. (Kopler et al., 2023) 3. (Kleen & Guatteo, 2023) 4. (Monteiro et al., 2021) 5. (Tuyttens et al., 2022)
6	Technology	Integration of sensors, IoT, machine learning, and wearable devices	Device durability limitations, data accuracy issues, privacy, and data security concerns	1. (Papakonstantinou et al., 2024) 2. (Aquilani et al., 2022) 3. (Kaur et al., 2023) 4. (Zhang et al., 2021) 5. (Álvarez García et al., 2024) 6. (Tzanidakis et al., 2023) 7. (Kleen & Guatteo, 2023) 8. (Tuyttens et al., 2022)
7	Regulation & Ethics	Supports regulatory compliance, facilitates automated reporting	Ethical concerns, data protection issues, and altered human-animal relationships	1. (Papakonstantinou et al., 2024) 2. (Kleen & Guatteo, 2023) 3. (Tuyttens et al., 2022)

Strategies and Recommendations

The transition to PLF within Indonesia's traditional beef cattle sector requires more than a generic, phased adoption strategy. A critical synthesis of the literature reveals that the primary barrier is not merely technological or financial, but systemic, rooted in a misalignment between top-down, high-tech solutions and the on-the-ground realities of smallholder socio-ecology. Therefore, recommendations must move beyond descriptive summaries to propose a context-embedded innovation framework.

For Indonesia, and specifically for regions such as NTB, this means prioritizing "appropriate precision" technologies that are modular, low-cost, and built on existing indigenous knowledge. Initial interventions should focus on augmenting, not replacing, traditional practices. For example, mobile-enabled advisory systems that deliver voice-based alerts on feed shortages or disease outbreaks (leveraging high mobile penetration) offer a more viable entry point than complex sensor networks. This approach directly addresses the dual challenges of low digital literacy and infrastructural gaps while fostering immediate perceived value.

The role of government and academia must shift from being mere providers of subsidies and training to becoming architects of an inclusive innovation ecosystem. This requires:

- Policy Integration: Actively embedding PLF modules into the operational frameworks of existing national programs like SIKOMANDAN and UPSUS SIWAB, moving these initiatives from a focus solely on biological productivity to include *digital capacity* as a core metric of success.
- Farmer-Centric Co-Design: Establishing living labs in key production hubs like Sumbawa, where farmers, technologists, and social scientists collaboratively prototype, test, and adapt PLF tools. This ensures that solutions are culturally acceptable and economically viable while maintaining the socio-economic fabric of rural communities.
- Literacy Beyond Operation: Capacity building must evolve to create "digitally savvy entrepreneurs," not just device operators. Training should encompass data ownership, cost-benefit analyses of technologies, and negotiation skills for cooperative technology procurement, thereby mitigating the risks of marginalization and dependence.

Ultimately, for PLF to be a revolution rather than a disruptor in Indonesia, its implementation must be reframed as a socio-technical transition. Success hinges on designing adaptive governance models that align technological diffusion with targeted investments in rural digital infrastructure, inclusive financing mechanisms, and the strengthening of local institutions such as farmer cooperatives. This critical, integrated pathway is essential to ensure PLF contributes to equitable resilience and sustainable intensification of Indonesia's livestock sector.

CONCLUSION

Precision Livestock Farming (PLF) has transformative potential to enhance productivity, animal welfare, and sustainability in Indonesia's beef cattle sector. However, without inclusive and context-sensitive implementation, PLF risks exacerbating existing inequalities between small-scale traditional farmers and larger commercial enterprises. Key barriers such as high costs, inadequate infrastructure, low digital literacy, and socio-cultural resistance must be addressed through coordinated efforts among government, academia, and industry stakeholders. A phased adoption strategy, supported by targeted policies, subsidies, capacity-building programs, and farmer cooperatives, is essential to ensure that PLF serves as a tool for equitable development rather than disruption. Ultimately, the success of PLF in Indonesia will depend on its alignment with national agricultural priorities and its adaptability to the realities of traditional farming communities.

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