18(2s), Spring 2026

Journal of Animal Environment

(E-ISSN 2717-1396, ISSN 2717-1388)

Original Research Paper

Legal Challenges and Policy Implications of AI-Enabled Precision Livestock Farming in Developing Countries

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Abstract: Artificial intelligence (AI)-enabled Precision Livestock Farming (PLF) is transforming livestock production through intelligent monitoring, predictive analytics, automated decision-making, and resource optimization. However, its rapid adoption in developing countries has introduced complex legal, ethical, and policy challenges that hinder responsible implementation. This review critically examines the evolving legal landscape governing AI-driven PLF, focusing on data ownership, privacy protection, algorithmic accountability, intellectual property rights, animal welfare regulations, and cross-border data governance. The study systematically analyzes existing literature, international regulatory initiatives, and national policy frameworks to identify key legal gaps and governance limitations affecting developing economies. Furthermore, it compares AI governance models and regulatory approaches adopted across different jurisdictions, highlighting their applicability, strengths, and implementation challenges within resource-constrained agricultural systems. Based on this comparative assessment, a comprehensive policy and regulatory framework is proposed that integrates risk-based AI governance, transparent data-sharing mechanisms, ethical compliance, institutional capacity building, and standardized certification practices. The review concludes that harmonized legal frameworks, adaptive regulatory mechanisms, and coordinated stakeholder participation are essential for ensuring trustworthy, equitable, and sustainable AI adoption in livestock farming while supporting food security, innovation, and long-term agricultural development in developing countries.

Keywords: Artificial Intelligence, Precision Livestock Farming, Legal Frameworks, AI Governance, Developing Countries

I. Introduction

The rapid advancement of Artificial Intelligence (AI) has transformed modern agriculture by enabling intelligent, data-driven decision-making across crop and livestock production systems. In particular, AI-enabled Precision Livestock Farming (PLF) has emerged as a transformative approach that integrates machine learning, deep learning, computer vision, Internet of Things (IoT) sensors, wearable devices, robotics, unmanned aerial

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Received: 24th April, 2026; Revised: 11th May, 2026; Accepted: 24th May, 2026; Available Online: 6th June, 2026

(DOI): 10.70102/AEJ.2026.18.2s.83

systems, and cloud-edge computing to monitor livestock health, behavior, productivity, and environmental conditions in real time. These technologies enable early disease detection, precision feeding, reproductive management, behavioral monitoring, welfare assessment, and predictive analytics, thereby improving productivity, reducing operational costs, enhancing resource efficiency, and supporting sustainable livestock production. As global demand for meat, milk, eggs, and other animal-derived products continues to increase, AI-driven PLF has become an essential technological solution for ensuring food security while minimizing environmental impacts and greenhouse gas emissions [1]. Developing countries are increasingly embracing digital agriculture to modernize livestock farming and improve the livelihoods of rural communities. Governments, agricultural research organizations, and private technology providers have initiated various programs to encourage the adoption of AI-based livestock monitoring systems, smart wearable sensors, automated milking technologies, and mobile-based advisory platforms. These innovations offer significant opportunities for improving animal health management, reducing disease outbreaks, increasing production efficiency, and optimizing farm resource utilization [2]. However, despite these technological advancements, the adoption of AI-enabled PLF remains constrained by inadequate digital infrastructure, limited internet connectivity, insufficient financial resources, lack of technical expertise, fragmented institutional support, and inconsistent regulatory environments. These barriers are particularly pronounced among smallholder farmers, who constitute a substantial proportion of livestock producers in developing economies.

Beyond technological and economic challenges, AI-enabled Precision Livestock Farming raises several complex legal and policy issues that require immediate attention. AI systems continuously collect and process vast amounts of agricultural data, including animal health records, production metrics, environmental conditions, and farm management information. This extensive data collection introduces critical concerns regarding data ownership, privacy protection, informed consent, data security, and commercial exploitation [3]. In many developing countries, legal provisions governing agricultural data remain underdeveloped, resulting in uncertainty regarding the rights and responsibilities of farmers, technology providers, cloud service operators, and government agencies. Another significant challenge concerns accountability and liability associated with AI-driven decision-making. AI algorithms increasingly influence disease diagnosis, treatment recommendations, feeding schedules, breeding strategies, and automated livestock management operations [4]. When these systems produce inaccurate predictions or operational failures leading to financial losses or animal welfare violations, determining legal responsibility becomes highly complex. Existing legal frameworks often lack clear provisions defining the liability of AI developers, software vendors, equipment manufacturers, veterinarians, farm operators, and regulatory authorities. Similarly, intellectual property protection for AI algorithms, predictive models, digital livestock datasets, and proprietary software presents additional legal complexities, particularly in balancing innovation incentives with equitable access to advanced agricultural technologies.

Ethical and regulatory concerns further complicate AI adoption within livestock farming. Although AI technologies can improve animal welfare through continuous health monitoring and early disease detection, they may also encourage excessive automation that overlooks ethical considerations regarding humane treatment and responsible farming practices [5]. Moreover, cybersecurity threats, cross-border agricultural data sharing, cloud-based AI services, and jurisdictional conflicts create additional governance challenges, especially when livestock data are processed across multiple countries with different legal and regulatory requirements. The absence of harmonized standards and internationally accepted governance mechanisms further increases regulatory uncertainty and limits the scalability of AI-enabled livestock solutions. Although existing literature extensively investigates the technological capabilities and performance of AI in Precision Livestock Farming, comparatively fewer studies critically examine the associated legal, regulatory, and policy implications, particularly within the context of developing countries [6]. Most research focuses primarily on technological innovation while providing limited discussion on governance mechanisms necessary to ensure responsible, transparent, and accountable AI deployment. Therefore, a comprehensive understanding of the evolving legal landscape is essential to support sustainable digital transformation in the livestock sector.

II. Literature Review

The literature review examines the evolution of AI-enabled Precision Livestock Farming, existing legal frameworks, and digital agriculture policies, highlighting technological progress, governance approaches, regulatory limitations, and research gaps requiring comprehensive legal and policy solutions for developing countries.

A. Evolution of AI in Precision Livestock Farming

Artificial Intelligence (AI) has significantly transformed Precision Livestock Farming (PLF)

over the past two decades, evolving from simple automated monitoring systems to intelligent decision-support platforms. Early PLF technologies primarily relied on radio-frequency identification (RFID), sensor networks, and automated feeding systems to collect basic animal information [7]. Recent advances in machine learning, deep learning, computer vision, wearable biosensors, Internet of Things (IoT), robotics, and cloud-edge computing have enabled continuous monitoring of animal health, behavior, productivity, and environmental conditions. AI algorithms now support disease prediction, estrus detection, feed optimization, welfare assessment, and precision breeding with improved accuracy and reduced human intervention. Researchers have demonstrated that AI-based livestock management enhances productivity, reduces operational costs, and minimizes environmental impacts [8]. Despite these technological advancements, challenges related to infrastructure availability, interoperability, data quality, affordability, and adoption among smallholder farmers continue to limit widespread implementation, particularly across developing countries.

B. Legal and Regulatory Frameworks for AI

The rapid deployment of AI technologies in agriculture has increased the need for comprehensive legal and regulatory frameworks governing their development and use. Existing AI regulations primarily focus on data protection, algorithmic transparency, cybersecurity, liability, intellectual property rights, and ethical AI principles. Several developed countries have introduced AI governance strategies emphasizing trustworthy, human-centric, and accountable AI systems [9]. However, agriculture-specific AI regulations remain limited, particularly regarding autonomous decision-making in livestock management. Legal uncertainty exists concerning responsibility for algorithmic errors, ownership of AI-generated insights, software certification, and compliance with animal welfare legislation. Developing countries often lack dedicated regulatory mechanisms for AI-enabled livestock farming, resulting in fragmented governance and inconsistent enforcement [10]. Strengthening legal frameworks through harmonized standards, transparent governance models, adaptive regulations, and stakeholder collaboration is essential to ensure responsible AI deployment while promoting innovation, public trust, and sustainable agricultural development.

C. Data Governance and Digital Agriculture Policies

Data governance has become a fundamental component of AI-enabled Precision Livestock Farming because intelligent systems continuously generate, process, and exchange large volumes of agricultural data. Effective governance requires clear policies defining data ownership, privacy protection, informed consent, cybersecurity, interoperability, access rights, and data-sharing mechanisms among farmers, technology providers, researchers, and government agencies. Several countries have introduced digital agriculture policies supporting smart farming, cloud-based agricultural services, open data initiatives, and digital infrastructure development. However, policy implementation remains inconsistent across developing countries due to limited institutional capacity, inadequate legal frameworks, insufficient investment, and weak digital infrastructure. Poor governance can reduce farmer confidence and restrict AI adoption [11]. Table 1 summarizes existing studies, highlighting legal gaps and governance challenges in AI. Future digital agriculture policies should promote secure data ecosystems, standardized governance protocols, cross-sector collaboration, equitable data access, and ethical AI practices to enable sustainable, transparent, and inclusive livestock farming systems.

Table 1. Summary of Related Work on Legal Challenges and Policy Implications of AI-Enabled Precision Livestock Farming

Country/Region	AI Technology	Key Findings	Limitation	Research Gap
European Union [12]	ML, IoT	Strong data privacy framework improves farmer trust.	Focused mainly on developed countries.	Limited applicability to developing economies.
United States	Computer Vision	Transparent AI improves decision reliability.	Limited discussion on agricultural regulations.	Need livestock-specific AI liability framework.

Australia [13]	IoT, Sensors	Farmers require explicit ownership rights.	No standardized governance mechanism.	Comprehensive agricultural data governance absent.
China [14]	Deep Learning	National AI policies accelerate digital agriculture.	Ethical concerns insufficiently addressed.	Need balanced governance and ethics integration.
India	ML, IoT	Digital initiatives encourage AI adoption.	Weak institutional implementation.	Stronger legal enforcement mechanisms required.
Brazil [15]	Wearable Sensors	AI improves health monitoring and welfare assessment.	Limited legal compliance evaluation.	Standardized welfare regulations required.
Africa	Cloud AI	Cloud platforms improve accessibility.	Data sovereignty issues unresolved.	Harmonized international data-sharing policies needed.
ASEAN	Edge AI	Secure platforms reduce cyber risks.	Limited regulatory harmonization.	Regional AI cybersecurity standards lacking.
Developing Countries	Hybrid AI	Fragmented regulations slow AI deployment.	Weak institutional coordination.	Unified AI governance framework required.

III. Legal Challenges of AI-Enabled Precision Livestock Farming

This section analyzes major legal challenges including data ownership, privacy protection, AI accountability, intellectual property rights, animal welfare compliance, and cross-border data governance, emphasizing their implications for responsible AI deployment and regulatory development in livestock farming.

A. Data Ownership and Privacy

AI-enabled Precision Livestock Farming (PLF) generates enormous volumes of data through wearable sensors, cameras, drones, automated feeding systems, and environmental monitoring devices. These datasets include animal health records, behavioral patterns, production performance, geolocation, and farm management information. A major legal challenge is determining data ownership, as multiple stakeholders—including farmers, technology vendors, cloud service providers, and government agencies—may claim rights over collected information. In many developing countries, agricultural data protection laws remain inadequate or unclear, increasing the risks of unauthorized access, commercial misuse, and privacy violations. Farmers often lack awareness of data-sharing agreements and consent mechanisms, creating an imbalance between technology providers and end users. Establishing transparent data governance frameworks, robust cybersecurity measures, informed consent procedures, and clear ownership rights is essential to protect agricultural data while encouraging innovation, trust, and responsible AI adoption across livestock farming ecosystems.

B. AI Accountability and Liability

AI systems increasingly support automated decision-making in livestock farming by predicting diseases, optimizing feeding schedules, monitoring animal welfare, and recommending breeding strategies. However, inaccurate predictions, software failures, sensor malfunctions, or biased algorithms may result in economic losses, animal

health risks, or regulatory violations. Determining legal responsibility for such outcomes remains a significant challenge because multiple parties, including AI developers, software vendors, equipment manufacturers, veterinarians, cloud providers, and farm operators, contribute to system performance. Existing legal frameworks often do not clearly define liability for autonomous AI decisions or algorithmic errors. Furthermore, the limited transparency of complex machine learning models complicates investigations into system failures and legal accountability. Figure 1 illustrates AI accountability, responsibility, liability, and regulatory roles in livestock farming.

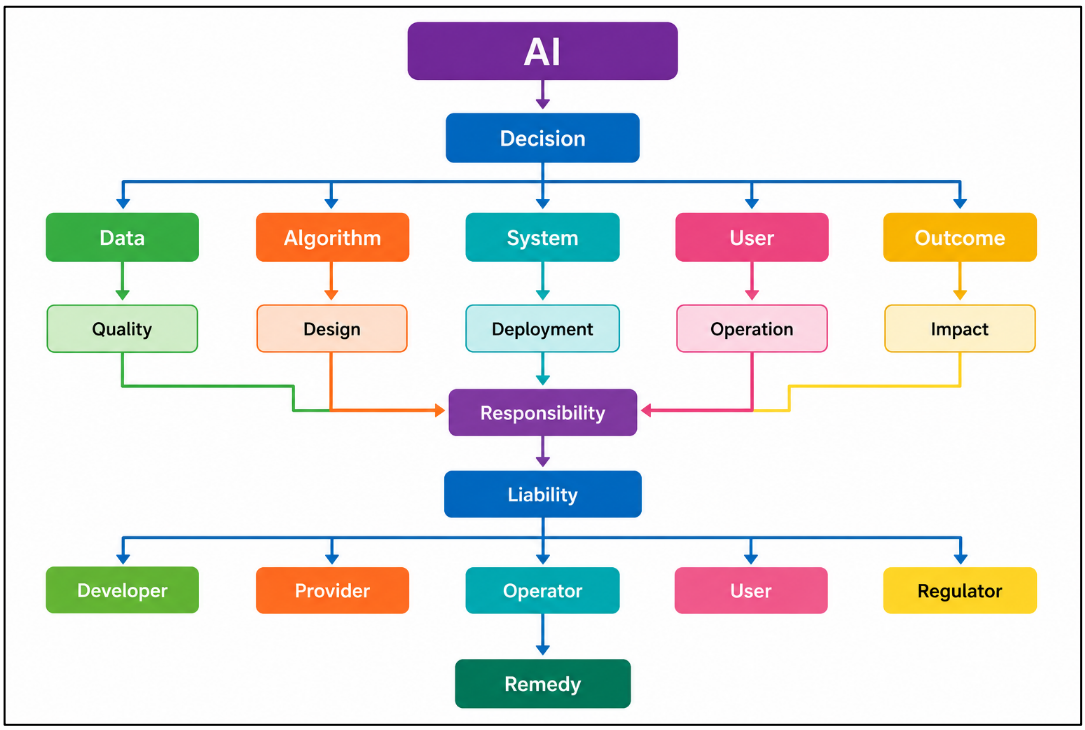

Figure 1. AI Accountability and Liability Framework for Precision Livestock Farming

Developing risk-based regulatory frameworks, mandatory audit mechanisms, explainable AI requirements, and clearly defined contractual responsibilities will improve accountability, strengthen public confidence, and ensure responsible deployment of AI technologies in livestock farming.

C. Intellectual Property Rights

The integration of AI into Precision Livestock Farming has increased the importance of intellectual property rights (IPR) for protecting innovative algorithms, predictive models, software platforms, sensor technologies, and digital livestock datasets. Technology companies invest substantial resources in developing proprietary AI solutions, making patent, copyright, trade secret, and licensing protections essential for encouraging innovation. However, excessive proprietary control may restrict technology accessibility, particularly for smallholder farmers in developing countries. Legal disputes may also arise regarding ownership of AI-generated insights, automated recommendations, and data derived from farm operations. Existing intellectual property laws often do not adequately address machine-generated outputs or collaborative data ecosystems involving multiple stakeholders.

D. Animal Welfare and Ethical Compliance

Animal welfare represents a fundamental consideration in AI-enabled Precision Livestock Farming because intelligent technologies increasingly influence management decisions affecting animal health, comfort, and productivity. AI applications can improve welfare by enabling continuous monitoring, early disease detection, precision nutrition, stress assessment, and behavioral analysis. However, excessive automation may prioritize production efficiency over ethical treatment, potentially reducing human oversight and neglecting animal-specific welfare needs. Ethical concerns also arise from algorithmic bias, inaccurate behavioral interpretation, and inappropriate automated interventions that may negatively affect livestock well-being. Many developing countries possess limited legal standards addressing AI-assisted animal management, creating inconsistencies in welfare enforcement and regulatory compliance.

IV. Policy Implications for Developing Countries

This section discusses national AI policies, governance models, certification standards, and institutional enforcement mechanisms required to promote ethical, transparent, and sustainable AI adoption while strengthening regulatory capacity, innovation, and digital transformation within livestock farming systems.

A. National AI and Agricultural Policies

The successful adoption of AI-enabled Precision Livestock Farming (PLF) in developing countries requires comprehensive national policies that integrate artificial intelligence with agricultural development strategies. Governments should formulate dedicated AI roadmaps that promote digital agriculture, encourage innovation, and ensure equitable access to advanced livestock technologies. These policies must address data governance, cybersecurity, ethical AI deployment, digital infrastructure, research funding, technology transfer, and farmer capacity building. Financial incentives, subsidies, and public-private partnerships can accelerate the adoption of AI solutions among smallholder farmers who often face economic and technological constraints. National policies should also support localized AI applications tailored to regional livestock practices, climatic conditions, and socioeconomic environments. Furthermore, integrating AI into existing agricultural extension services, veterinary healthcare systems, and rural digital programs can improve technology accessibility and farmer awareness.

B. Regulatory Governance Models

Effective regulatory governance models are essential for ensuring that AI-enabled livestock farming operates in a transparent, accountable, and legally compliant manner. Developing countries should adopt risk-based governance frameworks that classify AI applications according to their potential impact on animal welfare, public safety, data privacy, and economic stability. Such models should establish clear responsibilities for AI developers, technology providers, veterinarians, regulatory authorities, and livestock producers throughout the AI lifecycle. Regulatory sandboxes can facilitate innovation by allowing emerging AI technologies to be tested under controlled legal environments before commercial deployment. Governance models should also incorporate principles of explainable AI, algorithmic transparency, human oversight, cybersecurity, fairness, and continuous monitoring to minimize unintended consequences. Multi-stakeholder participation involving government agencies, academic institutions, farmer organizations, industry representatives, and civil society is critical for developing balanced regulations.

C. Standards and Certification Frameworks

Standardization and certification play a crucial role in building trust, interoperability, and quality assurance for AI-enabled Precision Livestock Farming technologies. Developing countries should establish national standards aligned with internationally recognized guidelines for AI ethics, cybersecurity, data governance, software reliability, sensor performance, and animal welfare compliance. Certification frameworks should evaluate AI systems based on transparency, accuracy, robustness, explainability, privacy protection, and operational safety before they are deployed on commercial farms. Standardized protocols for data collection, storage, interoperability, and exchange can facilitate collaboration among farmers, researchers, technology providers, and regulatory agencies while reducing compatibility issues across digital platforms. Certification processes should also include periodic audits, post-deployment monitoring, and performance validation to ensure continuous compliance with regulatory requirements.

D. Institutional Capacity and Enforcement Challenges

The effectiveness of AI governance in livestock farming largely depends on the institutional capacity of regulatory bodies and enforcement agencies responsible for implementing legal and policy frameworks. Many developing countries face shortages of technical expertise, financial resources, digital infrastructure, and specialized regulatory personnel capable of evaluating AI technologies. Weak institutional coordination among agriculture, information technology, legal, and veterinary authorities often results in fragmented governance and inconsistent policy implementation. Figure 2 illustrates institutional barriers affecting effective AI governance and regulatory enforcement capacity.

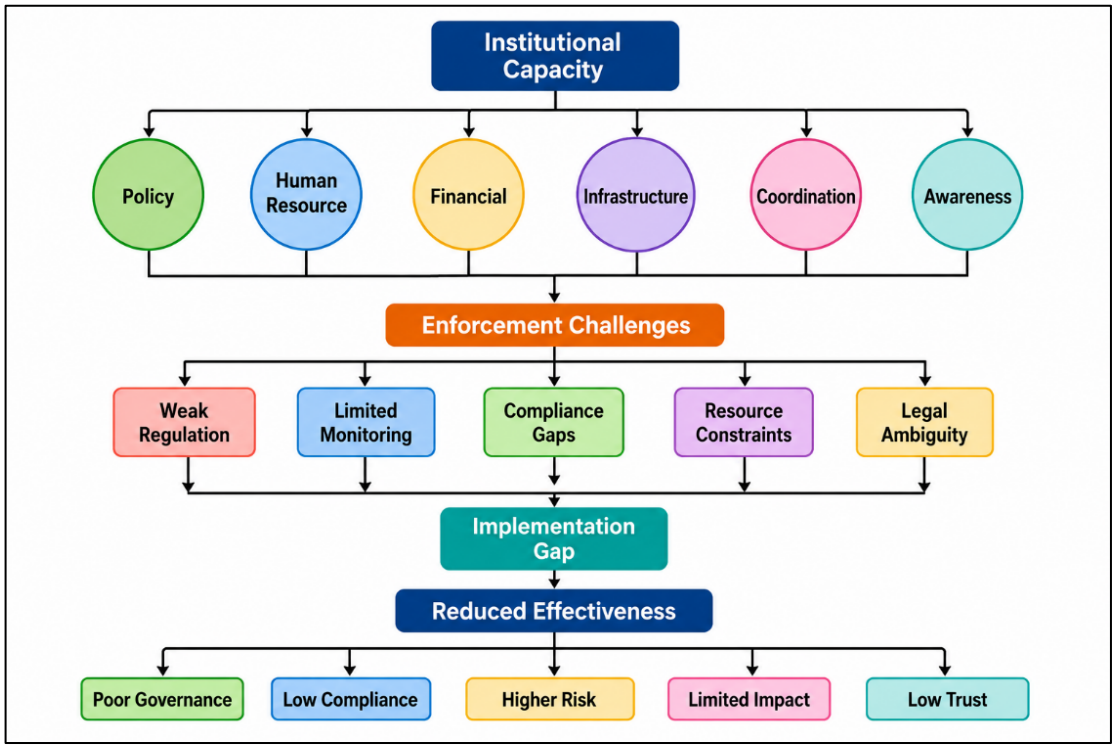

Figure 2. Institutional Capacity and Enforcement Challenges for AI Governance in Precision Livestock Farming

Limited awareness among farmers, policymakers, and local administrators further reduces compliance with emerging AI regulations and ethical standards. Strengthening institutional capacity requires investment in technical training, digital infrastructure, interdisciplinary research, regulatory modernization, and continuous professional development for government officials. Collaboration between universities, research organizations, international agencies, and private technology providers can support knowledge transfer and evidence-based policymaking.

V. Comparative Analysis and Future Policy Framework

This section compares existing legal frameworks and AI governance models, evaluates strengths and limitations through SWOT analysis, and proposes an integrated policy framework supporting accountable, risk-based, and sustainable AI governance for precision livestock farming in developing countries.

A. Comparative Analysis of Existing Legal Frameworks

Existing legal frameworks governing AI-enabled Precision Livestock Farming vary considerably across developed and developing countries. Developed economies have introduced comprehensive regulations addressing artificial intelligence, data protection, cybersecurity, digital governance, and ethical AI principles. These frameworks generally emphasize transparency, accountability, privacy protection, algorithmic risk assessment, and human oversight while supporting technological innovation through structured regulatory mechanisms. In contrast, most developing countries rely on fragmented agricultural laws, general information technology regulations, or data protection policies that provide limited guidance for AI-based livestock applications. As a result, issues related to data ownership, algorithmic liability, cross-border data exchange, intellectual property, and animal welfare remain inadequately regulated. Comparative analysis indicates that integrated legal approaches combining agriculture, digital governance, and AI regulation provide greater legal certainty and encourage responsible technology adoption.

B. Comparative Assessment of AI Governance Models

AI governance models adopted worldwide differ in their regulatory philosophy, implementation strategies, and institutional structures. Rule-based governance emphasizes strict legal compliance and predefined regulatory requirements, whereas principle-based governance focuses on ethical values such as transparency, fairness, accountability, and human oversight. Risk-based governance models classify AI applications according to potential societal, economic, and safety risks, enabling proportionate regulatory interventions. Co-regulatory approaches encourage collaboration between governments, industry, academia, and civil society to develop adaptive governance mechanisms

that evolve alongside technological innovation. Comparative assessment suggests that hybrid governance models combining legal regulation with ethical guidelines, technical standards, and stakeholder participation provide greater flexibility and long-term effectiveness.

C. SWOT Analysis of AI Adoption in Livestock Farming

A SWOT analysis provides valuable insights into the strategic factors influencing AI adoption in Precision Livestock Farming. Key strengths include improved animal health monitoring, enhanced productivity, optimized resource utilization, automated decision-making, reduced operational costs, and better environmental sustainability. AI technologies also enable early disease detection, precision feeding, and predictive management that improve farm profitability and animal welfare. Weaknesses include high implementation costs, limited digital infrastructure, inadequate technical expertise, interoperability challenges, and dependence on reliable internet connectivity, particularly in developing countries. Opportunities arise from expanding digital agriculture initiatives, supportive government policies, public-private partnerships, cloud computing, precision veterinary services, and increasing demand for sustainable livestock production. However, significant threats remain, including cybersecurity risks, privacy violations, legal uncertainty, algorithmic bias, regulatory fragmentation, and resistance to technological adoption among rural communities. Addressing these weaknesses and threats through effective governance, institutional support, capacity building, and investment strategies will maximize the long-term benefits of AI-enabled livestock farming while minimizing associated legal, ethical, and operational risks.

D. Proposed Policy and Regulatory Framework

A comprehensive policy and regulatory framework is essential to ensure the responsible, transparent, and sustainable adoption of AI-enabled Precision Livestock Farming in developing countries. The proposed framework should integrate legal governance, ethical AI principles, technical standards, institutional coordination, and stakeholder participation into a unified regulatory ecosystem. Core components include clear regulations for data ownership, privacy protection, cybersecurity, intellectual property rights, algorithmic accountability, and animal welfare compliance. A risk-based regulatory approach should classify AI applications according to their potential impacts while requiring transparency, explainability, independent auditing, and continuous performance evaluation. Standardized certification mechanisms should verify software reliability, data quality, interoperability, and operational safety before commercial deployment. Governments should establish dedicated AI regulatory authorities that collaborate with agricultural agencies, research institutions, industry partners, and farmer organizations to ensure effective implementation.

VI. Result and Discussion

Existing studies on AI-enabled Precision Livestock Farming primarily emphasize technological advancements such as machine learning, IoT, computer vision, wearable sensors, and predictive analytics for improving animal health, productivity, and resource efficiency. However, relatively few investigations comprehensively examine the associated legal, ethical, and policy dimensions, particularly in developing countries. Current literature provides limited discussion on data ownership, AI accountability, regulatory governance, intellectual property, and cross-border data management, highlighting the need for integrated legal and policy frameworks supporting responsible AI adoption.

Table 2. Comparative Assessment of AI Governance Frameworks for Precision Livestock Farming

Governance Framework	Regulatory Readiness (%)	Data Protection (%)	AI Transparency (%)	Policy Maturity (%)
Traditional Agricultural Policy	58.42	54.83	48.16	56.27
Data Protection-Based Framework	72.85	91.74	69.48	73.91
Ethical AI Framework	78.61	81.53	89.84	80.27
Risk-Based AI Governance	91.38	88.72	93.41	90.16

Table 2 compares four AI governance frameworks for Precision Livestock Farming using regulatory readiness, data protection, AI transparency, and policy maturity. Traditional Agricultural Policy

records the lowest performance, with 58.42% regulatory readiness, 54.83% data protection, 48.16% AI transparency, and 56.27% policy maturity. Figure 3 compares AI governance frameworks across regulatory readiness, transparency, and policy maturity.

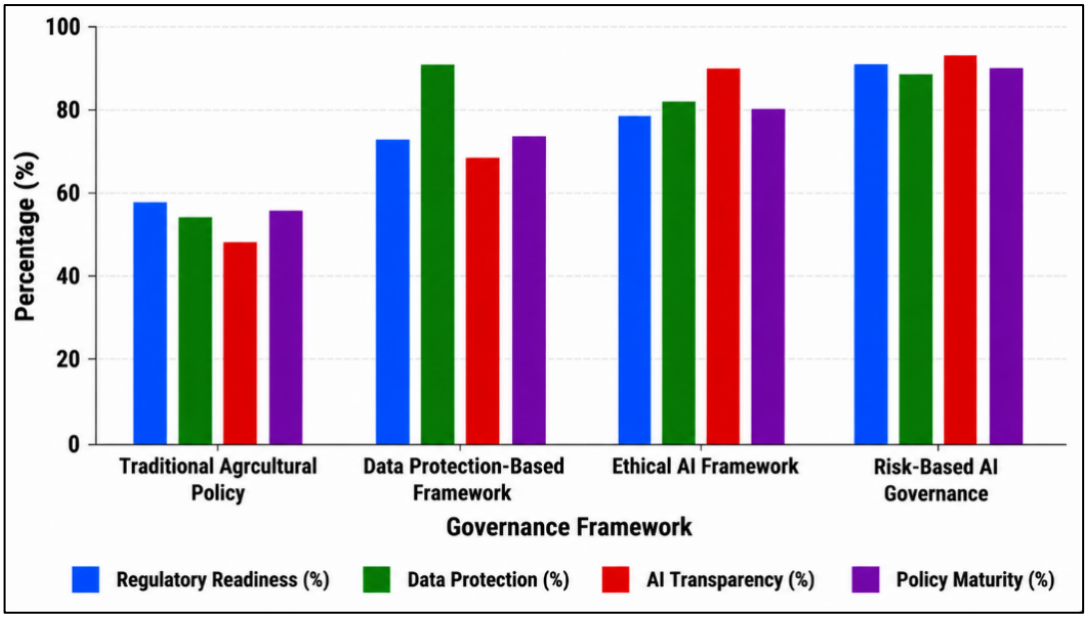

Figure 3. Comparative Analysis of AI Governance Frameworks

The Data Protection-Based Framework improves privacy to 91.74%, while achieving 72.85% regulatory readiness, 69.48% transparency, and 73.91% policy maturity. The Ethical AI Framework further enhances governance with 78.61% readiness, 81.53% data protection, 89.84% transparency, and 80.27% policy maturity.

Table 3. Comparative Analysis of Major Legal Challenges in AI-Enabled Precision Livestock Farming

Legal Challenge	Severity Score (%)	Regulatory Coverage (%)	Implementation Difficulty (%)	Risk Reduction with Proposed Framework (%)
Data Ownership and Privacy	94.72	66.84	89.15	93.41
Intellectual Property Rights	81.65	72.41	74.83	86.92
Animal Welfare Compliance	84.91	69.36	76.52	89.74
Cross-Border Data Sharing	88.54	57.93	86.18	92.63

Table 3 presents a comparative analysis of major legal challenges affecting AI-enabled Precision Livestock Farming. Data Ownership and Privacy exhibits the highest severity score (94.72%) and implementation difficulty (89.15%), while current regulatory coverage remains relatively low (66.84%). Figure 4 compares legal challenge severity with existing regulatory coverage across key domains.

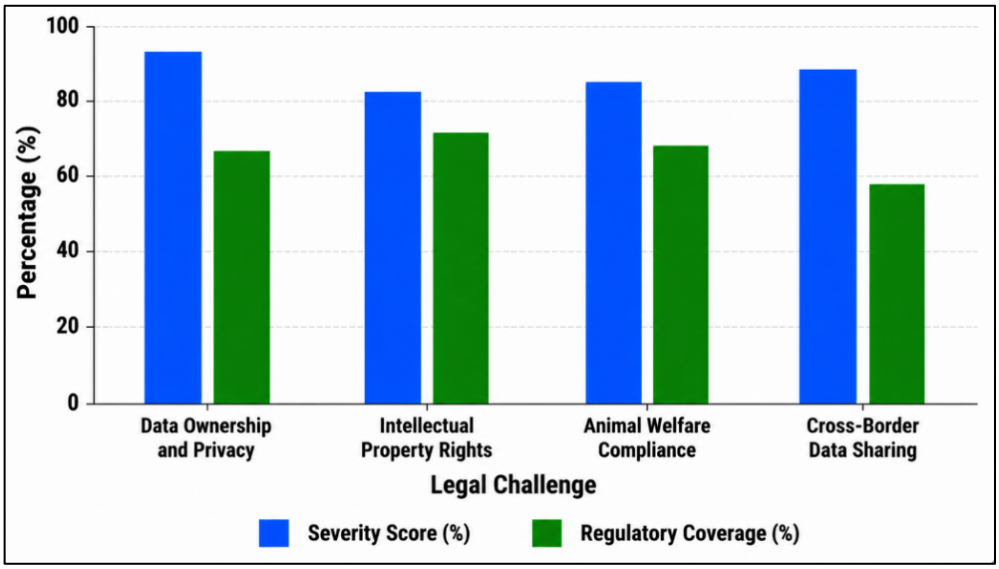

Figure 4. Comparative Analysis of Severity Score and Regulatory Coverage

Cross-Border Data Sharing also poses substantial challenges, with a severity of 88.54%, regulatory coverage of only 57.93%, and implementation difficulty of 86.18%. Animal Welfare Compliance records 84.91% severity and 69.36% regulatory coverage, indicating the need for stronger legal oversight.

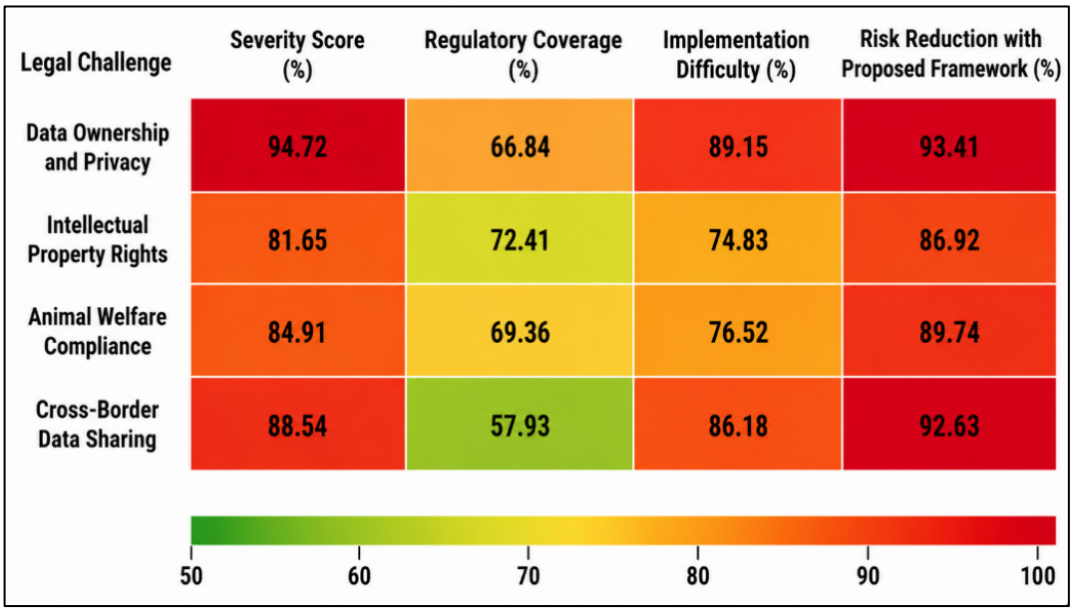

Figure 5. Comparison of Severity Score, Regulatory Coverage, Implementation Difficulty, and Risk Reduction

Figure 5 compares legal risks, regulatory coverage, implementation difficulty, and mitigation effectiveness comprehensively. Intellectual Property Rights show comparatively lower severity (81.65%) and implementation difficulty (74.83%). The proposed framework significantly mitigates these risks, achieving risk reduction values ranging from 86.92% to 93.41%, demonstrating its effectiveness in addressing critical legal and regulatory challenges.

VII. Conclusion

Artificial Intelligence has emerged as a transformative technology for Precision Livestock Farming by enabling intelligent monitoring, predictive analytics, automated decision-making, and efficient farm management. Nevertheless, the widespread adoption of AI in developing countries is accompanied by significant legal, ethical, and regulatory challenges that extend beyond technological implementation. This review systematically examined critical issues related to data ownership, privacy protection, algorithmic accountability, intellectual property rights, animal welfare compliance, and cross-border data

governance while evaluating existing legal frameworks and AI governance models. Comparative analysis demonstrated that fragmented regulations, limited institutional capacity, inadequate digital infrastructure, and inconsistent policy implementation remain major barriers to responsible AI adoption in livestock farming. Furthermore, the study highlighted the importance of harmonized governance, standardized certification mechanisms, transparent AI systems, and adaptive regulatory approaches capable of addressing rapidly evolving technologies. The proposed policy and regulatory framework integrates risk-based governance, ethical AI principles, stakeholder collaboration, institutional strengthening, and standardized compliance practices to support sustainable digital transformation.

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