



Original Research Paper

Governance, Ethics, and Legal Challenges of AI Adoption in Animal Environmental Monitoring

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Abstract

Artificial Intelligence (AI) is increasingly being adopted in animal environmental monitoring to support continuous observation, predictive assessment, animal welfare management, and sustainable livestock production. The integration of AI with Internet of Things (IoT) sensors, wearable devices, computer vision, and environmental monitoring platforms enables the analysis of complex relationships between environmental conditions, animal behaviour, health, and welfare. However, increasing dependence on AI introduces significant governance, ethical, and legal challenges that must be addressed for responsible and trustworthy adoption. This study examines key concerns associated with AI-enabled animal environmental monitoring, including data governance, ownership, privacy, cybersecurity, algorithmic transparency, explainability, bias, fairness, accountability, human oversight, animal welfare, legal liability, and regulatory compliance. It further presents a responsible AI adoption framework integrating data governance, model validation, ethical and risk assessment, stakeholder accountability, human supervision, continuous monitoring, and auditability throughout the AI lifecycle. The study emphasizes that predictive accuracy alone is insufficient for determining the suitability of AI systems, particularly when automated recommendations influence animal health, welfare, and environmental management decisions. Responsible adoption requires balancing technological innovation with ethical safeguards, regulatory requirements, transparent decision-making, and professional judgement. The proposed perspective supports the development of trustworthy, accountable, and sustainable AI-enabled animal environmental monitoring systems.

Keywords: Artificial Intelligence, Animal Environmental Monitoring, AI Governance, Animal Welfare, Responsible AI, AI Ethics, Legal Challenges, Sustainable Livestock Management

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1. Introduction

Artificial Intelligence (AI) is increasingly transforming animal production and environmental monitoring by enabling continuous data collection, automated analysis, predictive assessment, and intelligent decision-making. Modern livestock and animal management systems generate substantial volumes of data through environmental sensors, wearable devices, cameras, Internet of Things (IoT) platforms, automated feeding systems, and farm management technologies. AI techniques can process these heterogeneous data to identify environmental stress, detect changes in animal behaviour, assess welfare conditions, predict potential health risks, and support sustainable management decisions.

Animal health and welfare are strongly influenced by environmental conditions such as temperature, humidity, air quality, ventilation, water quality, stocking density, and exposure to environmental stressors. Conventional monitoring approaches generally depend on periodic observations and manual measurements, which may not adequately capture rapidly changing environmental and behavioural conditions. AI-enabled monitoring provides an opportunity to continuously analyse environmental and animal-related parameters and identify patterns that may indicate emerging welfare or environmental risks. Machine learning, deep learning, computer vision, and predictive analytics can further support early detection of abnormal conditions [1]. When integrated with IoT sensors and automated monitoring infrastructure, these technologies enable data-driven management of animal environments. Such capabilities can contribute to improved animal welfare, efficient resource utilization, reduced environmental impact, and more sustainable livestock production. However, increasing reliance on AI also introduces significant governance, ethical, and legal concerns. AI systems may collect sensitive farm, operational, environmental, and behavioural data, while automated recommendations can directly influence decisions affecting animals and production systems. Questions therefore arise regarding data ownership, privacy, algorithmic transparency, accountability, security, fairness, regulatory compliance, and responsibility for incorrect or harmful AI-assisted decisions [2].

AI-based animal environmental monitoring integrates data from multiple sources to develop a comprehensive understanding of the conditions surrounding animals. Environmental sensors can continuously measure temperature, humidity, gases, ventilation, light, and other parameters, while wearable sensors and computer-vision systems provide information related to animal movement,

feeding behaviour, activity, physiological responses, and welfare indicators. AI models can establish relationships between environmental conditions and animal responses to support environmental stress detection, welfare assessment, disease-risk prediction, and management recommendations [3]. For example, abnormal combinations of temperature, humidity, reduced activity, and altered feeding behaviour may provide early indications of heat stress or health deterioration. Predictive models can consequently support intervention before adverse conditions become severe. Despite these benefits, AI adoption should not be considered purely as a technological issue. Decisions produced by automated systems can affect farmers, veterinarians, technology providers, regulatory agencies, and animals themselves [4]. Responsible deployment therefore requires appropriate mechanisms for transparency, human oversight, data governance, system validation, accountability, and ethical use.

This study examines the governance, ethical, and legal challenges associated with adopting AI in animal environmental monitoring. The scope extends beyond the technical performance of AI models to consider how intelligent monitoring technologies can be deployed responsibly, transparently, securely, and in accordance with animal-welfare and regulatory requirements. The study specifically examines AI governance and accountability, data ownership and privacy, algorithmic transparency and explainability, bias and fairness, cybersecurity, human oversight, animal-welfare considerations, legal liability, and regulatory compliance. It further considers the responsibilities of major stakeholders, including farmers, veterinarians, technology developers, data providers, policymakers, and regulatory authorities. Based on these considerations, the study aims to establish a responsible AI adoption perspective for animal environmental monitoring. The proposed approach emphasizes a balance between technological innovation and appropriate governance safeguards so that AI-enabled monitoring can contribute to sustainable animal management while maintaining accountability, transparency, legal compliance, and animal welfare.

2. AI Technologies for Animal Environmental Monitoring

Artificial Intelligence has become an important component of modern animal environmental monitoring systems because of its ability to process large volumes of heterogeneous data and identify relationships between environmental conditions, animal behaviour, health, and welfare. AI-enabled monitoring commonly integrates environmental sensors, wearable devices, computer-vision systems,

Internet of Things (IoT) platforms, and farm management databases [5]. These technologies transform continuously collected observations into meaningful information for environmental assessment, early risk identification, and management decision support.

2.1 Environmental and Animal Monitoring Data

Effective AI-based monitoring depends on the availability and quality of environmental and animal-related data. Environmental monitoring systems commonly record temperature, relative humidity, air quality, ammonia and carbon dioxide concentrations, ventilation, light intensity, water conditions, and other parameters associated with the housing environment. These variables provide important information for determining whether animals are exposed to potentially stressful or unsuitable conditions [6]. Animal-level information can be obtained through wearable sensors, cameras, microphones, RFID systems, and automated feeding or milking equipment. Such systems can capture movement, activity, feeding behaviour, body temperature, vocalization, posture, resting patterns, and other welfare-related indicators. Combining animal-level observations with environmental measurements enables AI models to investigate how changes in environmental conditions influence animal responses. Data quality is particularly important because missing observations, sensor errors, inconsistent sampling intervals, and inaccurate measurements can influence model predictions [7]. Appropriate preprocessing, validation, synchronization, and integration are therefore required before heterogeneous monitoring data can be used for AI-based analysis.

2.2 AI-Based Monitoring and Prediction Techniques

Machine learning algorithms can identify complex relationships within environmental and animal datasets that may be difficult to detect using conventional monitoring approaches. Classification models can categorize welfare or environmental conditions into different risk levels, while regression models can estimate continuous parameters such as environmental stress indices or physiological responses. Deep learning provides additional capabilities for analysing high-dimensional and unstructured information. Convolutional Neural Networks can process images and video for animal detection, posture recognition, behavioural assessment, and identification of visible abnormalities [8]. Recurrent and sequence-based models can analyse temporal data obtained from sensors and wearable devices, allowing changes in environmental and behavioural conditions to be

evaluated over time. Predictive analytics can further estimate the probability of environmental stress, welfare deterioration, or disease-related conditions. Such predictions can provide early warnings and allow preventive actions to be initiated before conditions become critical. However, predictive performance alone does not establish the suitability of an AI system [9]. Reliability, interpretability, robustness, and appropriate validation are also essential when model outputs influence animal-management decisions.

2.3 IoT, Sensors, and Intelligent Monitoring Systems

IoT technologies provide the connectivity required for continuous animal environmental monitoring. Distributed sensors installed within animal housing facilities can automatically collect environmental parameters and transmit them to gateways, edge devices, or cloud platforms. Wearable devices can simultaneously provide animal-specific measurements, creating an interconnected monitoring environment. Edge computing can process selected information close to the data source, reducing communication delays and supporting rapid responses to critical events. Cloud platforms provide greater computational resources for data storage, historical analysis, AI model execution, and integration across multiple farms or monitoring locations [10][11]. The combination of IoT, edge computing, cloud services, and AI therefore enables monitoring systems to move from simple data acquisition toward predictive and intelligent decision support. Nevertheless, increased connectivity also creates governance and cybersecurity concerns. Connected sensors and cloud platforms may expose operational and animal-related information to unauthorized access, manipulation, or misuse [12]. Device reliability, secure communication, access control, data storage, and system interoperability consequently become important considerations for responsible AI deployment.

2.4 Applications in Animal Welfare and Sustainable Management

AI-enabled environmental monitoring can support several aspects of animal welfare and sustainable management. Continuous analysis of temperature, humidity, air quality, animal activity, and behavioural information can facilitate early recognition of heat stress, poor ventilation, abnormal behaviour, and potentially adverse housing conditions. Automated alerts can assist farmers and animal-care professionals in responding more rapidly to emerging risks.

AI can also support resource-efficient management by improving decisions related to ventilation, cooling, feeding, water utilization, housing conditions, and environmental control. Predictive information can help management systems activate resources according to actual or anticipated requirements rather than relying exclusively on fixed operating schedules. This can reduce unnecessary resource consumption while maintaining suitable environmental conditions.

The integration of AI into animal environmental monitoring therefore offers considerable potential for improving welfare, productivity, and environmental sustainability. At the same time, greater dependence on automated monitoring increases the importance of establishing clear governance structures. Questions concerning who controls collected data, how algorithms make decisions, who is responsible for inaccurate predictions, and how animal welfare is protected provide the foundation for examining the governance, ethical, and legal challenges associated with AI adoption.

3. AI Governance Challenges

The adoption of Artificial Intelligence in animal environmental monitoring requires governance mechanisms that define how AI systems are developed, validated, deployed, monitored, and controlled. Governance becomes particularly important when automated predictions influence animal welfare, environmental management, disease-risk assessment, or operational decisions. Although AI can improve monitoring efficiency and enable earlier interventions, inadequate governance may create risks related to unreliable predictions, inappropriate data use, limited transparency, cybersecurity vulnerabilities, and unclear responsibility. Effective AI governance should therefore establish mechanisms for accountability, data management, transparency, human oversight, and continuous system evaluation.

3.1 Governance of AI-Enabled Monitoring Systems

AI governance refers to the policies, procedures, responsibilities, and controls used to ensure that intelligent systems operate safely and consistently with organizational, ethical, and regulatory requirements. In animal environmental monitoring, governance should cover the complete AI lifecycle, including data collection, model development, testing, deployment, operational monitoring, model updating, and eventual replacement.

A major challenge is the involvement of multiple stakeholders. Farmers may operate monitoring systems, veterinarians may interpret health-related predictions, technology providers may develop AI models, cloud providers may store information, and regulatory authorities may establish compliance requirements. Without clearly defined responsibilities, failures can create uncertainty regarding accountability [13]. Governance mechanisms should consequently establish responsibility for system validation, data quality, model performance, risk management, and intervention decisions. AI-generated recommendations should complement professional and managerial judgement rather than automatically replacing human decision-making in situations involving significant animal-welfare consequences.

3.2 Data Governance and Ownership

Animal environmental monitoring systems continuously generate large volumes of data from environmental sensors, cameras, wearable devices, farm equipment, and management platforms. Data governance determines how these data are collected, stored, accessed, shared, retained, and used. One significant challenge concerns data ownership. Monitoring information may be generated on a farm but processed by external technology companies or stored on third-party cloud infrastructure. This creates questions regarding whether the farmer, technology provider, platform operator, or another stakeholder controls the collected data and any information subsequently derived through AI analysis. Clear agreements are therefore required regarding ownership, access rights, secondary data use, retention periods, data sharing, and deletion. Data quality must also form part of governance because inaccurate sensor measurements, missing observations, or inconsistent records can produce unreliable AI predictions. Maintaining data provenance and traceability can help establish how particular predictions were generated and which information contributed to them.

3.3 Transparency and Explainability

Many advanced AI models operate through complex computational processes that may not be easily understandable to farmers, veterinarians, or other end users. Limited transparency becomes particularly problematic when AI systems generate alerts or recommendations that influence animal treatment, housing conditions, environmental control, or other management interventions. Explainability mechanisms should provide understandable information about why a particular prediction or risk classification was produced. For example, an environmental stress warning could

identify elevated temperature, high humidity, reduced activity, and abnormal feeding behaviour as major contributing factors rather than presenting only a numerical risk score [14]. Transparency should also extend beyond individual predictions. Users should have appropriate information regarding the purpose of the system, data requirements, expected performance, known limitations, and circumstances under which predictions may become unreliable. Such transparency supports informed use and reduces the possibility of excessive dependence on automated recommendations.

3.4 Accountability and Human Oversight

Accountability represents a major governance challenge because AI-enabled monitoring involves several actors across the technology and decision-making chain. If an AI system fails to identify dangerous environmental conditions or generates an incorrect recommendation that adversely affects animal welfare, responsibility may be difficult to determine. Clear accountability should therefore be established among AI developers, system providers, farm operators, veterinarians, and other relevant stakeholders. Developers may be responsible for appropriate model design and testing, technology providers for system reliability and maintenance, and operational users for appropriate interpretation and implementation of recommendations. Human oversight is particularly important for high-impact decisions. AI should provide evidence and decision support while allowing qualified individuals to review alerts, consider contextual information, and override automated recommendations when necessary. Maintaining records of predictions, user actions, model versions, and interventions can further support accountability and auditability.

3.5 Governance Frameworks and Standards

Responsible AI adoption requires a structured governance framework that integrates technical controls with organizational responsibilities. Such a framework should address data quality, model validation, cybersecurity, transparency, accountability, human oversight, documentation, and continuous performance monitoring.

AI systems should be evaluated before deployment and periodically reassessed after implementation. Changes in animal populations, environmental conditions, sensor configurations, management practices, or data distributions may reduce model performance over time. Continuous monitoring can identify such model drift and determine when recalibration or retraining is required.

A risk-based governance approach is particularly suitable for animal environmental monitoring. Systems performing routine environmental observations may require relatively limited controls, whereas AI applications influencing animal health, welfare interventions, or critical environmental management decisions should undergo stronger validation and oversight. Governance requirements should therefore be proportional to the potential consequences of system failure.

Overall, effective governance provides the institutional and operational foundation for trustworthy AI adoption. Clear responsibility, transparent decision processes, controlled data management, systematic validation, and meaningful human oversight can reduce technological risks while supporting the benefits of intelligent animal environmental monitoring. These governance requirements are closely connected with broader ethical and legal considerations, which are examined in the following section.

4. Ethical and Legal Challenges

The integration of Artificial Intelligence into animal environmental monitoring creates ethical and legal concerns that extend beyond technical accuracy and operational efficiency. AI-enabled systems can continuously observe animals, collect farm and environmental information, predict welfare or health risks, and influence management decisions. Consequently, responsible adoption requires consideration of animal welfare, privacy, fairness, data protection, legal responsibility, and regulatory compliance. These issues become increasingly important as monitoring systems move from providing basic information toward recommending or automatically initiating interventions.

4.1 Animal Welfare and Ethical Considerations

Animal welfare represents a central ethical consideration in AI-enabled environmental monitoring. AI systems can contribute positively to welfare by continuously detecting environmental stress, abnormal behaviour, inadequate housing conditions, and potential health risks. Early identification of these conditions can enable faster intervention and reduce prolonged animal exposure to harmful environments. However, technology should not reduce welfare assessment to only those parameters that can be conveniently measured by sensors. Animal welfare involves complex physical, behavioural, and environmental factors that may not be completely represented by numerical measurements. Excessive dependence on automated predictions may therefore overlook contextual conditions requiring human observation or

professional veterinary judgement. An ethically responsible monitoring system should consequently use AI to complement rather than completely replace human expertise. Welfare-related decisions should prioritize animal well-being instead of considering productivity or economic efficiency as the sole optimization objectives.

4.2 Privacy and Responsible Data Use

Animal environmental monitoring may appear to involve primarily non-personal information, but modern monitoring infrastructure can also collect data associated with farmers, employees, veterinarians, farm locations, operational practices, production performance, and business activities. Cameras and connected devices can additionally capture information about individuals working within monitored environments. Responsible data use requires clarity regarding what information is collected, why it is collected, where it is stored, who can access it, and whether it can be used for purposes beyond the original monitoring objective. Secondary use of farm data for commercial analytics, model development, benchmarking, or sharing with third parties may create privacy and ownership concerns. Data minimization, controlled access, secure storage, anonymization where appropriate, and clearly defined retention policies can reduce these risks. Stakeholders should also be appropriately informed about data collection and processing practices.

4.3 Algorithmic Bias and Fairness

AI models are strongly influenced by the datasets used for their development. Training data collected from particular animal breeds, geographic regions, climatic conditions, housing systems, or farm sizes may not adequately represent other production environments. A model developed primarily using data from intensive livestock systems, for example, may provide less reliable predictions when applied to small-scale or extensive farming environments. Such limitations can create algorithmic bias and unequal performance across farms or animal populations. Biased predictions may result in incorrect risk assessments, inappropriate interventions, or unequal access to the benefits of intelligent monitoring. Fairness therefore requires representative datasets and evaluation across different breeds, environmental conditions, production systems, seasons, and geographical contexts. Performance should not be assessed only through overall accuracy; subgroup-specific reliability and potential failure conditions should also be investigated. Periodic reassessment is necessary because changes in environmental and

operational conditions may introduce new forms of bias after deployment.

4.4 Legal Liability and Accountability

Legal responsibility becomes challenging when AI-generated recommendations contribute to decisions that cause economic loss, environmental damage, disease spread, or deterioration in animal welfare. Several parties may participate in an AI-enabled monitoring system, including farmers, veterinarians, software developers, sensor manufacturers, cloud providers, and AI service operators.

If a system fails to detect dangerous heat stress because of an inaccurate sensor, for example, responsibility could potentially involve the device manufacturer, AI provider, system operator, or individual responsible for acting on the monitoring information. Similarly, incorrect disease-risk predictions could create consequences if automated recommendations are accepted without appropriate professional assessment. Clear contractual and operational allocation of responsibilities is therefore necessary. Documentation of model outputs, system warnings, sensor status, human interventions, software updates, and model versions can provide an audit trail for determining how decisions were reached. High-impact applications should maintain meaningful human oversight so that responsibility cannot simply be transferred from decision-makers to an algorithm.

4.5 Regulatory Compliance and Data Protection

AI-enabled animal monitoring operates across several regulatory domains rather than under a single set of rules. Depending on the application and jurisdiction, requirements may relate to data protection, cybersecurity, animal welfare, veterinary practices, product safety, environmental management, and emerging AI-specific regulation. Compliance becomes more complex when monitoring platforms operate across geographical boundaries or when farm data are processed through cloud infrastructure located in different jurisdictions. Organizations must therefore determine which regulatory requirements apply to data collection, storage, processing, transfer, automated decision-making, and system operation.

Regulatory compliance should be incorporated throughout the AI lifecycle rather than addressed only after system development. Privacy-by-design, security-by-design, appropriate documentation, model validation, risk assessment, access controls, and audit mechanisms can support this approach. Organizations should also maintain mechanisms for updating AI systems when legal or regulatory

requirements change. Overall, ethical and legal challenges demonstrate that successful AI adoption cannot be evaluated solely through predictive accuracy or economic benefits. Animal welfare protection, responsible data practices, fairness, accountability, legal clarity, and regulatory compliance must be integrated into the design and operation of AI-enabled animal environmental monitoring systems. These considerations provide the foundation for developing a responsible AI adoption framework that balances technological innovation with ethical safeguards and legal responsibilities.

5. Responsible AI Adoption Framework

The responsible adoption of Artificial Intelligence in animal environmental monitoring requires an integrated framework that combines technological performance with governance, ethical safeguards, legal compliance, and animal welfare considerations. The framework should cover the complete AI lifecycle, beginning with data collection and model development and continuing through deployment, monitoring, human intervention, and periodic evaluation. Its primary purpose is to ensure that AI improves environmental management and animal welfare without creating unacceptable risks related to data misuse, algorithmic bias, unreliable predictions, or unclear accountability.

5.1 Principles of Responsible AI Adoption

Responsible AI adoption should be guided by the principles of transparency, accountability, fairness, privacy, security, reliability, and human oversight. AI models should provide predictions that can be interpreted by relevant users, particularly when recommendations affect animal health or welfare. Appropriate documentation should describe the intended purpose, data requirements, limitations, and expected operating conditions of the system. Animal welfare should remain a fundamental design consideration. AI systems should not optimize productivity or operational efficiency at the expense of animal well-being. Similarly, automated recommendations should support farmers, veterinarians, and animal-care professionals rather than completely replacing their judgement in high-impact situations.

5.2 Risk Assessment and Mitigation

Risk assessment should be performed throughout the AI lifecycle. Potential risks can originate from inaccurate sensors, incomplete datasets, biased training data, model errors, cybersecurity threats, system failures, or inappropriate interpretation of AI

outputs. The significance of each risk depends on both its likelihood and its potential consequences. Applications can therefore be classified according to their level of impact. Routine monitoring of environmental variables may represent comparatively low risk, whereas systems responsible for disease alerts, welfare interventions, or automated environmental control require more rigorous validation and oversight. Risk mitigation measures should include data-quality assessment, model validation, cybersecurity controls, periodic performance evaluation, backup procedures, and mechanisms for human intervention. Systems should also provide warnings when input data are unreliable or when predictions fall outside validated operating conditions.

5.3 Stakeholder Roles and Responsibilities

Responsible AI requires clearly defined responsibilities among all stakeholders involved in the monitoring ecosystem. Technology developers should ensure appropriate model design, testing, documentation, and performance evaluation. Sensor and platform providers should maintain device reliability, cybersecurity, and secure data management. Farmers and system operators should ensure that monitoring technologies are used according to their intended purpose and that critical alerts receive appropriate attention. Veterinarians and animal-welfare professionals should provide domain expertise when AI outputs influence health or welfare decisions. Regulatory authorities should establish minimum requirements for safety, transparency, data protection, accountability, and system validation. Shared responsibility is important, but it should not result in unclear accountability. The role of each stakeholder should therefore be documented throughout the AI lifecycle.

5.4 Policy and Regulatory Recommendations

Policies governing AI-enabled animal monitoring should adopt a risk-based and application-specific approach. Regulatory requirements should be proportional to the potential consequences of AI failure. High-impact applications affecting animal health, welfare, or critical environmental conditions should require stronger validation, documentation, auditability, and human oversight. Policies should also establish clear requirements for data ownership, access, sharing, retention, security, and secondary use. Minimum standards for model transparency and performance reporting can help users understand the capabilities and limitations of AI systems. Interoperability standards are equally important because animal monitoring frequently combines sensors, AI platforms, cloud services, and farm

management systems from different providers. Common technical and data standards can improve compatibility while reducing dependence on individual technology vendors.

5.5 Sustainable and Trustworthy AI Adoption

Responsible AI should contribute simultaneously to animal welfare, environmental sustainability, and trustworthy decision-making. Environmental monitoring systems can support more efficient use of water, energy, ventilation, cooling, feed, and other resources while detecting conditions that may negatively affect animals. However, the environmental cost of the AI infrastructure itself, including computing, data storage, connectivity, and device replacement, should also be considered.

A practical responsible AI adoption process can be represented as:

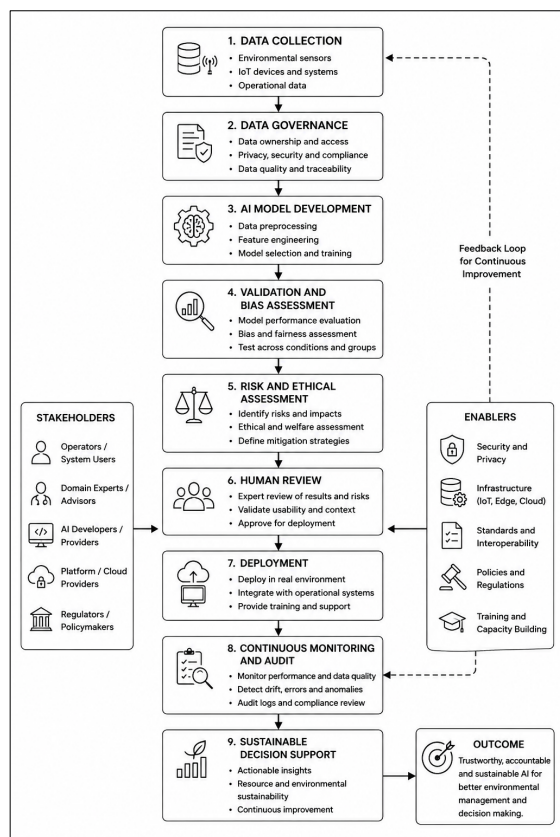


Figure 1: Responsible AI Adoption Framework for Animal Environmental Monitoring

This framework establishes governance and ethical safeguards as continuous components rather than separate activities performed after model development. Feedback from farmers, veterinarians, welfare professionals, and other stakeholders should be incorporated into periodic system evaluation.

Overall, responsible AI adoption in animal environmental monitoring requires a balance between innovation and control. Combining reliable data, validated AI models, transparent decision-making, ethical safeguards, legal compliance, stakeholder accountability, and continuous monitoring can enable AI technologies to support sustainable animal management while maintaining public and stakeholder trust.

6. Conclusion

Artificial Intelligence is transforming animal environmental monitoring by enabling continuous data collection, automated analysis, predictive assessment, and intelligent decision support. The integration of AI with IoT sensors, wearable devices, computer vision, and environmental monitoring systems provides significant opportunities for improving animal welfare, environmental sustainability, resource efficiency, and livestock management. However, responsible adoption requires attention beyond technological performance and predictive accuracy. This study highlights major governance, ethical, and legal challenges related to data ownership, privacy, cybersecurity, algorithmic transparency, fairness, accountability, human oversight, animal welfare, legal liability, and regulatory compliance. Addressing these challenges requires a responsible AI framework that integrates appropriate safeguards throughout the complete AI lifecycle, from data collection and model development to deployment, monitoring, and periodic evaluation. Clear stakeholder responsibilities and transparent decision-making mechanisms are particularly important when AI recommendations influence animal health and welfare. Future AI-enabled animal monitoring systems should therefore prioritize explainability, reliability, security, fairness, and human-centered decision-making. Regulatory and governance mechanisms should also evolve alongside technological developments. By balancing innovation with ethical safeguards, legal compliance, animal welfare principles, and effective governance, AI can provide trustworthy and sustainable decision support for modern animal environmental monitoring and management.

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