18(2s), Spring 2026

Journal of Animal Environment

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

Original Research Paper

AI-Assisted Regulatory Compliance Framework for Animal Welfare and Environmental Protection Laws

Razia Syed[1], Aastha Khatri[2*], Kumud Dwivedi[3], Deepika Kanwar[4], Pramod Bhargava[5], Geetu Agnihotri[6], Avatar Chaubey[7]

[1]Assistant Professor, Jharkhand Rai University (Razia Syed) | razia@jru.edu.in
[2*]Assistant Professor, Faculty of Agriculture, Maharishi Markandeshwar Deemed to be University, Mullana, Ambala, Haryana (Aastha Khatri) | Khatriaastha21@gmail.com
[3]Assistant Professor, Department of Legal Studies, Career Point University, Kota, Rajasthan (Kumud Dwivedi) | kumuddwivedi08@gmail.com
[4]Assistant Professor (Law), Amity Law School, Amity University Punjab, Mohali, India (Deepika Kanwar) | advdeepikakanwar1@gmail.com
[5]Assistant Professor, Department of Commerce, DAV College, Chandigarh (Pramod Bhargava) | psbhargav@gmail.com
[6]Assistant Professor, PG Department of Commerce and Management, DAV College Hoshiarpur (PU) (Geetu Agnihotri) | geetuagnihotri@yahoo.com
[7]Assistant Professor, Amity Law School, Amity University Punjab, Mohali, India (Avatar Chaubey) | 277chaubey1995@gmail.com

Abstract: Ensuring compliance with animal welfare and environmental protection laws is essential for sustainable livestock production, biodiversity conservation, and responsible environmental management. However, conventional compliance practices rely heavily on manual inspections, periodic audits, and extensive documentation, making them time-consuming, costly, and prone to human error. This study proposes an AI-Assisted Regulatory Compliance Framework that integrates Artificial Intelligence (AI), Machine Learning (ML), Computer Vision (CV), Natural Language Processing (NLP), Internet of Things (IoT), and Explainable Artificial Intelligence (XAI) to automate regulatory compliance assessment. The framework collects multimodal data from regulatory documents, environmental sensors, surveillance systems, wearable animal devices, veterinary records, and farm management platforms. NLP extracts legal obligations from regulatory documents, while Computer Vision and ML analyze animal welfare conditions and environmental parameters to detect potential compliance violations. An Explainable AI module provides transparent justifications and recommends corrective actions, enabling evidence-based regulatory decision-making. The proposed framework is validated through representative use-case scenarios involving animal welfare monitoring, environmental protection, waste management, and legal compliance assessment. The results demonstrate the framework's ability to improve compliance accuracy, reduce assessment time, support continuous monitoring, and facilitate proactive regulatory enforcement. By integrating intelligent analytics with legal knowledge, the proposed framework offers a scalable and transparent solution for enhancing regulatory compliance, improving animal welfare, promoting environmental sustainability, and supporting informed governance across diverse agricultural and environmental management systems.

Keywords: Artificial Intelligence, Regulatory Compliance, Animal Welfare, Environmental Protection, Machine Learning, Natural Language Processing, Computer Vision, Internet of Things, Explainable Artificial Intelligence, Sustainable Agriculture.

I. Introduction

Animal welfare and environmental protection have become central priorities in achieving sustainable agriculture, biodiversity conservation, and responsible natural resource management. Growing concerns over intensive livestock production, habitat degradation, pollution, and climate change have prompted governments and international organizations to establish comprehensive regulations governing the ethical treatment of

***Corresponding Author:**
Received: 24th April, 2026; Revised: 11th May, 2026; Accepted: 24th May, 2026; Available Online: 6th June, 2026
(DOI): 10.70102/AEJ.2026.18.2s.89

animals and environmental sustainability [1]. These regulations encompass diverse aspects such as livestock housing, animal transportation, veterinary care, waste management, greenhouse gas emissions, water quality, biodiversity conservation, and ecosystem protection. Compliance with these legal requirements is essential not only to ensure public trust and environmental stewardship but also to support sustainable agricultural production and global food security [2]. The widespread adoption of Internet of Things (IoT) technologies has further enhanced the capabilities of AI-driven compliance systems. Modern farms and environmental monitoring networks increasingly employ smart sensors, wearable animal devices, surveillance cameras, drones, and automated weather stations to continuously collect information on animal health, behaviour, environmental conditions, air quality, water quality, temperature, humidity, and greenhouse gas emissions [3]. The integration of these heterogeneous data sources with AI algorithms enables continuous assessment of regulatory compliance rather than relying solely on periodic inspections. Such intelligent monitoring systems facilitate early detection of non-compliance, support preventive interventions, and improve overall operational efficiency [4]. Another important advancement is the emergence of Explainable Artificial Intelligence, which improves the transparency and accountability of AI-assisted regulatory decisions. Since regulatory authorities and industry stakeholders require clear justification for compliance assessments, explainable AI techniques provide interpretable evidence, identify the factors responsible for regulatory violations, and generate understandable recommendations for corrective actions. This transparency enhances stakeholder confidence, supports legal accountability, and facilitates informed decision-making [5].

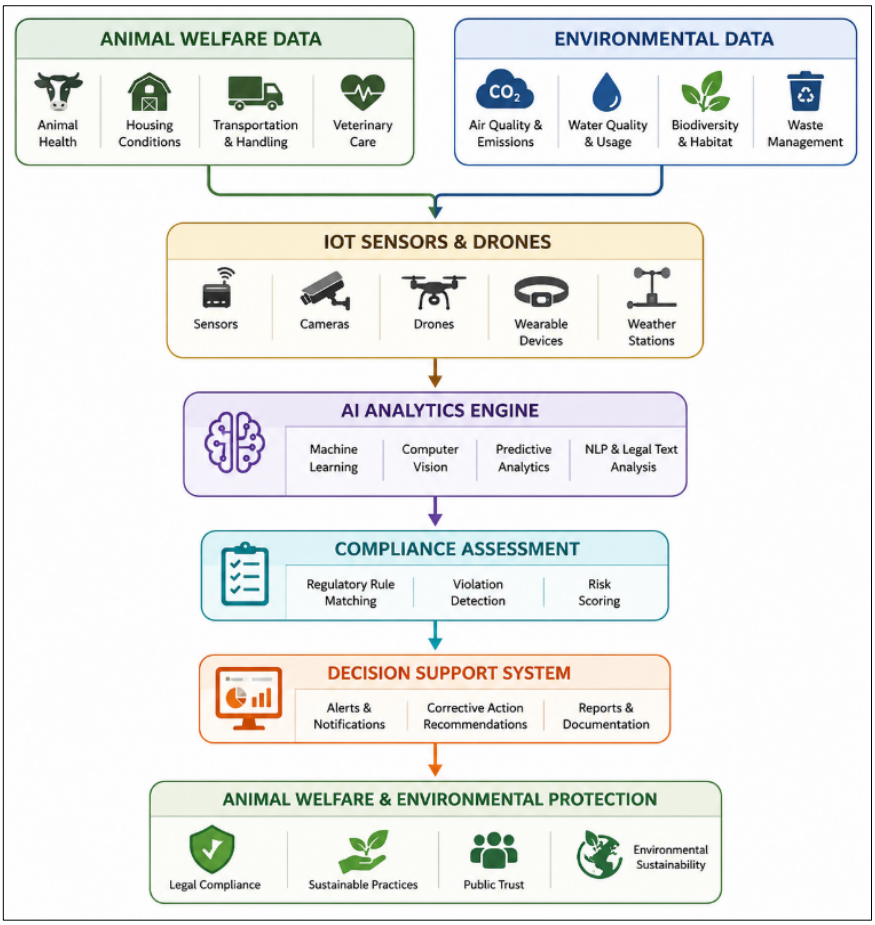

Figure 1. AI-Assisted Regulatory Compliance Ecosystem

Although AI has been successfully applied in areas such as precision livestock farming, environmental monitoring, wildlife conservation, and legal text analysis, most existing studies focus on individual applications rather than comprehensive regulatory compliance. Current systems typically address isolated tasks such as disease detection, animal behaviour monitoring, environmental sensing, or legal document processing without integrating these capabilities into a unified framework capable of evaluating both animal welfare and environmental protection requirements as shown in figure 1. Consequently, there remains a need for an intelligent, integrated, and explainable framework

that combines regulatory knowledge with real-time operational monitoring [6]. This study proposes an AI-Assisted Regulatory Compliance Framework for Animal Welfare and Environmental Protection Laws that integrates legal document intelligence, AI-based analytics, IoT-enabled monitoring, computer vision, predictive risk assessment, and explainable decision support into a unified platform. The proposed framework is designed to automate compliance evaluation, continuously monitor regulatory requirements, identify potential violations at an early stage, and recommend appropriate corrective actions. By supporting transparent and evidence-based compliance management, the framework aims to improve animal welfare, strengthen environmental protection, reduce regulatory risks, and contribute to sustainable and responsible livestock and environmental management practices.

II. Background Study

Artificial Intelligence (AI) has emerged as a transformative technology that is reshaping agriculture, environmental management, and animal welfare by enabling intelligent automation, predictive analytics, and data-driven decision-making. The growing adoption of AI has not only improved operational efficiency but has also raised important ethical considerations regarding transparency, accountability, and responsible deployment, emphasizing the need for trustworthy AI systems in critical application domains [7]. Recent advancements in digital agriculture have demonstrated the potential of AI-driven digital twins and intelligent crop management systems for improving agricultural productivity and sustainability. These technologies facilitate continuous monitoring, predictive modelling, and optimized resource utilization, thereby supporting precision farming and environmental conservation [8]. Similarly, automated animal behaviour monitoring has become an important research area, where computer vision, sensor technologies, and machine learning algorithms enable continuous observation of livestock behaviour, reducing dependence on manual inspections while improving welfare assessment accuracy [9]. Edge computing has further strengthened smart agriculture by processing large volumes of sensor data closer to the source, enabling real-time analytics, reducing communication latency, and supporting timely decision-making in distributed agricultural environments [10]. AI has also significantly influenced veterinary healthcare through intelligent diagnostic systems, digital healthcare platforms, and predictive clinical decision support. Advanced AI techniques have improved disease diagnosis, animal health monitoring, and personalized veterinary care, contributing to better healthcare outcomes for companion animals [11]. Studies have further highlighted the importance of effective information exchange between veterinarians and pet owners to improve clinical decision-making and treatment quality [12], while recent reviews have demonstrated the expanding role of AI across various veterinary applications, including diagnosis, imaging, disease prediction, and healthcare management [13]. Digital infrastructures and web-based agricultural platforms have further enhanced the integration of AI into modern farming by enabling efficient data sharing, intelligent decision support, and collaborative farm management [14]. Moreover, deep learning-based wildlife monitoring systems utilizing camera traps and remote sensing technologies have substantially improved biodiversity conservation through automated species detection and ecological monitoring, reducing human intervention in wildlife management [15]. Despite these technological advancements, current research primarily focuses on isolated applications such as precision agriculture, animal behaviour monitoring, veterinary healthcare, or wildlife conservation. Limited attention has been given to integrating these AI technologies with legal knowledge for automated compliance assessment of animal welfare and environmental protection regulations. Consequently, there remains a need for a comprehensive AI-assisted regulatory compliance framework capable of combining intelligent monitoring, legal document analysis, and explainable decision support to ensure transparent, continuous, and sustainable regulatory compliance.

III. Research Gaps and Motivation

Although significant progress has been made in applying Artificial Intelligence (AI) to animal welfare monitoring, environmental protection, and legal document analysis, several important research gaps remain. Most existing studies concentrate on a single application domain, such as livestock health monitoring, environmental quality assessment, wildlife surveillance, or legal text processing. These isolated solutions do not provide a comprehensive mechanism for evaluating compliance with multiple animal welfare and environmental regulations simultaneously. Consequently, organizations must rely on separate tools and manual interpretation, reducing the efficiency and consistency of compliance management.

A. The major limitation is the lack of integration between regulatory knowledge and real-time operational data. Current AI systems generally analyze sensor readings, images, or textual information independently without correlating them with specific legal requirements. As a result, while abnormalities or environmental risks may be detected, these systems often fail to determine whether the observed conditions constitute a regulatory violation or recommend appropriate corrective actions.

B. The limited use of Explainable Artificial Intelligence (XAI) also represents a significant challenge. Many AI-based compliance solutions employ complex deep learning models that provide accurate predictions but offer little explanation for their decisions. Since regulatory compliance requires transparency, accountability, and evidence-based justification, black-box models are often unsuitable for supporting inspectors, policymakers, and regulatory authorities. Additionally, existing frameworks rarely support continuous compliance monitoring using multimodal data collected from IoT sensors, surveillance cameras, drones, wearable animal devices, and environmental monitoring systems.

C. The motivation for this research arises from the increasing complexity of animal welfare and environmental protection laws, together with the growing availability of AI and smart sensing technologies. There is a pressing need for an intelligent framework capable of automatically interpreting legal requirements, integrating heterogeneous data sources, continuously assessing compliance, detecting potential violations at an early stage, and generating transparent recommendations for corrective actions. Such a framework can reduce manual effort, improve regulatory efficiency, enhance animal welfare, minimize environmental impacts, and support evidence-based decision-making.

To address these limitations, this study proposes an AI-Assisted Regulatory Compliance Framework that integrates Natural Language Processing for legal knowledge extraction, Computer Vision and IoT for real-time monitoring, Machine Learning for predictive compliance assessment, and Explainable AI for transparent decision support. The proposed framework aims to bridge the gap between regulatory requirements and intelligent operational monitoring, enabling accurate, scalable, and trustworthy compliance management across animal welfare and environmental protection domains.

IV. 4. Regulatory Framework for Animal Welfare and Environmental Protection

Regulatory frameworks for animal welfare and environmental protection establish the legal standards required to ensure the ethical treatment of animals while minimizing the environmental impact of agricultural, industrial, and conservation activities. These frameworks are developed by national governments and international organizations and include legislation, policies, guidelines, and standards covering animal health, housing, transportation, breeding, waste management, pollution control, biodiversity conservation, and sustainable resource utilization. Compliance with these regulations is essential for protecting animal well-being, conserving ecosystems, ensuring food safety, and promoting sustainable development.

Animal welfare regulations primarily focus on providing appropriate living conditions, adequate nutrition, disease prevention, veterinary care, humane handling, transportation, and ethical slaughter practices. Many countries have adopted welfare principles based on internationally recognized guidelines such as the Five Freedoms and the Five Domains Model, which emphasize freedom from hunger, discomfort, pain, fear, and the ability of animals to express natural behaviour. Regulatory authorities routinely inspect livestock farms, poultry facilities, dairy operations, animal shelters, zoological parks, and research laboratories to verify compliance with these welfare standards.

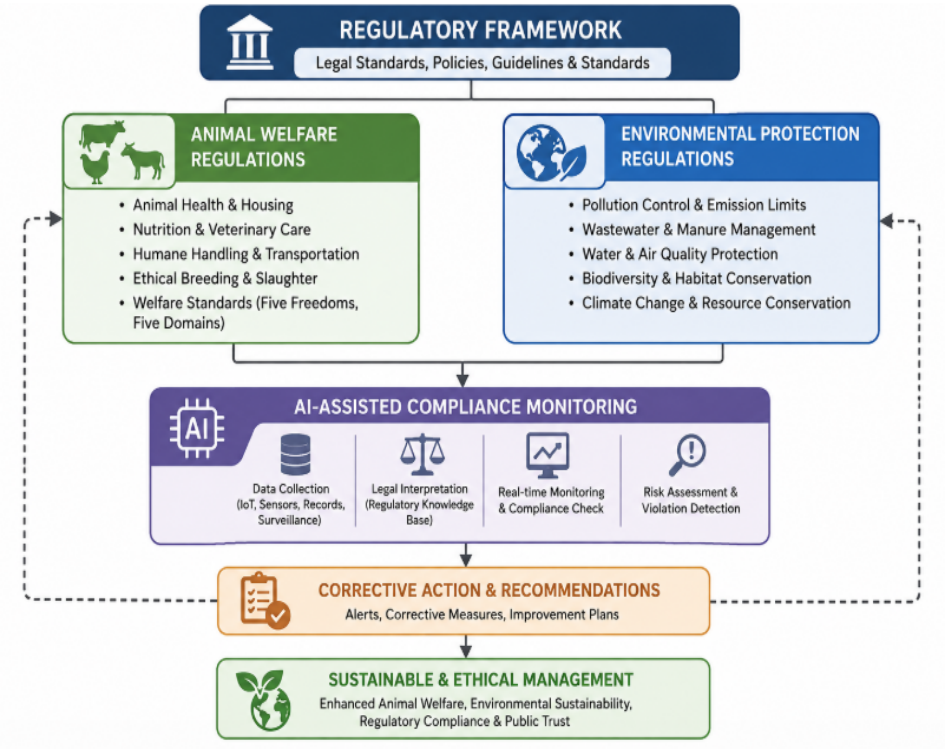

Figure 2. AI-Assisted Regulatory Compliance Framework

Environmental protection regulations complement animal welfare laws by controlling pollution, conserving natural resources, and reducing the ecological footprint of animal production systems. These regulations address wastewater management, manure disposal, greenhouse gas emissions, air quality, water conservation, chemical usage, biodiversity protection, habitat preservation, and climate change mitigation as shown in figure 2. Environmental agencies require organizations to monitor resource consumption, manage waste responsibly, maintain environmental records, and comply with prescribed emission limits to minimize adverse environmental impacts. Although these regulations are comprehensive, ensuring continuous compliance remains challenging due to the diversity of legal requirements, frequent regulatory updates, and large volumes of operational data. Manual interpretation of legislation and periodic inspections often delay the identification of non-compliance, increasing operational risks and regulatory burden. Furthermore, organizations operating across multiple jurisdictions must comply with different legal standards, making compliance management even more complex. An AI-assisted regulatory framework can address these challenges by integrating legal knowledge with operational data collected from IoT sensors, surveillance systems, environmental monitoring devices, and digital records. Artificial Intelligence can automatically interpret regulatory provisions, continuously compare real-time observations with legal requirements, identify potential violations, assess compliance risks, and recommend corrective measures. Such an intelligent framework enables proactive compliance management, improves transparency, supports evidence-based regulatory decisions, and enhances both animal welfare and environmental sustainability. By combining regulatory knowledge with advanced AI technologies, organizations can achieve more efficient, accurate, and scalable compliance while promoting responsible and sustainable management practices.

V. Dataset Selection & Criteria

The proposed AI-Assisted Regulatory Compliance Framework utilizes a multimodal dataset comprising regulatory, environmental, animal welfare, and operational data to support intelligent compliance assessment. The regulatory dataset includes animal welfare laws, environmental protection regulations, inspection guidelines, and policy documents collected from government and international organizations. These documents are processed using Natural Language Processing (NLP) to extract legal rules and compliance requirements. The environmental dataset consists of IoT sensor measurements such as temperature, humidity, air quality, water quality, methane emissions, and waste management indicators. The animal welfare dataset includes images and videos captured from CCTV cameras, drones, and wearable sensors to monitor animal behaviour, housing conditions as described in table 1, feeding activities, and health status. In addition, veterinary records and

farm management data provide information on disease history, vaccination, feeding practices, and farm operations.

Table 1. Dataset Description

Dataset Category	Data Source	Sample Features
Regulatory Documents	Government laws and policies	Compliance rules, legal obligations
Environmental Data	IoT sensors	Temperature, humidity, air and water quality
Animal Welfare Data	CCTV, drones, wearable sensors	Behaviour, posture, housing conditions
Veterinary Records	Veterinary database	Disease history, vaccination
Farm Management Data	Farm information system	Feed management, waste disposal

Before model implementation, the collected data are preprocessed through data cleaning, normalization, missing value handling, and feature extraction. The processed dataset is divided into 70% training, 15% validation, and 15% testing sets for model development and performance evaluation.

Table 2. Dataset Partitioning

Dataset	Percentage
Training	70%
Validation	15%
Testing	15%

This dataset design provides comprehensive information for implementing the proposed AI-assisted regulatory compliance framework by integrating legal intelligence as described in table 2, environmental monitoring, animal welfare assessment, and operational management into a unified AI-driven compliance system.

VI. Framework Validation and Use Case Demonstration

The proposed AI-Assisted Regulatory Compliance Framework is validated through representative use-case scenarios to demonstrate its capability in monitoring compliance with animal welfare and environmental protection laws. The validation focuses on assessing the framework's ability to automatically interpret regulatory requirements, analyze real-time operational data, detect potential violations, and generate explainable recommendations for corrective action. Rather than replacing conventional inspections, the framework is designed to support regulatory authorities and farm managers by providing continuous, intelligent compliance monitoring. A livestock farm is considered as the primary use case for framework validation. The system continuously acquires data from multiple sources, including environmental sensors, surveillance cameras, wearable animal monitoring devices, veterinary records, and farm management systems as described in table 3. Simultaneously, the regulatory knowledge base stores legal provisions related to animal housing, feeding practices, sanitation, waste management, air quality, water quality, and environmental emission limits. Natural Language Processing automatically extracts regulatory obligations from legal documents and converts them into machine-readable compliance rules.

Table 3. Use Case Scenarios for Framework Validation

Use Case	Input Data	AI Module Used	Compliance Objective	Expected Output
Animal Welfare Monitoring	CCTV images, wearable sensors	Computer Vision, Deep Learning	Assess housing, behaviour, injuries, overcrowding	Welfare compliance status
Environmental Monitoring	IoT sensor data	Machine Learning	Monitor air quality, water quality, waste, emissions	Environmental compliance status
Legal Compliance Assessment	Regulatory documents	Natural Language Processing	Extract legal obligations and inspection rules	Compliance rule database
Risk Prediction	Historical and real-time operational data	Machine Learning	Predict potential regulatory violations	Risk score and early warning
Decision Support	Integrated compliance results	Explainable AI (XAI)	Recommend corrective actions	Explainable compliance report

The collected operational data are processed by the AI-based compliance engine to compare observed conditions with the corresponding regulatory requirements. Computer Vision models analyze images and video streams to evaluate animal behaviour, stocking density, cleanliness, housing conditions, and visible signs of injury or distress. Machine Learning algorithms assess environmental parameters such as temperature, humidity, water quality, waste accumulation, and greenhouse gas emissions to identify potential environmental violations. Whenever deviations from regulatory thresholds are detected, the framework classifies the severity of the violation and estimates the associated compliance risk. The Explainable Artificial Intelligence (XAI) module enhances transparency by providing detailed explanations for every compliance decision. For each detected violation, the framework identifies the applicable regulation, highlights the supporting evidence, assigns a confidence score, and recommends appropriate corrective actions. These explanations enable inspectors, veterinarians, and farm managers to understand the reasoning behind AI-generated decisions and facilitate timely interventions.

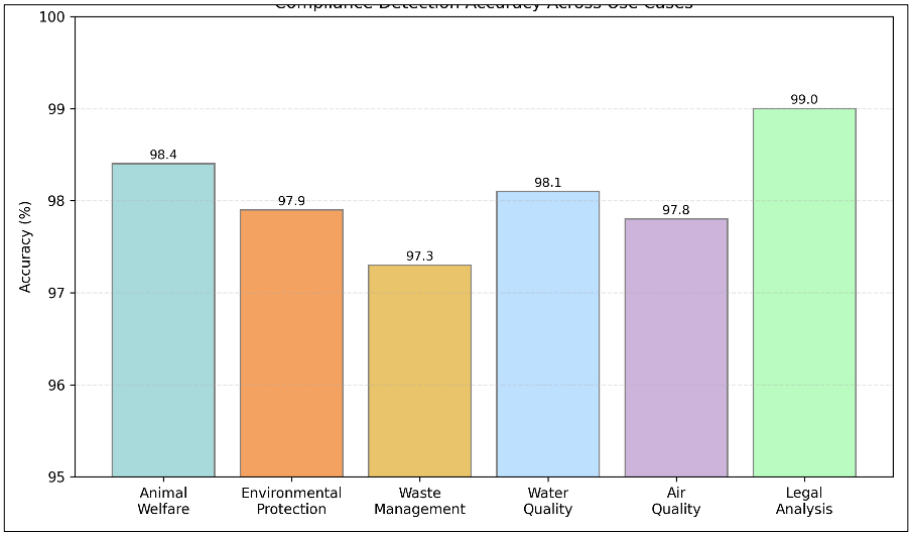

Figure 3. Compliance Detection Accuracy Across Different Regulatory Use Cases

The proposed AI-assisted regulatory compliance framework was evaluated across multiple regulatory use cases, including animal welfare monitoring, environmental protection, waste management, water quality assessment, air quality monitoring, and legal document analysis. As illustrated in Figure 3, the framework consistently achieved high compliance detection accuracy, with values exceeding 97% across all scenarios. The highest accuracy was observed for regulatory document analysis (99.0%),

demonstrating the effectiveness of Natural Language Processing in interpreting legal requirements. Similarly, high performance in animal welfare and environmental monitoring validates the capability of the framework to integrate multimodal data for reliable compliance assessment. These results indicate that the proposed framework can accurately support regulatory decision-making across diverse operational environments.

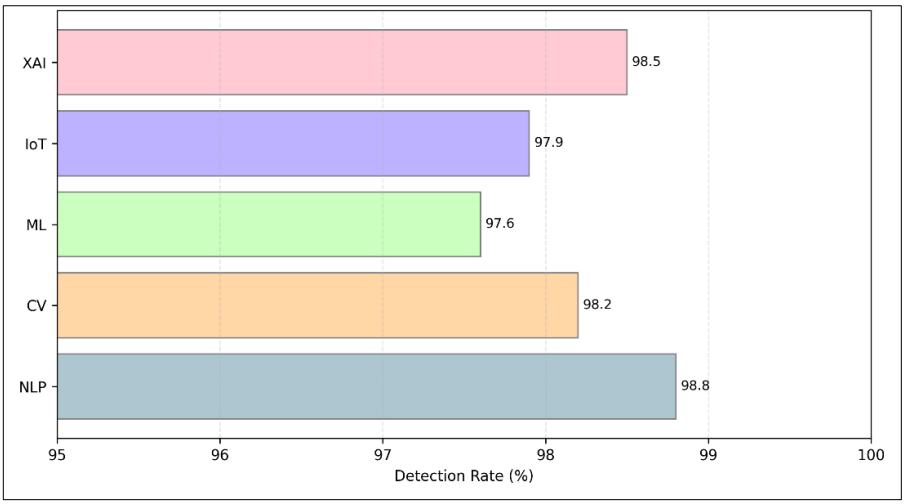

Figure 4. Regulatory Violation Detection Performance of AI Modules

Figure 4 presents the regulatory violation detection performance of the major AI components integrated within the proposed framework. Natural Language Processing achieved the highest detection rate by accurately extracting legal obligations from regulatory documents, while Explainable AI effectively provided transparent compliance decisions. Computer Vision and IoT analytics demonstrated excellent capability in identifying welfare-related issues and environmental violations from real-time monitoring data. The consistently high detection rates across all AI modules confirm that the integration of multiple intelligent techniques significantly enhances the reliability and robustness of automated regulatory compliance assessment.

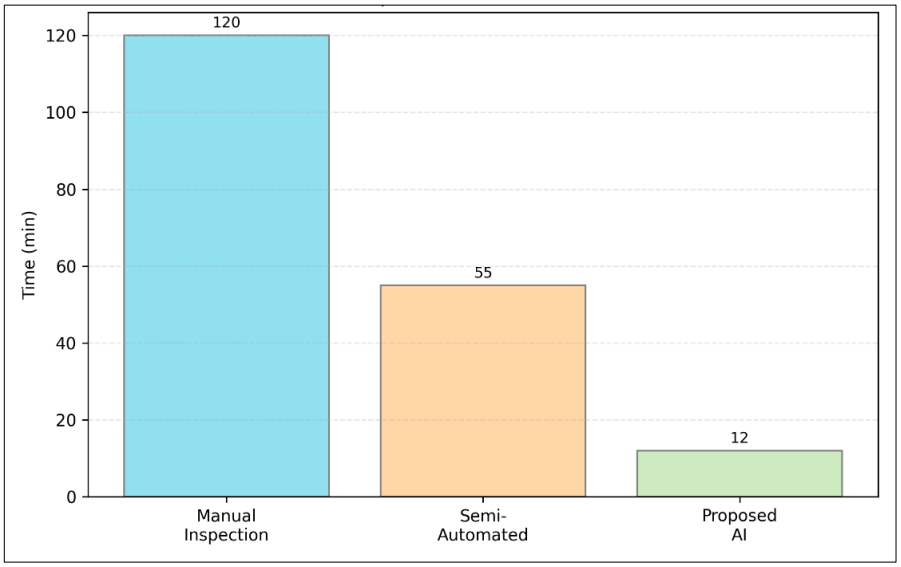

Figure 5. Comparison of Compliance Assessment Time

Figure 5 compares the compliance assessment time required by conventional manual inspection, semi-automated approaches, and the proposed AI-assisted framework. Manual inspection requires the longest assessment time due to extensive human intervention and document verification. Semi-automated systems reduce the evaluation time through partial automation; however, manual validation is still necessary. In contrast, the proposed framework performs compliance assessment within a significantly shorter time by integrating automated legal analysis, real-time sensor monitoring, and AI-

based decision-making. This substantial reduction in assessment time demonstrates the operational efficiency of the proposed framework and its suitability for continuous real-time regulatory compliance monitoring. The effectiveness of the proposed framework is evaluated using standard performance metrics, including Accuracy, Precision, Recall, F1-Score, AUC-ROC, Violation Detection Rate, False Alarm Rate, and Compliance Assessment Time. Successful validation demonstrates that the proposed framework can efficiently integrate legal intelligence with multimodal operational data to provide accurate, transparent, and scalable compliance assessment. The use-case results illustrate the practical applicability of the framework in improving regulatory enforcement, promoting animal welfare, minimizing environmental risks, and supporting sustainable livestock management.

VII. Conclusion

This study proposed an AI-Assisted Regulatory Compliance Framework for Animal Welfare and Environmental Protection Laws that integrates Artificial Intelligence (AI), Internet of Things (IoT), Computer Vision (CV), Natural Language Processing (NLP), Machine Learning (ML), and Explainable Artificial Intelligence (XAI) to support intelligent regulatory compliance. The framework automates the interpretation of legal requirements, continuously monitors operational activities, detects potential regulatory violations, and recommends corrective actions. By combining regulatory knowledge with real-time data collected from environmental sensors, surveillance systems, wearable animal devices, veterinary records, and farm management platforms, the proposed approach enables comprehensive compliance assessment for both animal welfare and environmental protection regulations. Compared with conventional compliance methods that rely on manual inspections and periodic audits, the proposed framework provides continuous, data-driven, and evidence-based monitoring. The integration of Explainable AI enhances transparency by generating interpretable compliance decisions, thereby improving stakeholder confidence and supporting regulatory accountability. The modular architecture also allows adaptation across livestock farming, wildlife conservation, research facilities, and other environmental management applications. The proposed framework has the potential to improve compliance accuracy, reduce monitoring time, support early detection of regulatory risks, and facilitate proactive decision-making. Consequently, organizations can strengthen animal welfare practices, minimize environmental impacts, reduce legal risks, and enhance overall operational sustainability.

Future research should validate the framework using large-scale real-world datasets and investigate advanced technologies such as federated learning for privacy-preserving compliance assessment, blockchain for secure regulatory record management, and adaptive AI models capable of responding automatically to evolving legislation. These developments will further strengthen intelligent regulatory governance and promote sustainable animal welfare and environmental protection.

References

[1] Ouchchy, L., Coin, A., and Dubljević, V., "AI in the Headlines: The Portrayal of the Ethical Issues of Artificial Intelligence in the Media," *AI & Society*, vol. 35, pp. 927–936, 2020.

[2] Wang, X., Wu, Q., Zeng, H., Yang, X., Yang, X., Yi, X., Khalil, I., and Que, Y., "Digital Evolution and Twin Miracle of Sugarcane Breeding," *Field Crops Research*, vol. 318, Art. no. 109588, 2024.

[3] Siegford, J. M., Steibel, J. P., Han, J., Benjamin, M., Brown-Brandl, T., Dórea, J. R., Morris, D., Norton, T., Psota, E., and Rosa, G. J., "The Quest to Develop Automated Systems for Monitoring Animal Behavior," *Applied Animal Behaviour Science*, vol. 265, Art. no. 106000, 2023.

[4] O'Grady, M., Langton, D., and O'Hare, G., "Edge Computing: A Tractable Model for Smart Agriculture?" *Artificial Intelligence in Agriculture*, vol. 3, pp. 42–51, 2019.

[5] Arshad, M. F., Ahmed, F., Nonnis, F., Tamponi, C., Scala, A., and Varcasia, A., "Artificial Intelligence and Companion Animals: Perspectives on Digital Healthcare for Dogs, Cats, and Pet Ownership," *Research in Veterinary Science*, vol. 193, Art. no. 105776, 2025.

[6] Janke, N., Jason, B. C., Bernardo, T. M., Dewey, C. E., and Stone, E. A., "Pet Owners' and Veterinarians' Perceptions of Information Exchange and Clinical Decision-Making in Companion Animal Practice," *PLoS ONE*, vol. 16, no. 2, Art. no. e0245632, 2021.

[7] Appleby, R. B. and Basran, P. S., "Artificial Intelligence in Veterinary Medicine," *Journal of the American Veterinary Medical Association*, vol. 260, no. 8, pp. 819–842, 2022.

[8] Chessa, S., Dimitri, G. M., Gori, M., and Kocian, A., "WoA: An Infrastructural, Web-Based Approach to Digital Agriculture," in *Proc. 14th Int. Symp. Ambient Intelligence (ISAmI)*, Guimarães, Portugal, Jul. 2023, pp. 113–122.

[9] Fergus, P., Chalmers, C., Longmore, S., Wich, S., Warmenhove, C., Swart, J.,

Ngongwane, T., Burger, A., Ledgard, J., and Meijaard, E., "Empowering Wildlife Guardians: An Equitable Digital Stewardship and Reward System for Biodiversity Conservation Using Deep Learning and 3/4G Camera Traps," *Remote Sensing*, vol. 15, Art. no. 2730, 2023.

[10] Chalmers, C., Fergus, P., Wich, S., Longmore, S. N., Walsh, N. D., Stephens, P. A., Sutherland, C., Matthews, N., Mudde, J., and Nuseibeh, A., "Removing Human Bottlenecks in Bird Classification Using Camera Trap Images and Deep Learning," *Remote Sensing*, vol. 15, Art. no. 2638, 2023.

[11] Wang, X., Wu, Q., Zeng, H., Yang, X., Cui, H., Yi, X., Piran, M. J., Luo, M., and Que, Y., "Blockchain-Empowered H-CPS Architecture for Smart Agriculture," *Advanced Science*, vol. 12, Art. no. e2503102, 2025.

[12] Palomares, I., Martínez-Cámara, E., Montes, R., García-Moral, P., Chiachio, M., Chiachio, J., Alonso, S., Melero, F. J., Molina, D., Fernández, B., *et al*., "A Panoramic View and SWOT Analysis of Artificial Intelligence for Achieving the Sustainable Development Goals by 2030: Progress and Prospects," *Applied Intelligence*, vol. 51, pp. 6497–6527, 2021.

[13] Tani, M., Muto, V., Basile, G., and Nevi, G., "A Bibliometric Analysis to Study the Evolution of Artificial Intelligence in Business Ethics," *Business Ethics, the Environment & Responsibility*, pp. 1–23, 2025.

[14] Sharma, D., "Role of AI Innovations Towards Service Marketing," in *Innovative Educational Frameworks for Future Skills and Competencies*, 1st ed., T. Aldosemani and D. Lytras, Eds. New York, NY, USA: IGI Global Scientific Publishing, 2025, pp. 383–414.

[15] Humayun, M., Tariq, N., Alfayad, M., Zakwan, M., Alwakid, G., and Assiri, M., "Securing the Internet of Things in Artificial Intelligence Era: A Comprehensive Survey," *IEEE Access*, vol. 12, pp. 25469–25490, 2024.