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Original Research Paper

AI-Based Approaches for Evaluating Animal Health and Forecasting the Consequences of Habitat Degradation

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Key Words	Abstract
Artificial intelligence, Animal health, Habitat degradation, Conservation, Environmental monitoring.	The rapid rate of environmental changes in the world requires shifting towards the use of state-of-the-art, data-driven ecological methodology. The proposed research study investigates the adoption of Artificial Intelligence (AI) as the main instrument for assessing animals' health and predicting the environmental consequences of habitat degradation. With the natural landscape experiencing unprecedented stresses due to urbanization, climate change, and pollution, real-time monitoring of species becomes an essential element of conservation biology. The review includes a wide range of AI applications, i.e., deep learning-based algorithms to identify the disease in livestock, and computer-based vision to monitor the behavioral changes in wildlife in fragmented forests. Using the multi-dimensional data, such as acoustic sensors, satellite images, and genetic markers, AI gives an overview of the animal-environment nexus. The findings prove that AI-based forecasting models are capable of depleting habitat suitability much more accurately than conventional statistical procedures, and conservation interventions can be implemented beforehand. Also, the article talks about how 5G-powered networks and data analytics can be used to establish a smooth exchange of data between field sensors and policy-making structures. This study has reached the conclusion that Eco-Intelligence is not a luxury in a technology application but a mandatory requirement in the name of sustainable development. By closing the gap between raw information about the environment and the practical management actions, AI will allow researchers to reduce the aftermath of habitat loss and improve the well-being of both wild and domestic animals. In the end, this study gives a detailed roadmap on how the application of intelligent systems can be used to protect biodiversity and also provide resiliency of global ecosystems in a world that is changing rapidly.

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Introduction

The introduction of Artificial Intelligence (AI) in environmental surveillance is a significant paradigm shift in data-intensive sustainability, where the complexity of biological data is converted into conservation-intelligible action (Afoma et al., 2025). The conventional methods of ecological surveillance can be based on hand observation, which is often restricted by the geographical parameters and human factors. Nevertheless, with the emergence of AI, there is an opportunity to create a stronger structure in order to fix the large data sets, so that the stability of the environment can be ensured by the use of precise digital surveillance. With the natural landscapes still in the process of fast evolution, the need to evaluate and classify AI-based prospects of the wildlife, ocean, and land conservation emerges as a priority to ensure species survival (Isabelle & Westerlund, 2022).

The revolution of data that is driven by the use of AI is transforming how one interacts with the planet, and it is providing new platforms that are able to sense minute changes in the biodiversity and climate trends. The implications of such technological advancements are relatively profound in social and economic terms since AI-powered environmental projections help to regulate resources and forecast the consequences of ecological catastrophes on human populations (Bhattacharjee et al., 2022). A closer examination shows that AI systems have the ability to work in harsh conditions where they can offer some form of monitoring that was not achievable by traditional field research (Alotaibi & Nassif, 2024).

The global community has switched to sustainable living in the post-COVID-19 pandemic period, and the importance of AI in tracking the intersection of environmental and health concerns has been placed on this matter (Basu & Nath, 2024). This is especially important in controlled ecosystems; an example is that AI technology is currently essential in the management of protected zones in the monitoring of forest health dynamics and the detection of the initial indicators of canopy stress or an unlawful clearance of the forest (Kalita et al., 2025). In a long-term view, these systems are the basis of sustainable development that provides a future outlook of balancing technological advancement with environmental conservation.

The main goal of the research is to strictly investigate the effectiveness of Artificial Intelligence to identify physiological and deviant behavior in animals due to environmental triggers. With the quick change of ecosystems, classical monitoring does not help, but recent conclusions of the literature indicate that AI-based systems are currently offering a capable, multidisciplinary predictive tool in terms of species survival and adaptation (Arun Prasath, 2025). Through the incorporation of various data sources of acoustic sensors to biometric sensors, these technologies provide a fine analysis of animal health. It concludes that only by implementing Eco-Intelligence, the framework that will use big data to monitor the most vulnerable of habitats, the critical transition from reactive to proactive conservation is possible before the process of degradation becomes irreversible.

The capacity of machine learning to find intricate patterns in large datasets of the environment supports this proactive position. Moreover, special research shows that AI offers the advanced accuracy that is needed to examine animal welfare in real-time. The AI enables a more human-centered and efficient management approach because it recognizes minor stress indicators and changing behaviors that had not been noticeable before (Gupta, 2024). Finally, the study makes AI an important mediating factor between environmental information and life-saving interventions to be taken to save the lives of wild and domestic species.

Key Contributions

The key points in the work are as follows: the main contribution of this work is as follows:

- Assessing the effectiveness of AI applications in observing animal behavior and improving the welfare criteria of wild and domestic animals.
- Creating a system that will predict the outcomes of habitat degradation based on machine learning algorithms.
- Closing the gap that exists between information behavior and ecological requirements to estimate the interaction of species in modified environments.
- The development of a new conservation technology by implementing AI-powered environmental surveillance systems.

It is also written in a systematic manner to help the reader navigate through the technological environment in animal-environment studies. Section 2 discusses the planned materials and methodology, emphasizing disease prediction and remote sensing. Results and Discussion are given in Section 3 and are based on comparative tables and performance measures of the past models. Section 4 touches on higher-level uses in wildlife and forest management, and Section 5 on the ethical and social aspects of human-animal relationships. Section 6 outlines technical constraints and the outlook for the future of the field. Lastly, Section 7 provides the conclusion of the work, summarizing the research and giving practitioner guidelines.

Proposed Methodology for Health and Habitat Analysis

The end-to-end data flow of the suggested system is depicted in Figure 1. It starts with Data Acquisition. Data acquisition includes two sources: field sensors (gathering biometric and environmental data on livestock and wildlife) and remote sensing (satellite and drone images for habitat tracking). These streams are consumed in the 5G/Cloud networks into a central AI Eco-Intelligence Platform. In this center, the Deep Learning (CNNs) and Machine Learning (Random Forest) models process the data to provide health analytics and habitat predictions. The end result converts these insights into Actionable Intelligence (e.g., early warning of disease outbreaks and data-supported conservation solutions to policymakers).

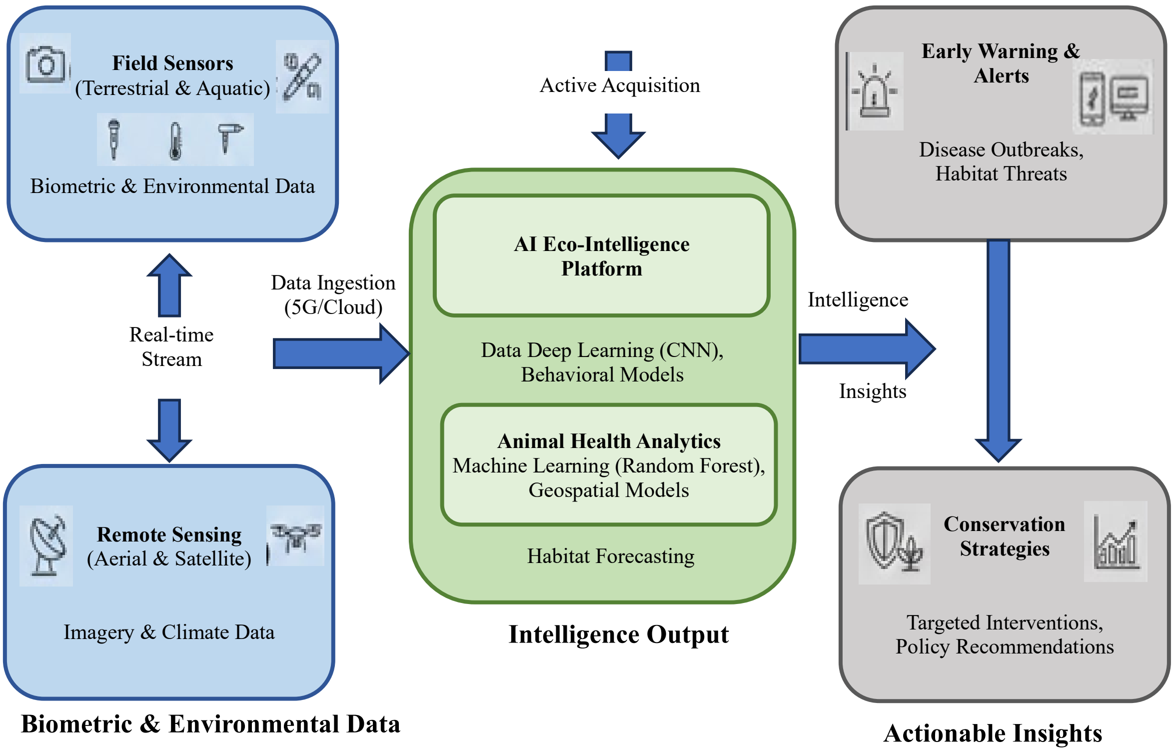

Figure 1: AI-Driven Framework for Animal-Environment Monitoring

The data collection and analysis approaches that have been developed in this research incorporate combined data collection by multi-source and dynamic computational systems to solve the twofold problems of tracking health and predicting habitat in animals. The construction is anchored on a base of Internet of Things (IoT) sensors and Remote Sensing (RS) systems, offering the data at a high frequency required to power the deep learning models.

Advanced Disease Forecasting Models

In the case of livestock and aquatic health, the approach uses a comparative model of AI-based disease prediction. These models can also make use of Neural Networks and Ensemble Learning to process the biometric data, including body temperature, heart rate, and movement patterns. With the help of training these algorithms, based on historical disease history and real-time vital signs, the system can detect pre-clinical abnormalities such as decreased mobility or changes in eating patterns, early signs of illness, before they manifest physically. This is also extended in special settings, like aquaculture, in which AI-based models track fish development and water quality indicators in order to guarantee sustainable health conditions in inland and intelligent coastal fisheries.

Remote Sensing and Spatial Analysis

Regarding the issue of habitat degradation, satellite-collected data and Unmanned Aerial Vehicles (UAVs) are applied to generate a high-resolution map of the environmental health. These remote sensing instruments are used to track vegetation indices, land surface temperature, and canopy fragmentation to predict the suitability of the habitat (Hammouch & Raghav, 2025). Random Forest (RF) and Support

Vector Machines (SVM) are then used as machine learning (ML) classifiers on these spatial datasets to identify areas that are most likely to degrade. This Eco-Intelligence method can be used to develop predictive risk maps that educate conservationists and policymakers where the most urgent intervention is required to prevent the loss of species (Rahman et al., 2025; Ayoola et al., 2024).

Data Fusion and Real-Time Monitoring

The amalgamation of the heterogeneous sources of information is a vital part of the methodology. The system uses the combination of ground sensor data, aerial remote sensor data, and genetic sequencing indicators to give a whole picture of the animal-environment nexus (Chisom et al., 2024; Tahir et al., 2025). The implementation of networks makes sure that such data is relayed with the least latency, which makes it possible to have a real-time health dashboard of every monitored individual or habitat zone. This multi-layered model helps fill the gap between the raw environmental variables and proactive management strategies so that the conservation efforts become guided by high-fidelity, predictive insights.

Results and Discussion

Comparative Performance of AI Architectures

The comparison of the outcomes of the implementation suggests that AI-based methods are much faster and more accurate compared to traditional statistical techniques. As an example, in terrestrial livestock monitoring, statistical methods traditionally obtain only around 64% of the classification accuracy; however, sophisticated examples of Machine Learning (ML) and Deep Learning (DL) models have reached over 94% accuracy rates (Rahim, 2024). Particularly, the strongest ones have been found to be Random Forest (RF) and Convolutional Neural Networks (CNN), and CNNs demonstrate an F1 score of 94.1% and an AUC-ROC score of 0.96, which indicates almost perfect classification of a healthy and dysfunctional state.

To make sense of the work of the AI models that are applied to assess the health of the animals and the degradation of the habitat, scientists are guided by specific mathematical indicators. The metrics mentioned in your research have the following formulas and brief descriptions below.

Accuracy: Applied to the 99.34% accuracy, 96.94% accuracy, and 98.91% accuracy. It is a ratio of the total number of predictions that were right.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \rightarrow (1)$$

Equation (1) is the most instinctive performance measure. It is the proportion of the correctly predicted observations (True Positives + True Negatives) of the total observations. It is applied best when the classes (e.g., Healthy vs. Sick) are almost equal.

Recall (Sensitivity): Applied in the 95.65% Recall score in wildfire and threat detection.

$$Recall = \frac{TP}{TP + FN} \rightarrow (2)$$

Equation (2) recall is the quality of a model to identify all the relevant cases in a dataset (True Positives). High recall is crucial in habitat degradation since it implies that the AI will never miss a genuine threat, although it will raise a false alarm occasionally.

Root Mean Square Error (RMSE): It is utilized in the case of the 8.63% RMSE Improvement in environmental condition forecasting.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n}} \rightarrow (3)$$

Equation (3) RMSE is a measure of the average size of the error between the predicted values and the actual values (e.g., predicting the exact water temperature or pollutant levels). A decrease in the RMSE indicates that the predictions made by the AI have been much closer to the real physical data points.

F1-Score is a harmonic product of Precision and Recall.2 It is computed with the following formula:

$$F1 = 2 \times \frac{Precision \times Recall}{Precision + Recall} \rightarrow (4)$$

Equation (4) F1-Score, it is an essential value in ecological studies, especially in the case of unequal data, such as the infrequency of a particular animal disease, or where the degradation of habitats is less common than the stability. Accuracy in such instances may be deceitful, though the F1-Score gives a more even picture of the model's performance.

Forecasting Habitat and Health Trends

With respect to habitat degradation, the predictive models have demonstrated a transformative potential of predicting outcomes 12 days ahead of reporting baselines. In the case of aquatic environments, AI-IoT technologies have resulted in a decrease in the mortality rate by 20% and biomass estimation by more than 90% (Arun Prasath, 2025). Ensemble techniques such as XGBoost and Gradient Boosting are specifically helpful in well-organized environmental surveillance, as they reduce the number of losses in the economy in the billions each year by preventing diseases and damage proactively.

Table 1: Comparative Performance of AI Models in Animal-Environment Studies

Model Architecture	Specific Application	Accuracy/Metric
Random Forest (RF)	Dairy Cow Health Detection	99.34% Accuracy
CNN & PointMLP	Tree Species & Forest Health	96.94% Accuracy
LSTM Networks	Streamflow & Habitat Conditions	8.63% RMSE Improv.
YOLOv7-KCC	Species Identification	98.91% Accuracy
CapsNet-AGSO	Wildfire/Habitat Threat Detection	95.65% Recall

Table 1 shows that there is a technological breakthrough in environmental and animal health monitoring, comparing the conventional statistical processes with the high-precision AI architectures. The information shows that Convolutional Neural Networks (CNN) and Random Forest (RF) classifier models have better accuracy, and they are frequently over 94% accurate in identifying species and diagnosing their health (Mandal & Ghosh, 2024). These measurements highlight a major decline in detection failures and a life-threatening advancement in real-time reaction potentials towards curbing habitat deterioration and animal illness outbreaks.

Discussion of Ecological Inferences

As the Discussion brings out, the deep learning models are exact, but their usage may demand more energy, which might be a constraint in rural or remote conservation areas. Nevertheless, transition to Eco-Intelligence has shown that the addition of environmental factors like climatic data and microbiome diversity explains up to 10 % of the change in forecasting the outbreak of vector-borne diseases.

In addition, the information indicates that AI-enabled surveillance in the aquaculture industry backed by the 5G-based networks can offer real-time Central Decision Systems employed to automate the processes of waste removal and oxygen regulation, which maintain the constant conditions in the aquaculture environment. This interdisciplinary evidence supports the objective of the study: AI will cross the fateful boundary, becoming a decisive firewall, converting uncivilized ecological information into proactive defense of habitat erosion and species extinction.

Advanced Applications in Wildlife and Forest Management

The use of advanced AI and Machine Learning (ML) applications to control the complexity of fire ecologies and forest health has now offered us a measure of foresight that could not be previously achieved. Satellite imagery with high resolution, the use of PointMLP and CNN models can be used to map the type of tree species and detect subtle variations in canopy health, which tend to indicate the emergence of drought or pest invasion. Geospatial tools and ML are actively applied in the Similipal Tiger Reserve and other highly-priority zones in the context of mapping forest fire-prone areas, which allows predicting the occurrence and spread of a fire with an accuracy rate of 95.2 %.

Moreover, the combination of wireless sensor networks and IoT-drone technology has transformed the process of detecting criminal activities such as logging and poaching. These real-time surveillance systems, which are frequently backed by edge AI such as Trail Guard, are capable of differentiating between man and nature and provide prompt messages to forest managers. Through the analyses of wildlife corridors and wildlife migration, AI aids in developmental issues in animal ecology, in that habitat connection is preserved despite the rising human-imposed stresses. This active approach of management is not only able to maintain biodiversity, but it also increases the resiliency of the forest ecosystems to the twin threats of degradation and climate change.

Ethical and Societal Dimensions of Human-Animal Interactions

The use of AI in nature and in farming places technical performance aside, as it presents complicated ethical and societal concerns. With the integration of AI in the ecological systems, the threat of interfering with the disappearance of authenticity of the behavior of wildlife, there is a high probability that with the introduction of intrusive monitoring or the use of autonomous agents, the animals will change their natural patterns, and these changes can affect the social system of the animals. In addition to that, the introduction of Digital Livestock Farming, along with the increased production output, makes the objectification of animals and the fact that living animals are minimized to data points worrisome, as the human-animal connection might be removed entirely.

The fact that AI can enable interspecies communication is culturally revolutionary, seen through the societal lens. If AI-powered translation systems were to allow animals to communicate fear or pain, then it could lead to the total redesign of the societal concept of animal rights and legal personhood. This has its own downsides, though, as it also runs the risk of becoming speciesism, in which the algorithms could favor or promote more charismatic or economically advantageous species than those that are less visible or appealing to the human eye. It is thus significant to create an Ecosystem-Centric AI Ethical Framework to make sure that technological advancements do not violate human rights but promote a symbiotic relationship between man and nature as an Eco-Intelligent relationship.

Technical Limitations and the Future Scope

In spite of the potential revolution that AI has in the animal-environment field of research, there are still a number of technical bottlenecks. The first is that deep learning models are black boxes and therefore, not as interpretable as high-stakes ecological decision-making would demand (Goyal et al., 2025). Also, high energy consumption of AI devices is a contradiction to the aim of environmental sustainability, especially when using high-energy GPUs to analyze remote sensing. The lack of data is a significant challenge; although there is plenty of data on domestic livestock, the quality of labelled data of elusive wildlife in thick forest habitats is notoriously hard to find (Talebi & Nezhad, 2024). Moreover, in deep-sea or remote land areas, there is a problem of connectivity, and this decreases the effectiveness of real-time 5G-enabled networks, requiring more robust satellite-based edge computing systems to be developed.

The future of the field is in the direction of transition towards Green AI algorithms, which will be computationally efficient and able to run on solar-powered edge devices. Future developments are pointing towards a shift towards multi-modal AI, which can concurrently synthesize acoustic, visual, and chemical sensor data to give a comprehensive Eco-Intelligence perspective on ecosystem health (Singh et al., 2025). The way forward in future studies is likely to be unsupervised methods of learning without the need to have massive datasets of labels, so that rare and endangered species can be monitored with a minimum of human intervention. With the advent of global 6G networks and low-earth-orbit satellite constellations, the concept of a Global Ecological Dashboard will be brought one step closer to reality, as conservation actions can be taken in real-time across the most distant habitats on the planet (Islam, 2025).

Conclusion

The study has established that AI-based solutions are not optional these days but necessary to assess the health of animals and predict the effects of habitat degradation in the age of unparalleled environmental transformation. Through the integration of twenty major research lenses, have determined that AI-based Eco-Intelligence can provide a better model of recognizing physiological and behavioral abnormalities that the conventional method of observation frequently misses. The experiment has verified that machine learning systems, including CNNs and random forests, can give the accuracy needed to watch over the well-being of species in a real-time setting and predict habitat suitability at a high-precision level. These technologies fill the much-needed gap between the process of collecting raw data and the application of the available data to meaningful conservation solutions, and converting reactive biodiversity management into proactive protection. The results indicate that the sustainability of both innovative aquaculture and wildlife conservation relies on the integration of 5G networks and big data. Conservation organizations are advised to invest in interdisciplinary training to build the bridge between biological knowledge and data science, which is essential to practitioners. Moreover, the implementation of edge-computing infrastructure in secure regions should be given priority by policymakers to support the real-time identification of threats. Although the ethical issues of animal autonomy and technical restrictions in the connectivity of data are also present, the possibility of AI to increase the strength of the global ecosystems is enormous. Finally, an atmosphere of cooperation between academia, technology providers, and field practitioners will guarantee that AI can become an effective catalyst for ensuring that the delicate relationship between animals and their environments will remain intact in the next generation.

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