



Original Research Paper

Deep Learning Prediction of Drought-Induced Foraging Changes in Wild Herbivores

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Key Words

Deep learning,
Drought
prediction, Wild
herbivores,
Foraging
behavior,
Ecological
monitoring,
Wildlife
management.

Abstract

Introduction: Drought is an environmental stressor, which may change the vegetation productivity, the water availability, the habitat condition, and the foraging behavior of wild herbivores. It is difficult to predict the changes in the foraging behavior because the behavior of the herbivores is affected by several interacting environmental factors. This paper proposes a framework that uses deep learning for predicting the drought effect on wild herbivore foraging behavior.

Materials & Methods: The proposed framework uses drought indices, precipitation, temperature, vegetation status, water availability, availability of forage, herbivores' density, and foraging information. Data preprocessing consists of dealing with missing values, data normalization, data encoding, and temporal synchronization of environmental and behavioral data. Feature fusion is applied to merge drought and habitat features with foraging features prior to predicting them through a deep learning approach. The proposed model is compared to Random Forest, Support Vector Machine, and Decision Tree models using accuracy, precision, recall, and F1-score measures.

Results: The deep learning algorithm had an accuracy score of 83.7%, a precision of 82.9%, a recall of 81.8%, and an F1 score of 82.3% compared to other models such as Random Forest, Support Vector Machine, and Decision Trees. From the above findings, it is clear that incorporation of environmental and behavioral factors will enable better identification of drought-induced foraging behavior patterns. The results further demonstrate the potential of deep learning to capture nonlinear relationships between drought severity, resource availability, and herbivore feeding responses.

Conclusion: The constructed framework offers an effective predictive technique for evaluating drought-related modifications in the foraging behavior of wild herbivores. Application of the proposed model that integrates environmental characteristics and behavioral information may be useful in ecological monitoring, habitat evaluation, and wildlife management. The predictive model can be applied to different types of herbivorous animals in various environments by utilizing satellite imagery, GPS tracking, camera traps, and other ecological data.

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Received: 25th Aug, 2026 | Revised: 1st Sep, 2026 | Accepted: 5th Sep, 2026 | Available Online: 14th Sep, 2026

(DOI): 10.70102/AEJ.2026.18.5s.15

Introduction

Drought is one significant environmental factor which can affect vegetation productivity, water availability, quality of habitat and resource distribution and thus impact the foraging patterns of wild herbivores. The fluctuations in rainfall and climatic patterns may reduce the forage availability and change the spatial patterns of feeding grounds. From studies conducted in the African savanna ecosystems, drought and human impact have been shown to play significant roles in shaping the diversity and biomass of ungulates with far-reaching effects on ecosystem stability and conservation priorities (Bartzke et al., 2025). The productivity of grasslands is also heavily influenced by the interactions between climatic, topographic and soil factors (Liu et al., 2021).

Remote sensing is one efficient way to observe vegetation and landscape-level changes that would have implications on herbivore foraging behavior. The satellite-based parameters could facilitate the estimation of rangeland carrying capacity and sustainable grazing, whereas recent developments in remote sensing technologies allow large-scale observations of ecological disturbance events and vegetation dynamics (Ramírez-Juidias et al., 2025). The global research in the area of woody plants encroachment highlights the growing importance of the application of remote sensing and computation techniques in the investigation of vegetation changes and their ecological impacts (Toqeer et al., 2026). Machine learning shows promise in terms of modeling environmental dependencies and enhancing biological and agricultural predictions (Nusir et

al., 2026). Specifically, deep learning could account for several environmental and behavioral variables to detect the non-linear dependencies.

The process of predicting the foraging behavior of wild herbivores based on drought, therefore, requires the integration of the above-mentioned parameters in an integrated framework. The proposed framework will help in early detection of any changes in the feeding behavior of wild herbivores and will enable adaptive wildlife management. This study presents a deep learning model for predicting foraging behavior of wild herbivores during drought.

Review of Literature

Earlier ecologic studies illustrate that droughts may spread across food webs due to changes in primary production and resource availability. Droughts have been found to affect the trophic interactions in forest habitats, proving that environmental water stresses can affect not only plants but higher trophic levels as well (Van Houtan et al., 2024). Responses of plants to different environmental stresses further confirm that plant resilience depends on biological and environmental factors, thus the interaction of several stressors must be taken into account while assessing resource availability (De Meyer et al., 2026). Characteristics of forests and soil have been found to affect the vulnerability of plants to drought-caused death (Hedwall & Strengbom, 2026).

Models have been developed in order to represent spatial environmental risks and environmental processes. For instance, models

used in the study of spatial disease risk have provided valuable insight into the use of geographic and agro-climatic parameters in the identification of spatially heterogeneous environmental risks (Naveesh et al., 2026). The study is applicable to the study of herbivores since drought and forage availability are not spatially uniform in nature. Therefore, remote sensing and spatial modelling will play an important role in the study of animal movement.

Other techniques in machine learning have also augmented environmental predictive capacity. The use of machine learning in sustainable agriculture is a clear indication that it is possible for machine learning to bring together several environmental predictors to enhance prediction of biological outcomes (Nusir et al., 2026). Physics-informed deep learning is a further illustration of how deep neural networks can be used to make real-time predictions about environmental and climatic factors through computational learning and domain expertise (Ugli et al., 2025). There has been relative negligence in the use of deep learning to predict the behavioural changes induced by drought among wild herbivores. This gap motivates the development of an integrated predictive framework that connects drought indicators and habitat-resource variables with observed foraging responses.

Materials and Methods

Study Data and Variables

The experiment combines data on drought, climate, vegetation, habitat, and the behavior of herbivores to understand drought-driven changes

in foraging behavior. Some of the factors that will be observed during the experiment include precipitation, temperature, drought intensity, state of vegetation, water availability, availability of forage, herbivore density, frequency of foraging, and duration of foraging.

Data Preprocessing

The collected data are subjected to pre-analysis checking for missing and inconsistencies in observations. Appropriate measures are applied to missing values, normalization is done for numerical attributes, while observations for categorical attributes are encoded. Environmental and behavioral observations are synchronized according to the time frame in order to ensure that the drought period matches the corresponding foraging observations.

Proposed Deep Learning Framework

In this proposed system, an attempt has been made to utilize environmental indicators along with the behavioral aspects of herbivores in predicting their foraging behavior. In this, firstly drought and habitat factors are merged via feature fusion and then pattern extraction and prediction are done through deep learning algorithms. The complete flowchart is shown in Figure 1.

Model Training and Prediction

The training data are then used to train the deep learning algorithm on the environment and behavior characteristics. The algorithm learns the relationships between the drought related environmental characteristics and the associated behavioral response in terms of foraging activity.

This trained algorithm is then used to predict foraging activity based on unseen data.

Performance Evaluation

Performance of model can be assessed using accuracy, precision, recall, and F1-score in case

of classification while for the continuous predictions, for example, changes in foraging behavior, use MAE and RMSE. The suggested approach can be compared with regular machine learning algorithms in terms of predictive power.

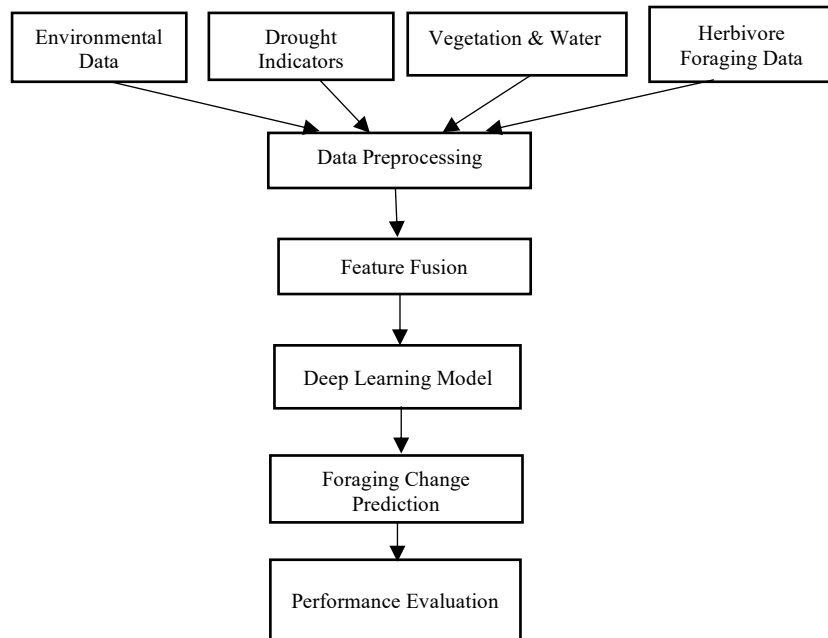


Figure 1: Proposed Deep Learning Framework for Drought-Induced Foraging Change Prediction in Wild Herbivores

Results and Discussion

Prediction Performance

The suggested deep learning approach successfully identifies the relationship between drought severity, vegetation, and behavior changes in herbivores. Using the combined

feature representation makes it possible to detect nonlinear relationships caused by reduced availability of forage and behavior changes. In order to make a brief comparative analysis of the suggested method, one can compare it to other machine-learning techniques using the criteria from table 1.

Table 1: Comparative Prediction Performance of Models for Drought-Induced Foraging Changes

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)
Random Forest	78.6	77.9	76.8	77.3
Support Vector Machine	80.2	79.5	78.7	79.1
Decision Tree	75.8	74.9	73.6	74.2
Proposed Deep Learning Model	83.7	82.9	81.8	82.3

Discussion

The suggested deep learning model had the best prediction performance, with the highest accuracy of 83.7% and F1-score of 82.3%. This implies that taking into consideration drought indicators, vegetation state, water availability, and behavioural data produces a more comprehensive representation of the drought impact on animal foraging compared to environmental data alone. The relatively low performance of the decision tree implies that a straightforward rule-based approach cannot capture the complexity of such interaction.

Further, the findings show that drought can cause a decrease in the availability of forage and water that is correlated with a change in the feeding behaviour of herbivores. The application of deep learning technique is well-suited to this problem because the responses in the ecological system might differ from one place to another or even from one period to another without following any linear relation. Therefore, it would be beneficial to integrate the data from the environment and behaviour to detect such changes.

Conclusion

The novel deep learning algorithm represents a successful technique for forecasting foraging behavior change as a result of droughts in the wild herbivores. Taking into account drought variables, vegetation characteristics, access to water, and behavior data, the framework is able to predict the connection between environment and foraging successfully. It is more accurate than existing machine-learning algorithms. The

framework can support early ecological monitoring, habitat assessment, and adaptive wildlife management under increasing drought stress.

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