“Impact of Climate Changes on Birds”

A Project Report submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING

Submitted by

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GITAM SCHOOL OF TECHNOLOGY
GITAM (Deemed to be University)
VISAKHAPATNAM
2024

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DECLARATION

I hereby declare that the project report entitled **Impact of Climate Changes on Birds** is an original work done in the Department of Computer Science and Engineering, GITAM School of Technology, GITAM (Deemed to be University) submitted in partial fulfillment of the requirements for the award of the degree of B.Tech. in Computer Science and Engineering/ Computer Science and Engineering (AI&ML/DS/CS/IoT). The work has not been submitted to any other college or University for the award of any degree or diploma.

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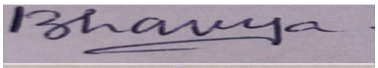
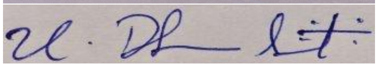
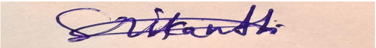
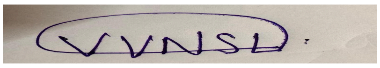
VU21CSEN0101035	**P Bhavya**	
VU21CSEN0100505	**U Dheeraj**	
VU21CSEN0100131	**Ch Srikanth**	
VU21CSEN0101271	**V Swetha**	
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CERTIFICATE

This is to certify that the project report entitled "**Impact of Climate Changes on Birds**" is a bonafide record of work carried out by **P Bhavya(VU21CSEN0101035)**, **U Dheeraj(VU21CSEN0100505), Ch Srikanth(VU21CSEN0100131), V Swetha(VU21CSEN0101271)** students submitted in partial fulfillment of requirement for the award of degree of Bachelors of Technology in Computer Science and Engineering / Computer Science and Engineering (AI&ML/DS/CS/IoT).

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1. Abstract

This project aims to study the impact of climate change on bird species distribution using Species Distribution Modeling (SDM). Leveraging machine learning algorithms such as MaxEnt and Logistic Regression, the project predicts future shifts in bird habitats under different climate scenarios (RCP 4.5 and RCP 8.5). By integrating data from GBIF, eBird, and climate models from WorldClim and CMIP5, we aim to provide visual maps and reports that guide conservation efforts, highlighting species and regions at risk.

keywords: Climate Change,Species Distribution,Predictive Analysis,Machine Learning.

2. Introduction

Climate change poses significant threats to biodiversity worldwide, particularly impacting species with specialized habitats, like birds. Rising global temperatures, changing precipitation patterns, and habitat degradation are causing bird species to shift their geographical range, often negatively affecting their breeding, feeding, and migration patterns. This project uses machine learning techniques to model and predict how bird species distribution will change under future climate conditions in India.

The primary objectives of this project are:

1. Predict Species Range Shifts: Forecast how bird species' habitats will shift in response to climate change.
2. Inform Conservation Strategies: Provide data-driven insights to prioritize conservation efforts.
3. Visualize Changes: Develop visual tools such as interactive maps to display habitat changes and generate reports for policymakers and conservationists.

3. Literature Review

A short review of previous papers published on the problem identified

Authors	Method	Advantages	Disadvantages
Janowiak et al., 2017[1]	Correlative Species Distribution Model (SDM)	This model is easy to use, and it only needs data on species presence and environmental information. It's effective for creating maps of where species can live, even if absence data is unavailable.	It focuses only on where species are found, missing potential new areas. It doesn't consider how species interact with each other, and using too many variables can make it less accurate when predicting new conditions
Parvathy VG, Dr. Manusankar C and Sumaja Sasidharan[2]	Machine Learning (ML): Bayesian analysis, Support Vector bioclimaticMachine (SVM), Random Forest, and Maximum Entropy (MaxEnt).	The advantages of using these models include their ability to analyze large datasets quickly and accurately, revealing patterns in bird behavior and predicting species distribution by considering multiple environmental factors. Models like Random Forest are particularly good at managing complex data interactions.	On the downside, these models need high-quality, extensive data to work well. If the data is limited or biased, predictions can be wrong. Additionally, the complexity of the algorithms can make them hard to understand, which may hinder practical applications in conservation efforts
Jens-Christian Svenning et al.[3]	Species Distribution Modeling (SDM).	Using SDM allows for quantitative predictions of past organism distributions and can testecological hypotheses, thus providing valuable insights into historical biogeography and community dynamics. This modeling can help understand the impact of historical climate changes and glacial refugia on species distributions.	On the downside, SDM relies heavily on assumptions such as niche stability and equilibrium postulates, which may not always hold true. Additionally, the choice of predictor variables and the validation of models can introduce uncertainties, potentially leading to inaccurate conclusions about past distributions and ecological patterns.
Hans-Christian Schaefer[4]	spatial analysis	The model combines community reassembly	Complexity: Combining

		and adaptation, using spatial analysis to predict localized climate impacts on migratory birds. It highlights adaptations in migratory behavior, offering a more comprehensive understanding of how climate change affects bird communities..	adaptation and reassembly may introduce challenges in isolating specific effects. Predictive Limitations: Relies on current climate projections, which are subject to change, leading to potential inaccuracies. Limited Data: Regional data may not fully capture global migratory bird responses.
M.B. Araújo et al.[5]	Ensemble forecasting of models.	Ensemble forecasting aggregates predictions from multiple models, which helps capture a range of possible outcomes and reduces the uncertainty associated with any single model. This approach enhances the robustness of forecasts, making them more reliable for guiding policy decisions on biodiversity conservation	Ensemble forecasting can still inherit the biases and limitations of the individual models used in the ensemble. Additionally, the complexity of analyzing and interpreting the combined results can pose challenges, making it difficult to draw clear conclusions about species distribution shifts under future climate scenarios.
Gregory et al. 2008[6]	Climatic envelope model	The advantage of this model is that it effectively combines climate projections with bird population data to assess how climate change affects species distribution and abundance.	Disadvantage is its reliance on accurate and comprehensive data. If the data on bird populations or climate conditions is incomplete or biased, the model's predictions may be unreliable. Additionally, the model may not capture all the ecological interactions, potentially oversimplifying complex ecological dynamics.
James W. Pearce-Higgins[7]	statistical distribution model	This model allows researchers to assess how climate factors affect the distribution and abundance of bird species, even when detailed demographic data is lacking. This enables broader predictions across many species, helping to identify potential conservation needs under	The model's predictions depend heavily on the quality and accuracy of the input data. If the data is limited or biased, the projections may not reflect real-world conditions accurately. Additionally, the model may oversimplify complex ecological interactions, potentially missing critical factors that influence bird populations.

		future climate scenarios.	
Zahra Ramezani Moghadam et al.[8]	MaxEnt (Maximum Entropy) modeling	The advantage of using MaxEnt models is that they effectively handle incomplete data and provide insights into how species might shift their ranges in response to climate change. This is particularly useful for conservation planning, as it helps identify potential future habitats and inform management strategies for vulnerable species.	On the downside, MaxEnt models depend on the quality and completeness of the input data, which can introduce uncertainty in the predictions if the data is limited or biased. Additionally, while ensemble forecasting integrates multiple models for improved predictions, it can complicate the interpretation of results and increase computational demands, making the process more resource-intensive.
Dachverband Deutscher Avifaunisten e.V., Münster, Germany Sven Trautmann[9]	Linear Mixed Models (LMM).	Using linear mixed models allows researchers to account for both fixed effects (such as temperature) and random effects (like variations between different sites), providing a more nuanced understanding of the relationships between climate change and community attributes. This flexibility enables a robust longitudinal data analysis, helping to assess trends over time accurately.	Linear mixed models have their complexity, making them difficult to interpret and requiring careful consideration of model assumptions. Additionally, if the underlying data is sparse or the random effects are not well-characterized, the model's predictions may be unreliable, potentially leading to misleading conclusions about community responses to climate change.
Frank A. La Sorte[10]	linear mixed models along with ordinary least-squares (OLS) regression and space-for-time substitution.	Using these models allows for a nuanced analysis of community attributes over time while accounting for spatial and temporal variations. This helps understand how climate changes affect bird communities, providing insights that can inform conservation strategies.	This approach relies heavily on the quality and consistency of the input data. If the data is limited or biased, the model's predictions may not accurately reflect real-world dynamics. Additionally, the complexity of biological systems means that the models might oversimplify interactions, potentially missing important ecological factors that influence community structure.
Mainwaring MC, Nord A and Sharp SP (2021)[11]	Observational study on weather and bird behavior/ecology	Provides insights into how different weather conditions impact bird behavior and ecology in natural environments.	Variability and generalizability of localized weather data might limit the accuracy of the conclusions for birds across various regions.
Lingyi Tang(2022)[12]	GIS and Climate Big Data in Bird Migration Research	Effective use of Geographic Information Systems(GIS) and	Outdated data may compromise the accuracy of climate models, and GIS-based habitat

		climate data for mapping and understanding bird migration patterns.	classifications could oversimplify complex landscapes, leading to misrepresentation.
Persia Abishal B and Sujitha Juliet(2023)[13]	Machine learning(CNN) for image-based bird species ID	Provides an efficient method to identify bird species using image data, aiding in automated classification tasks.	The dataset used for training may not be diverse enough to account for all bird species. CNN may struggle with images taken under poor lighting or at unusual angles.
Arpit Deomurari, Ajay Sharma, Dipankar Ghose and Randeep Singh(2023)[14]	Citizen science data for predicting bird distribution	Utilises citizen science, expanding data collection possibilities and supporting comprehensive geographic coverage.	Geographic sampling biases in Citizen Science Data may skew predictions, affecting the accuracy of species distribution modeling.
Junhua Hu, Huijian Hu and Zhigang Jiang(2010)[15]	Species distribution modeling for endangered birds	Focused study on endangered migratory species, contributing to conversation efforts by modeling climate change impacts on wintering distribution.	The limited sample size of 46 occurrence records may affect the robustness of the model for the black-faced spoonbill's distribution.
Alexander C. Lees, Thomas M. Brooks	Predictive models evaluating the impact of climate change and deforestation on endemic bird species distribution in the Belém Area of Endemism (BAE).	Helps identify refuge areas and predict adaptation to future climates, supporting conservation efforts.	Modeling future scenarios is complex due to uncertain bird adaptations, and ongoing human activities like logging complicate habitat protection.
Mario Diaz, William E. Cooper Jr.	Machine learning models used to predict how weather changes, especially extreme events, affect bird migration patterns.	Can predict the impact of everyday weather changes and long-term adaptation, assisting in understanding different regional bird responses.	Lack of attention to everyday weather conditions like rainfall and difficulties in generalizing findings due to regional differences.
Paul C. Kruger, Annette S. Le Viellez(2004)	A comprehensive review of existing literature on climate change effects on bird populations.	Provides an in-depth overview of the broad impacts of climate change on birds, helping inform conservation efforts.	Limited to secondary data; does not include newer findings or recent trends.
Elsevier (2024)	Analysis of climate change impacts on bird migration, breeding, and survival patterns, and their roles in ecosystems.	Highlights how birds contribute to ecosystems and biodiversity, offering insights into climate adaptation.	Difficulties in predicting long-term outcomes of ecosystem changes due to incomplete data on migratory patterns.
Ibis Journal, Wiley (2006)	Predictive species distribution models assessing climate	Offers detailed predictive data that can guide conservation strategies.	Potential inaccuracies due to the complexity of climate models and limited ecological

	change impacts on bird habitats.		data.
Anna B. Gorshkova(2023)	Study of ecological traits of birds and how their geographical ranges may shift with changing climates.	Examines species-level adaptations to climate change, offering useful data for conservation.	Not all species may be able to shift ranges due to habitat loss and competition.
Persia Abishal B and Sujitha Juliet (2024)	Research on changing migratory patterns of birds in Vietnam due to climate change.	Sheds light on region-specific impacts of climate change on bird migration.	Challenges in conserving altered migration paths and adapting to new migratory patterns.
Sarah & Waller, Matthew(2024)	Study of bird-louse relationships in arid regions under climate change.	Indicates broader ecological stress and declining health in bird populations, useful for monitoring ecosystem health.	Focus on parasitic communities may not reflect overall biodiversity or bird adaptability in arid regions.
Janowiak et al (2024)	Citizen science-based study estimating the spread of alien bird species in urban areas.	Utilizes a wide range of citizen-gathered data to track species distribution.	Biases in data collection due to uneven geographic representation.
Pautasso, Marco. (2012)	A comprehensive overview of climate change's observable impacts on terrestrial birds across Europe.	Offers valuable data for long-term conservation efforts and policies in Europe.	Limited to specific European data; findings may not be generalisable to other regions.
Emmanuel prouf	Research on weather patterns and bird populations in North America	Highlights vulnerability of grassland birds to climate change	Difficulty in predicting species-specific responses to climate change
chad wilsey (2022)	Study on public engagement with scientific data on climate change and birds	Addresses gaps in communication to foster action on climate change	The challenge of motivating behavioral and policy changes in non-expert audiences
Brooke L . bateman(2022)	Research on the northward shift of bird distributions over a century	Tracks long-term changes in bird distributions	Challenges in conservation as species relocate
Rosenthal, S(2020)	Study on bird habitat shifts due to climate change	Highlights the need to adapt conservation strategies	Conservation areas may no longer align with shifting bird habitats
Roberto Ambrosini(2023)	Use of ringing and observation data to model migration timing	Helps predict migration timing of partial migrant species	Climate variation makes prediction difficult
Alessandro Andreotti (2018)	Study on biodiversity indicators in marine zooplankton and birds	Identifies key indicators for monitoring climate change impacts	Difficulty in selecting reliable, long-term indicators

Lorenzo Serra(2023)	Research on the impact of climate change on migratory birds	Focuses on risks to migratory patterns and populations	Migratory birds struggle to adapt to rapid changes in climate
Fernando Spina (2024)	Study on the effects of climate change on Amazonian birds	Highlights the vulnerability of endemic species to habitat changes	Rapid environmental changes threaten highly specialized species
Simona Imperio(2023)	Study on climate change impact on birds in mangrove ecosystems	Examines how sea-level rise and temperature changes affect bird habitats	Threat to mangrove ecosystems due to habitat destruction
ResearchGate (2024)	Research on the expansion of bird species in rural and human-altered areas	Shows how climate change affects bird distribution	Ecological imbalances threaten native species

4. Problem Identification & Objectives

Problem Identification: Climate change poses a significant threat to bird species worldwide, impacting their habitats, food sources, and breeding patterns. Birds are particularly vulnerable as they are sensitive to changes in temperature and precipitation, which can shift or shrink their habitats.

Objectives:

- **Predict Species Range Shifts**: Model how bird habitats are expected to change in response to climate change.
- **Support Conservation**: Provide data-driven insights for prioritizing conservation actions.
- **Visualize Habitat Changes**: Create interactive visual tools, like maps, to communicate projected habitat shifts and help conservationists plan more effectively.

5. Existing System

Existing studies primarily use species distribution models (SDMs) and machine learning algorithms, such as Bayesian analysis, Random Forests, and Support Vector Machines (SVMs). These methods have shown that climate change disrupts migratory routes and habitats, but they often depend on extensive data for accuracy and are challenging to interpret for conservation planning.

Drawbacks:

- Complexity
- Generalization Issues
- Dynamic Environmental Factors
- Limited Variable Scope
- Overfitting Risks
- Integration Challenges

6. Proposed System

The proposed solution integrates advanced machine learning techniques, specifically Logistic Regression and MaxEnt (Maximum Entropy Modeling), to predict future bird species distributions under various climate scenarios:

MaxEnt predicts suitable habitats based on environmental constraints, ideal for presence-only data.

How It Works in Your Project: Since you're focusing on the impact of climate change, MaxEnt can help model how changing environmental conditions—such as temperature, precipitation, or habitat availability—might alter a bird's range. MaxEnt uses these environmental variables to generate a probability map showing the suitability of different regions for a bird species, allowing you to see which areas are most likely to support species presence under current and future climate scenarios.

Logistic Regression models the probability of species presence based on climate data.

How It Works in Your Project: Logistic regression provides a probabilistic prediction of species presence based on predictors such as temperature, precipitation, and habitat type. The coefficients it generates indicate how strongly each variable influences the likelihood of species presence. For example, if temperature has a positive coefficient, then higher temperatures may increase the likelihood of the species occurring in that region.

By using data from GBIF, eBird, WorldClim, and CMIP5, the system creates interactive maps and downloadable reports for conservationists and policymakers to identify and protect critical habitats.

The proposed solution improves upon existing systems by using diverse datasets from GBIF, eBird, WorldClim, and CMIP5, which enhances accuracy and reduces reliance on a single data source. Integrating Logistic Regression with MaxEnt simplifies model interpretation, making it easier to understand how different environmental factors influence species presence. This approach allows for better generalization across regions and species while incorporating real-time climate data to address dynamic environmental changes. By including multiple variables, the analysis becomes more comprehensive. Additionally, employing cross-validation helps prevent overfitting, ensuring reliable predictions. Finally, the system provides interactive maps and downloadable reports, making critical information easily accessible for conservationists and policymakers.

Requirements

Functional Requirements

1. Data Collection: Fetch bird occurrence data from APIs (GBIF, eBird).
2. Climate Data Integration: Download and integrate climate models (WorldClim, CMIP5).
3. Species Distribution Modeling: Implement MaxEnt and Logistic Regression for species distribution prediction.
4. Visualization: interactive mapping of bird habitats.

Non-Functional Requirements

1. Performance: The system should handle large datasets efficiently and process predictions in a reasonable time.
2. Scalability: The model should be able to scale from a small set of species to a broader region as required.
3. Usability: The interface should be simple and intuitive for users, including non-technical conservationists.
4. Accuracy: The model should aim for high predictive accuracy and be validated using cross-validation techniques.
5. Maintainability: The codebase should be modular, allowing future improvements and updates.

7. System Architecture

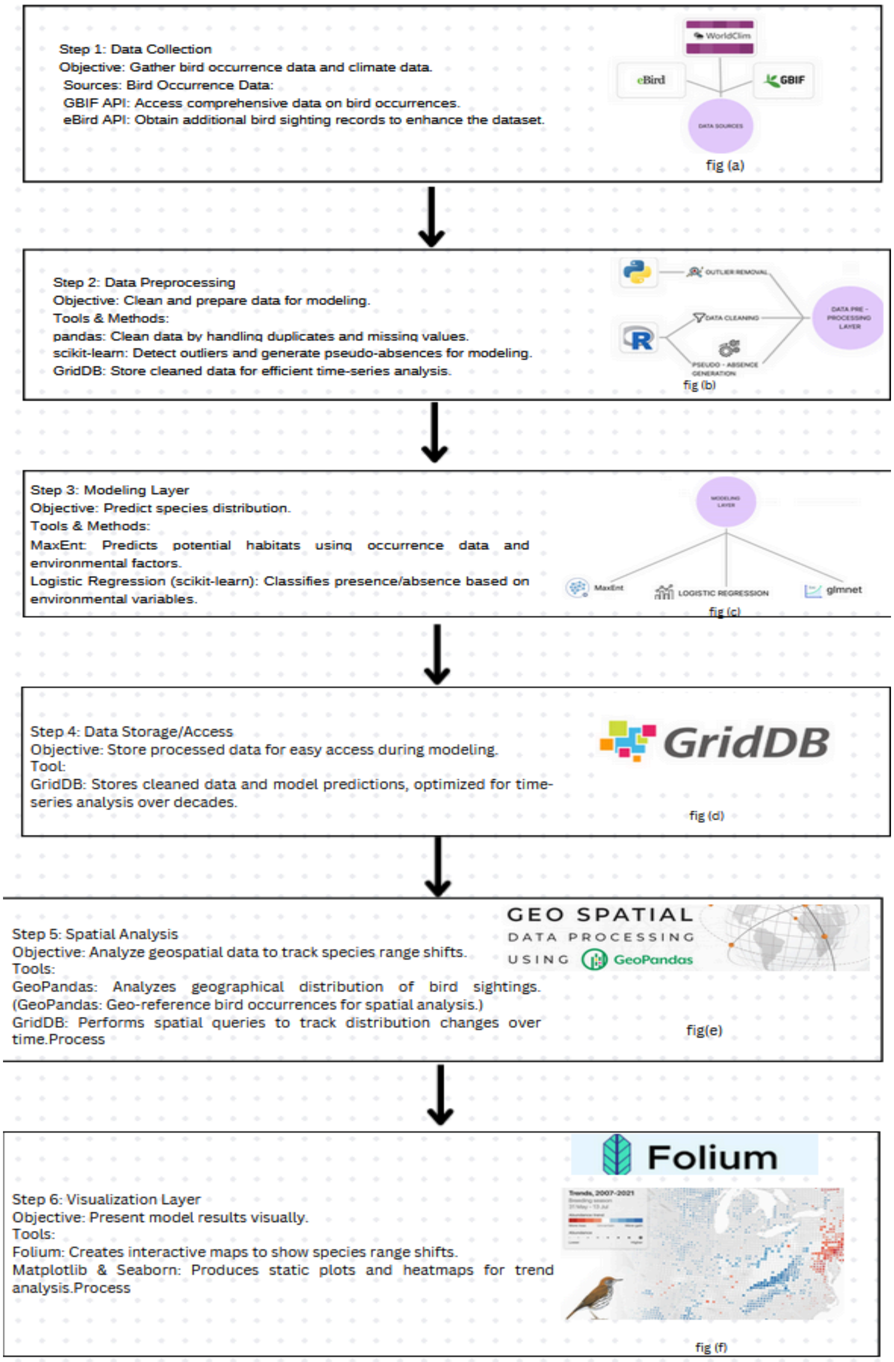
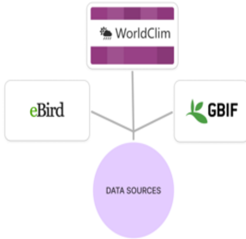


Figure 1

Figure 1:This architecture workflow outlines a species distribution model to predict

bird habitats using data collection, preprocessing, modeling, and spatial analysis, with results visualized through interactive maps.



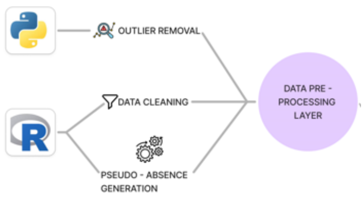
<u>Fig (a):</u>

GBIF: An open-access platform for biodiversity data.

eBird:The eBird API allows you to access bird occurrence data, enabling more comprehensive analysis of bird species distributions.

WorldClim:data source providing historical and future climate layers.It helps integrate environmental factors such as temperature and precipitation into species distribution models.

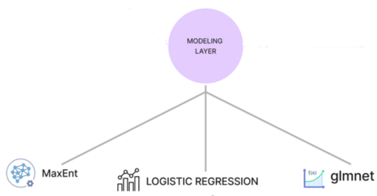
<u>Fig (b):</u>



outliers from the dataset, ensuring that extreme or erroneous data points are eliminated. This improves the quality and accuracy of the subsequent modeling steps.use **scikit-learn** to generate random background points (pseudo-absences)

<u>Fig (c):</u>

Maxent can model the probability of species presence based on environmental variables such as temperature, humidity, and land cover.(**predict the habitat suitability).**



Logical regression:it predicts the presence or absence.(**likelihood of species occurrence).**

Scikit-learn: provides you with all the necessary tools to model and analyze how climate variables affect bird species distribution, making it essential for your project.(cross validation,preprocessing)

<u>Fig (d):</u>

GridDB

GridDB is designed to efficiently store and query time series data. You can store historical bird sightings, climate data (temperature, humidity, etc.)

Fig (e):geospatial data in python is easier. GeoPandas extends the datatypes used by pandas to allow spatial operations on geometric types.

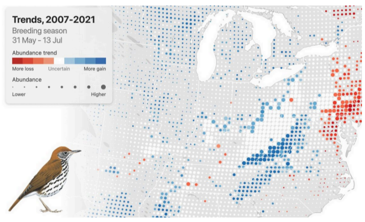


Fig (f): Folium makes it easy to visualize data that's been manipulated in Python on an interactive leaflet map.

UML Diagrams:

UML diagrams are essential for designing this project, providing clear, visual representations that improve understanding and communication among team members.

- Efficiency
- Clarity
- Enhanced Communication
- Streamlined Development
- Improved Integration

Use Case:

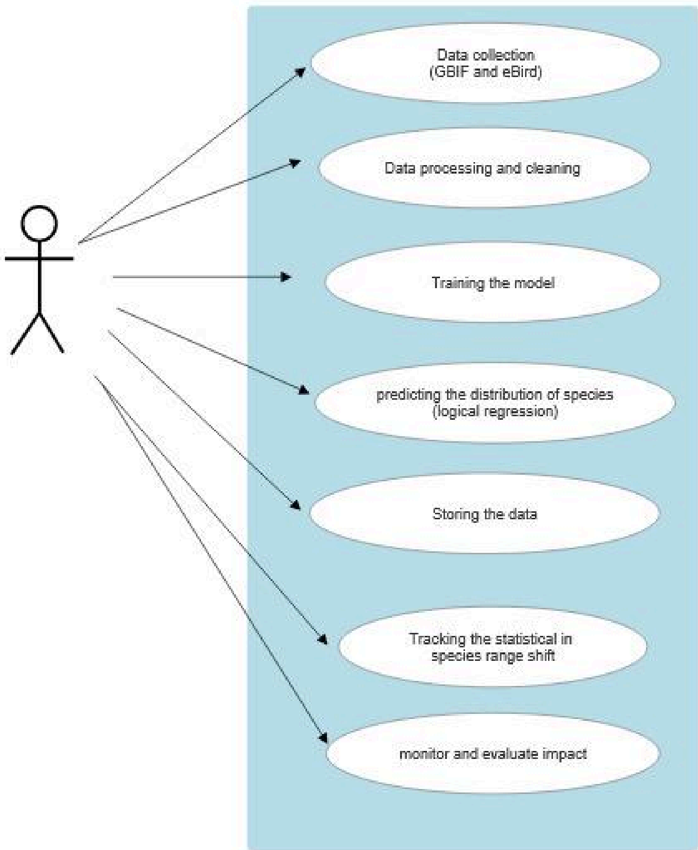


Figure 2

Figure 2: The use case diagram for the Bird Species Distribution Prediction System illustrates the interactions between key actors and the system's functions. Researchers input climate and bird species data, while machine learning models predict species range shifts. Conservationists utilize the generated reports and interactive maps to prioritize conservation efforts, and policymakers leverage these insights for informed decision-making.

Activity diagram:

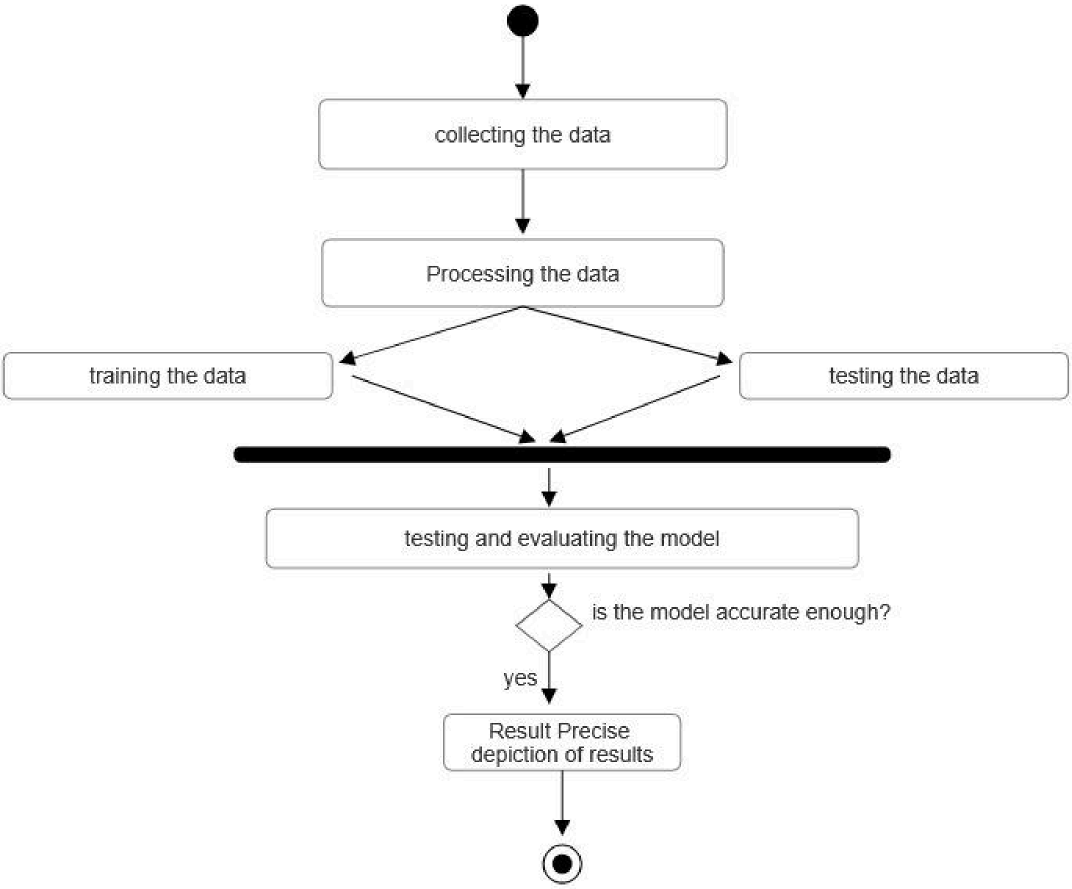


Figure 3

Figure 3:The activity diagram for "Impact of Climate Change on Birds" begins with data collection and preprocessing to prepare the dataset. The data is then split into training and testing sets. The model is trained on the training data and evaluated for accuracy using the testing data. If the model meets the accuracy threshold, it generates predictions on how climate change will affect bird populations. If not, adjustments are made until the desired accuracy is achieved, concluding with a reliable prediction outcome.

Data flow diagram:

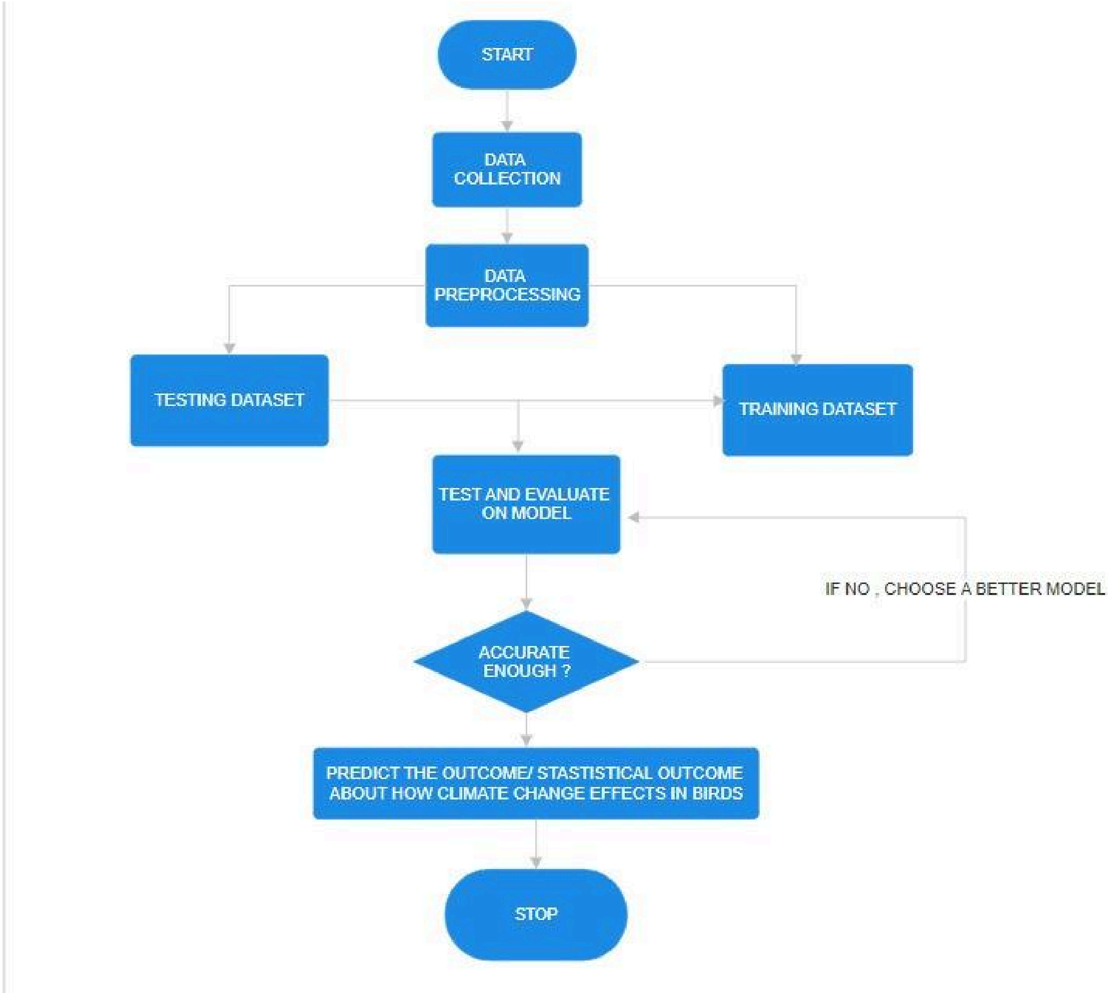


Figure 4

Figure 4:The data flow diagram illustrates a process to predict the impact of climate change on birds. It begins with data collection and preprocessing, followed by splitting data into training and testing sets. The model is then trained, evaluated for accuracy, and, if satisfactory, used to make predictions on climate change effects on bird populations, concluding the process.

8. Tools/Technologies Used

Canva for system arch and UML: Canva for system architecture and UML Canva is an online design tool that enables users to craft visual content and more. Renowned for its user-friendly nature, even for those without design experience, it offers pre-made templates and a simple drag-and-drop interface. While Canva can be used to design system architecture and UML (Unified Modeling Language) diagrams, it is primarily a graphic design platform and not specifically meant for technical diagramming. Nevertheless, it can still serve as a useful resource for producing visually engaging versions of these diagrams, especially when presenting them in reports, slides, or documentation.

GridDB :serves as a highly efficient and scalable database to handle and analyze large datasets related to bird populations and climate data. Given that climate data and bird migration or population statistics can involve time-series data and require high-speed processing, GridDB's time-series data storage capabilities are highly beneficial.
Folium: makes it easy to visualize data that's been manipulated in Python on an interactive leaflet map.

Scikit-learn: offers key functionalities for robust species distribution modeling. Its cross-validation techniques help ensure that models generalize well to new data, reducing the risk of overfitting. The library also provides preprocessing tools like scaling and encoding, which are crucial for preparing climate variables effectively. Together, these features support accurate, reproducible analysis, making it easier to explore how climate changes impact bird habitats.

Pandas:Pandas is a Python library used for working with data sets. It has functions for analyzing, cleaning, exploring, and manipulating .Helpful in data. managing and analyzing large datasets, like bird sightings and climate data. It enables easy data cleaning, merging, and summarizing, allowing you to spot patterns and trends in bird habitats influenced by climate change.

Geospatial: refers to data that is associated with a specific location on the Earth's surface. This type of data often includes coordinates like latitude and longitude, and can represent features such as cities, roads, or natural landmarks. Geospatial data is used in mapping and spatial analysis, helping to visualize and understand relationships between geographic locations.

Common applications include environmental monitoring, urban planning, and navigation systems.

9. Conclusion

The project provides crucial insights into the impact of climate change on bird distributions by predicting habitat changes under various climate scenarios. Through data-driven models and interactive tools, it informs targeted conservation strategies to preserve at-risk species. By helping conservationists and policymakers understand potential future habitats, this project supports efforts to mitigate biodiversity loss.

Status:

S.no	**Phase**	**Percentage of Progress**
1	Requirements Gathering	70%
2	Analysis	60%
3	Design	90%
4	Methodology identified	75%

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