Impact Of Climate Change On Birds

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ABSTRACT-- The natural environment is experiencing radical changes due to climate change, which poses serious threats to all living organisms in many biomes and biospheres. One of the groups most susceptible are migratory birds inhabiting such biomes. Migration is frequently complicated by temperature variation , change in precipitation and loss of habitat; all threats are interlinked. Temperature variations cause such environment modifications that influence critical parts of migration like timing, routes or destination , which affect availability of food and breeding ground and crucial stop over areas. Furthermore, the increase in oceanic levels and intensity and frequency of weather extremes places these species on further risk. This paper attempts to combine the already available information concerning the relationship between climate change impact and bird migration, practicing more on the instances of behavioral modification in certain species alongside the conservation measures that are being put in place. And it is clear that to these changes in the patterns of migratory birds there is importance in strategizing these patterns towards effective conservation of the global avian population from the adverse effects of climate change .

Keywords-- Bird migration, Temperature shifts, Habitat loss, Altered migration routes, Breeding grounds, Food source disruption.

The keywords given are the main ideas found within the documents dealing with bird movements, alterations of habitats as well as other effects related to climate changes [1] on birds. Such words substantiate major concerns on aspects such as the movements of birds, ecology change, the changes of the concerned birds and the attribution strategies to the changing climate. Collectively, they outline the most important aspects within the field of ornithology and the global environmental change.

I. INTRODUCTION

The growing influence of climate change on bird populations, despite including many species particularly the migratory ones , has emerged as an area of concern among ecologists. Human encroachment and invasion especially pollution and green house gas emissions are altering habitats such as food and breeding grounds, as well as patterns of animal movement including birds but these consequences go beyond the individuals affected to threatening species diversity and ecosystems as a whole [10].

Because they depend on environmental cues such as temperature, food, and habitat conditions to perfectly synchronize their migration and breeding periods, migratory birds are more vulnerable. As the temperature of the earth increases, there are changes in the timing, distance covered, and routes taken when birds are on migration, most of the time causing most of the birds to reach areas where they cannot find food or nesting resources. For example, if better temperatures drive some birds to leave their summer ranges earlier than normal, but food does not come out on time, the birds' chances of survival may be compromised.

Moreover, the rise of extreme climatic conditions [6] such as – storms, excess rainfall and drastic changes in temperatures – is another complication in that it can cause interruptions of migration patterns and destroy places where birds rest and replenish energy for further movements. Habitat destruction due to the increase in water levels and alteration of the shore and wetland ecosystems is another threat faced by avian species as the number of suitable habitats for stopping during migration is decreased [14].

It is critical to comprehend the impact of climate change [1] on the trends of bird populations, especially because it will play a key role in determining the conservation interventions. Studies points to the fact that there is a need to restore bird habitats, set up protected areas and engage the countries in the protection of the birds that fall in the migratory categories from climate change effects. Therefore, such conservation initiatives are paramount in ensuring the equilibrium that is necessary for the ecosystem [9] and the very important functions, which birds play, including the pollination of crops and controlling pest populations. Finally, while there are benefits from climate change [1] towards some bird species, for most of them it causes dire effects in relation to their migration, feeding patterns and territories making the need for conservation absolutely necessary.

II. OBJECTIVES

•Research the Impact of Temperature Variations on Adjustment: The way birds adjust to climatic variations is still unknown due to the phenomena of global warming, which results in changes in the timing, distances, and even the feeding of the birds.

•Examine the Effects of Weather Extremes: Investigate in what way the alteration of the migration patterns, rest stops and the whole behaviour of the migratory birds population is influenced by the increase in storms or changes in weather conditions and other climatic extremes.

•Research the Loss of Habitat as A Consequence of Global Warming: Pay attention to how rising global temperatures and climate change as a whole sea-ice melting anthropogenic land use changes impact birds nesting and foraging sites thus forcing them to change their patterns of migratory routes or breeding strategies.

•Explore the Impact of Climate Change on Human Behavior: Examine how changes in temperature and food supply impact the ecology of bird species, in terms of their departure and arrival dates, social interactions, feeding habits and geographical extensions.

•Propose Support Protective behavioral Solutions: proposed management strategies and conservation techniques [8] developed to alleviate the adverse effects of climate in relation to avian migration, with particular attention to rehabilitation and safeguarding of essential stop over areas [14].

III. ACRONYMS

•GCM - Global Climate Models

•IPCC - Intergovernmental Panel on Climate Change

•IUCN – International Union for Conservation of Nature

•CITES- Convention on International Trade in Endangered Species

•UNFCCC - United Nations Framework Convention on Climate Change

•CC - Climate Change

•GHG - Greenhouse Gas

•CO2 - Carbon Dioxide

•SLR - Sea Level Rise

•AEWA - Agreement on the Conservation of African-Eurasian Migratory Waterbirds

IV. OVERVIEW OF BIRDS

Birds are incredibly responsive to even the slightest shifts in their surroundings and their world is at risk due to climate change [1]. There are a multitude of consequences, including changes to its rate and timing of migration, breeding, habitats, and species diversity [10].

1. The Impact of Climate Change on Bird Migration It is physiologically impossible for a number of bird species to remain in one area at a certain period of time – they have to migrate in order to feed and reproduce [13].

Migrations are protectively adaptive in the context of climate but the climate change is ever more disrupting these adaptation mechanisms in various ways: – Change in temperature: Global warming results to a shift in the timing of movements in birds which sometimes results in a longer or shorter withdrawal. This leads to a situation where birds arrive while other resources such as food and breeding grounds are yet to be availed. – Rainfall and weather perturbations: Rainfall variability leads to changes in food availability along the migration corridors and severe weather dystrophies [6] such as hurricanes may break the migration process inducing delays or mass starvation and death.

2. Habitat disappearance and Sea level rise: Wetlands along the coast are some of the most utilized environments by avifauna in migration, which is also

the most threatened one due to global warming and more specifically rising sea levels. Such changes in habituate lead to difficulties especially for birds that travel long distances in search for resting and feeding pools. In addition, I’ve also found that, apart from the above, loss of forests and building of cities leads to habitat splitting which aggravates the situation for these birds.

3. Effects on Breeding and Reproductive Success: Temperature and habitat availability are two factors that greatly determine the breeding success of birds. A number of species compilations have to change their nesting locations, and some even seasons of breeding, or else some suffer from poor reproductive efforts due to depleted critical resources.

4. Examples of organisms put at risk: - Red Knotes (Calidris canutus): Global warming is causing- the early snowmelt which disrupts food for their chicks thus posing great threats to their survival. - Barn Swallows (Hirundo rustica): There have been alterations in their migration orientation due the usage of pesticides in conjunction with climate change [1] which has greatly affected the insect population. – Common swifts (Apus apus): Climate change [1] – induced variations in the populations of insects has lead to changing of both the migration and nesting patterns of the species.

5. Preservation and Progress for the Future: Bird conservation at any all-inclusive scheme seeks to geographical restoration of their habitats, creation of conservation corridors along flying routes and

respectively concerns with dynamics of the monitored bird population and their migration.

V.METHODOLOGIES USED IN THE APPROACH

1. Dataset Description and Data Modelling: The bird migration data set contains a vast of 61920 worth of entries which detail the major aspects of the movement of each of the recorded birds over time and geography. The data set has 8 attributes with each record denoting a determined time unit of the tracked bird. Some of the key fields are altitude (which is defined as the height of the bird from the sea level), date_time (the date and time when the particular position was recorded) and device_info_serial (the tracing equipment used to track the bird). This is an aspect of the essay in which latitudes and longitudes are used. In addition to latitudes and longitudes, the essay provides information about the direction of the bird_ flight and the ground speed clicked, referred to as direction and speed_2d respectively. There's also the bird_name field which relates to the bird that is being tracked and the unnamed index column that is assumed to be redundant. A few other variables such as direction and speed_2d have a few gaps, which imply that there could still be some data cleaning or imputation needed for these sections.

The goal of this methodology is to establish the altitude at which birds migrate using varying machine learning models for various purposes. Random Tabulation And Gradient Boosting Models Are Combined Tree Models-Which Provides Excellent Performance In Forecasting Of Non-Linear Data due to their ability to learn the intricacies of the data without overfitting. Random's forest contributes to overall accuracy by taking the average over several trees, which avoids the problem of overfitting. Gradually more and more trees are added in a way that each new tree improves upon the shortcomings of the previously added trees. Also xgboost the modification of gradient boosting was added because it is fast and offers better performance on the structured data. Ordinary linear regression is offered as the simplest possible model in order to explain the relationship between altitude and other provided features. The Support Vector Regression (SVR) model was also added to assess the performance of this approach in relation to high dimensional data problems which involves transforming the input features in order to enhance the prediction task performance. Each model is assessed based on crucial evaluation metrics (MAE, MSE, RMSE, and R^2 respectively) to conclude the most suitable model for altitude estimation in the given dataset.

Table 1..Dataset Description

Dataset Used	No.of Instances	N of attributes
Bird_migration	61,920	8

Table 2..Attribute description

SI.No	Attribute	DataType
1.	altitute	Int-64
2.	Date_time	object
3.	Device_info_serial	Int-64
4.	direction	Float-64
5.	Latitude	Float-64
6.	longitude	Float-64
7.	Speed_2d	Float-64
8.	Bird_name	object

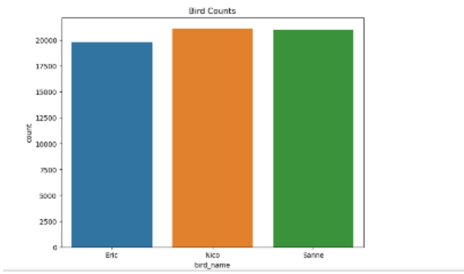

Fig1.No.of birds in dataset and their count

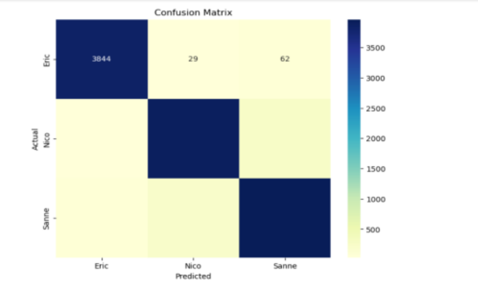

Fig2.Confusion matrix

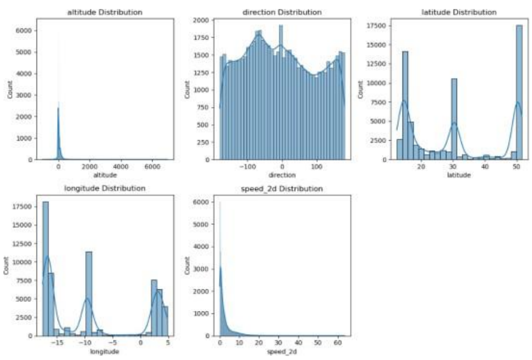

Fig3.Histograms for some attributes

2. Data Pre-Processing and Data Cleaning: The initial phase of the data preprocessing and cleaning stage of the code presents a very crucial step which is the process of feature selection from the data – in this case, the unnecessary indexed observational column, the device_info_serial column, and the date_time column as they do not contribute bear any significance on the expected model performance. Moving onto the number columns, where the direction and the speed_2d numerical values have some gaps that are absent from the records; rather, a mean imputation technique was utilized for fear of leaving any white patch when training the model.

As for the categorical data, there is a column called bird_name which is encoded to numerical values with the help of LabelEncoder library. This library is able to convert all the classical categorical data that lend themselves to such encoding into numerical format by mapping each class of data into an integer code. Thus, the data is being encoded with regards to two separate problems, one being regression based (that of predicting the height of a bird) and another one being pure classification based (the task of predicting the bird_name). Ye et al. have made available a separate set of the features which is used for every task except the target variables in this case altitude for the regression task and bird_name for the classification task.

Then the partition of the data into training and testing subsamples is done according with the 80/20 policy to both the regression and text classification datasets, with the aim of employing majority of the data for training the models and having some other data on which to test the performance of the models. Last but not least, the regression data (except for tree based models) undergoes feature standardization in order to enhance the effectiveness of Support Vector Regression (SVR) by adjusting the input features to the optimal condition for its operation.

3. Cross Validation: In order to enhance the robustness of model evaluation, cross validation can be applied to regression and classification problems alike. In this case, let us consider k fold cross validation, with K=5 or 10 as is commonly accepted. The data set under consideration is distributed among numerous parts referred to as 'folds'. For every model, the dataset is distributed in several parts and each part is used once to validate the set, while the other parts are used to fit the model which allows for expediting all configurations of the data.

This K-Folds cross-validation is performed in all regression modelling attempts involving Random Forests, Gradient Boosting, XGBoost, Linear Regression and SVR in an effort to provide an overall performance diver across all folds. This assessment therefore provides additional insight on how much such a model would deal well with new data that was not available during training. Appropriately scaled data would be employed for models that require it, such as SVR, but not for the tree-based models which are designed to work on the unprocessed data. Model evaluation metrics — mean average error (MAE), mean squared error (MSE), root mean squared error (RMSE) and R-square (R^2) are computed and then averaged over the folds.

Within the classification phase, stratified k-fold cross-validation strategy is applied ensuring that the distribution of bird species is reflected accurately across all the folds. This helps to ensure that both the training and validation subsets are of equal sizes despite having distinct frequencies in their classes. RandomForestClassifier is subject to evaluation over periotic phases during the performance of the bird species classification model and performance indicators such as accuracy, confusion matrix and classification report are all taken in averages. The benefit of this is in the prediction of the measurements, where the user knows which model is the best one but moreover how confident it is able to be across various data partitions in a user evaluation of modeling performance.

Table3..Results after cross validation

	MAE	***MSE***	***RMSE***	***R^2***
Random Forest	38.95 1915	9746.3797 28	98.723 755	0.433756
Gradient Boosting	40.32 3982	11385.792 818	106.70 4231	0.33851
XGBoost	40.00 1587	10372.486 191	101.84 5403	0.397381
Linear Regression	54.68 7018	14271.174 493	119.46 2021	0.170876
SVR	48.65 2178	14324.343 386	119.68 4349	0.167787

D.HyperParameter tuning:Hyperparameter tuning refers to the methodology of allocating the right set of parameters, which in most cases, are not learned during the training process but are key in directing the performance of the model. With the exception of parameters, such as the weights in a neural network that the model updates during its running, such attributes are controlled before the actual training starts since they affect model features like how complex the model will be, the learning rate and the depth of the trees among others. Hyperparameters optimization models the improvement of accuracy, generalizability and efficiency of the model.

As observed in the code, Hyperparameter tuning was performed for each algorithm implemented so that the algorithm could perform its best for regression and classification tasks. Each particular model has its own hyperparameters which specifies how the model will operate.

In the case of Random Forest (regressor or classifier), hyperparameters such as n_estimators (number of trees), max_depth (depth) and min_samples_split (minimum number of samples in a node to allow for a split) are tuned. They define how complex and distinct the trees will be, this in turn affects the model's generalization ability and helps in curbing overfitting.

For Gradient Boosting as well as XGBoost regressors, other settings such as learning_rate and subsample are also tuned. The learning rate determines how much each tree will influence the finale whilesubsample makes a portion of the training data available for each individual tree, this aids in depencency.

Concerning SVR, the following parametric values are tuned: C (the regularization cost), epsilon (the width of the margin), and kernel (the shape of the dividing surface). These hyperparameters are used to decide how close the model should follow the training examples, how thick the wall separating the decision surface and the training examples should be, and how complicated the mapping function that transforms the data should be.

The tuning process in this case is done using Grid Search Cross-Validation (GridSearchCV), which is a more rigorous process of simply fitting a model with all the hyperparameter combinations found by k-fold cross-validation. This way, every single set of parameters gets tested in full over a number of data splits with an aim of getting good performance estimates of the model in use. In some situations, a simple Grid Search proves to be every quite exhaustive and disappointing does not promise any betterting of the best combination of the specified grid, which of course is very desirable, considering it takes a lot of time to compute, particularly with bigger data sets or intricate models.

In other works, Randomized Search Cross-Validation and even Bayesian Optimization can be applied in a different case of tuning. Randomized Search is quick since it picks random options instead of combinations, thus, larger parameter combination is allowed. Bayesian Optimization, which is not included in the current research approaches, is also quite useful in parameter selection since it does not require full testing of parameters but makes selections on parameter due to trends in response in earlier performance allowing for less computational power and faster narrowing down to optimum performance.

These tuning methods add to the reliability of the model by minimizing overfitting and variance, thus making the model dependable to different data splits. In the above cross-validated and exhaustive run optimising these hyperparameters achieves improved models as they fit well the training data and generalise well to other data which is more useful for practical usage.

5.Results:

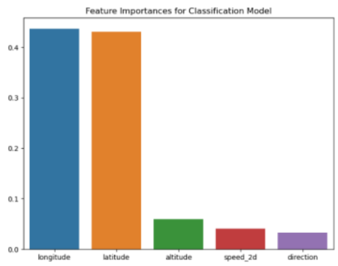

Fig4.Feature importance

Table4..Classification report

	precision	***recall***	***f1-score***	***support***
Eric	0.97	0.98	0.97	3935
Nico	0.94	0.93	0.94	4200
Sanne	0.93	0.93	0.93	4249
accuracy			0.95	12384
macro avg	0.95	0.95	0.95	12384
weighted avg	0.95	0.95	0.95	12384

Classification Model Accuracy: 0.9467054263565892

Table5..Accuracy Table

S.I.No	Algorithm	Accuracy
1.	RandomForest	94.6%
2.	GradientBoosting	85.4%
3.	SVM	81.72%
4.	KNN	79.6%

VI. RESULTS AND ITS ANALYSIS

1.GRADIENT BOOSING REGRESSOR: The Gradient Boosting Regressor is one of those models that comprise a good number of machine learning algorithms whose implementation and use is specific to the regression only. In gradient boosting every weak leaner typically a tree, is played to learn and improve approximation of a final function. The first tree is built from the data and each tree that follows minimizes a particular loss function, which in most cases is the mean squared error for regression problems. The Gradient Boosting Regressor Handles the task at hand better than others in that it can model the relationship between the features and the response qualitatively as well as quantitatively and therefore can correct for non-linearities in the data especially in cases of complex feedback.

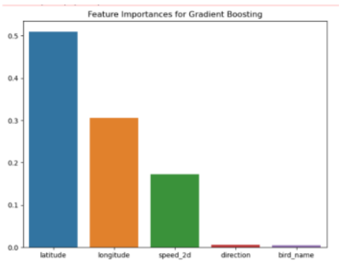

Fig5.Feature importance for GradientBoosting

In case you wish to include the Gradient Boosting Regressor in the analysis of the bird movements data, it may be used instead of the existing Random Forest Classifier for predicting the target class or variable (for example, `bird_name`). This would allow for better and more accurate observations able to adjust predictions even more so when the nature of the data is not linear in nature. As with many other ensemble models, this approach is also subject to the need for proper tuning of hyperparameters for instance the number of trees, learning rate and depth of individual trees to avoid overfitting and encourage progressive convergence. That being said confidence in this model comes from its ability to make accurate predictions from limited information due to the maturing of all previously made predictions which is ideal for data sets where there are clear structures but considerable noise that benefits from a series of learning steps.

2.XGBOOST REGRESSOR: The Regressor of XGBoost is an advanced machine learning algorithm that most often utilizes gradient boosting and is widely employed for regression purposes – it can also be used for classification in its classifier form. Perhaps the most notable feature of XGBoost is its high performance; speed, and the ability to work with complicated datasets. It is an ensemble of multiple weak learners which are built, in most cases, decision trees one after the other. Each tree hunts the mistakes made by the previous ones, and therefore, makes the process of predictions not instant but progressive. In this way, it is possible to say that XGBoost enhances its predictions by performing a gradient descent optimization of the loss metric. Important features include regularization parameters to fight overfitting and efficient missing values handling.

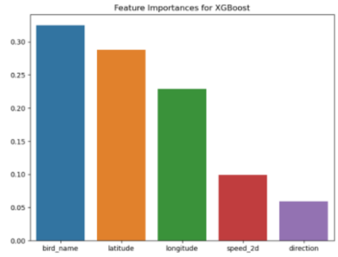

Fig6.Feature importance for XGBoosting

For this endeavor, an XGBoost Regressor may be used in order to predict a numerical onset related to bird migration (such as the distance or perhaps the rate of migration). The XGBoost model designed in this way would be exposed to various environmental and bird specific information present in the database such as data and degree patterns in order to make predictive approximations. Due to the model's ability to carry out feature importance analysis, the effects of the various causes of bird migrations would be established making it easier to make accurate projections for their study or conservation further enhancing the significance of the model.

3. SUPPORT VECTOR REGRESSOR (SVR): A Support Vector Regressor (SVR) is a regression model falling under the family of Support Vector Machines (SVMs). Most of the times, when we hear about SVM, we associate it with clustering, however SVR has modified this idea to provide elastic prediction of values. It operates by identifying a hyper plane in a higher dimensional space which best describes the data points within a specific range of distance, with the range being such that some points can lie far outside this distance. The main aim in this case is to restrict the loss to a level which is achievable with no dubious complexity added to the model making it outlier resistant.

SVR can be extended to non-linear cases by applying the kernel trick which is simply the mapping of the feature space into a higher dimensional space using a kernel function where linear, polynomial or radial basis function (RBF) kernels are all examples of such functions.

If one would consider the challenge of predicting bird migration patterns in using SVR, one would expect to predict for instance bird flight speeds, angles or even the bird's position with respect to time. By defining an appropriate error bound, SVR would be able to learn such patterns yet avoid overfitting to noise which would be beneficial in situations which call for model predictions that are vague and non oscillatory. For SVR, aside from the pature above, one would prepare the data for example aimed at features generated from bird movements.

4. RANDOM FOREST CLASSIFIER: The Random Forest Classifier is an efficient system in supervised learning that overcomes the limitations of individual algorithms. For a classification task, when building the model, several decision trees are constructed and the most frequent class in the prediction of the trees is taken as the final outcome, and and the average of the individual trees for regression. Each decision tree in a Random Forest operates by taking random samples of features and samples hence building a strong model by finding the mean of the predictions from all the trees. This introduced randomness mitigates overfitting issues common with most learning models especially in situations where the data structures are complicated and contain noise.

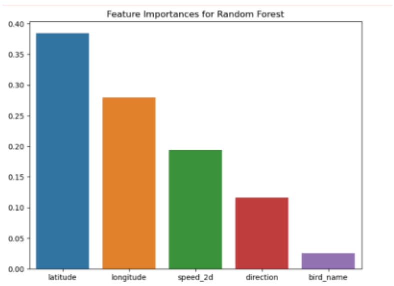

Fig7.Feature importance for Random Forest

Thus, in this research, it aims at implementing the Random Forest Classifier to estimate the bird species of the corresponding ID bird_name considering the associated features direction and speed_2d. The first step is therefore to encode the categorical variable and Missing Value Treatment, so as to ensure that the model uses more data in enhancing the classification performance. The performance of the model is tested by different evaluation metrics: an accuracy score, a confusion matrix that shows how each class performs with respect to other classes and the most important features that aid in prediction of the class. These metrics go a step further and enable one to assess whether the model can be implemented in practice or not and if possible suggest modifications.

VII. CONCLUSION

As a conclusion, the above research illustrates that global warming affects the migration of birds, thus protective measures for the affected species are required. Changing physical temperatures, the increase in storms, rising sea levels and urban encroachment which lead to the destruction of the natural habitat, influence the migrations, breeding and feeding patterns of many bird species. Such pressures on individual species equally threaten the integrity and richness of the ecosystem. This approach serves to model the migratory trends of the particular birds and incorporates variations as regard environmental changes which is posited to correlate with the variations in migration. It is this knowledge that allows for the development of appropriate conservation measures for instance identifying areas with rich biological resources or modifying the existing threats management to fit with what climate change brings about.

The results also call for the protection of all migratory routes and respective habitat areas on a global level since birds are known to inhabit different regions and habitats throughout their lifecycle. It has been proposed as per research findings that some of these strategies such as protecting migration pathways and restoring habitats can be put in place to help mitigate any adverse claim from climate changes on birds. Such focused climate adaptation research and collection of migratory data for specific prediction modeling can be effective in conservation strategies. This study has proved the merits of utilization of applied predictive analysis in ecology and what will be critical where birds are endangered through the devise and implementation of strategies aimed at their protection currently when there is global warming.

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DATASET LINK
https://www.kaggle.com/datasets/turhancankargin/bird-migration