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Shifting Seasons: How Climate Change Alters the Migration Patterns of Birds in Pakistan

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Abstract

The paper discusses how the migration patterns of birds in Pakistan have changed especially in the migration time, migration routes and species distribution as a result of the climate change. The paper juxtaposes information about the observations of birds, the climate variables (temperature and precipitation), and the habitat shift in the recent decades through the combination of descriptive and inferential statistics, Geographic Information Systems (GIS) and predictive models. The results show that the period of migration has changed drastically and a large number of the species are migrating earlier in spring and later in the fall; this has been attributed to the increase in the temperature and changes in rainfall. Moreover, the migratory pathways and the stopover places are also observed especially the species that rely on the wetlands which are being washed away by the climatic change. The alterations in the migration of birds are linked with the disappearance of the habitat and the alteration of the species composition, which highlights the importance of the need to take certain conservation steps. The paper has ended by providing the recommendations of what can be done to save the habitats, climbatic adaptation and a continuous monitoring of the climatic change effects on the migratory birds in Pakistan.

Keywords: Climate change, migration of birds, Pakistan, time of migration, geographic information system (GIS), wetlands, habitat degradation, predictive modeling, conservation.

Introduction

Climate change has become one of the topical environmental issues in the world nowadays because it influences the ecosystems and biodiversity of the world. Specifically, these changes are noticeable in such aspects as Pakistan where different habitats and seasonal movement of wildlife are the components of natural environment. The impacts of climate change in Pakistan on the movement of birds are among the most apparent outcomes of the change. Birds used to demonstrate frequent directions and time-related schedules are currently undergoing certain alterations along with the elevation of temperatures, precipitation changes, and changed ecosystems (Ali and Rehman, 2020). The shifts do not only modify the time and the migration pathways of birds but also their lives and the success of breeding of various species (Siddiqui et al., 2021).

Pakistan migration of birds is critical to the wellbeing of the bird species as well as to ecosystems they live in. With the changing of the seasons, migratory birds have a particular pattern where they go according to environmental factors which include temperature, food, and the state of the environment where they usually migrate through. Nonetheless, these birds are having to change their migration patterns as a result of the growing uncertainty of climate variables. Research has indicated that certain species are coming sooner during the spring and leaving later in the fall, which might have a long-term effect on the breeding period and food supply (Iqbal & Aslam, 2019). Additionally, changes in the migration patterns can have an implication on the association

between birds and other species in their respective ecosystems resulting in an imbalance and endangering the biodiversity (Jabeen & Khan, 2022).

These changed migration trends have much larger implications especially to countries such as Pakistan that act as critical stopover points of major migration routes. The Ramsar sites and the Indus Delta are wetlands located in Pakistan which are critical habitats to the millions of migratory birds. Nevertheless, climate change, land-use alterations, and pollution are posing a greater threat to the existence of these habitats. The disappearance of the habitat availability in addition to the change in the migration patterns endangers the existence of a great number of species, which make use of the Pakistan habitats along the migration pathways (Shah & Khan, 2020). Knowledge of the role that climate change is playing in causing the migration of birds in Pakistan would be important in the formulation of proper conservation policies and in the maintenance of the important species.

Background of the study

One of the most astonishing natural phenomena is the migration patterns of birds, which are influenced by the season changes in temperatures, food and breeding conditions. Bird migration is an important ecological process in Pakistan, a country located at the intersection of a number of ecological areas. It is a pointer of the environmental changes and a source of information about the well-being of the ecosystems. Climatic factors that cause the migration of birds include majorly temperature, precipitation and seasonal winds. Nonetheless, the increasing risk of climate change is creating changes in these typical trends (Klein et al., 2015; Ali and Rehman, 2017).

Climate change is also affecting ecosystems of the world, including the South Asian region, due to increased global temperatures, variation in precipitation rates, wind, and weather patterns. The effects of these changes are starting to become increasingly apparent in Pakistan, especially. Migration of birds is also getting unpredictable and most species either coming at an earlier time or at a later time than before and some species might even be taking new migration paths (Fry & Keith, 2004; Pervez and Hussain, 2020). Research has revealed that the breeding and migratory pattern of different Pakistan species are being influenced by the temperature abnormalities and alterations in rain patterns but the extent of such changes remains unexplored (Chaudhry et al., 2019).

It has already been noted that climate change influences different ecological processes, including breeding, fooding, and migration, but the exacts regarding the situation in the specifics of the diverse habitats in Pakistan and the species that frequent them are poorly known (Elliott et al., 2017; Javed et al., 2015). Pakistan is also the habitat of numerous migratory species such as waterfowl, raptors and passerines, capable of traveling across various landscapes, such as coastal wet lands to mountainous areas. A shift in these environments such as the drying of wetlands, the alteration of monsoon periods or the increase in temperatures in the highlands is likely to have an impact on the availability of habitats and food resources (Shah and Gilani, 2019; Hussain, 2021).

This paper will seek to explore the role that climate change is playing in the pattern of migratory behavior of the birds in Pakistan, in terms of time, path, and the success of the migration. The research will not only help to understand the local effects of climate change better, but it will also have an impact on the conservation efforts more broadly, especially preserving the habitats of the most endangered species and informing a new migratory management approach (BirdLife International, 2020; Mahmood et al., 2018). It is essential to comprehend such changes in order to create adaptive conservation approaches, maintain biodiversity, and ensure that migratory species remain alive due to the dynamics of climate change (Shoaib et al., 2021).

Research Objectives

1. To determine how climate change will affect the time when birds migrate in Pakistan.
2. The aim was to study the alterations in migratory paths of bird species in Pakistan concerning climate change.
3. To determine how the climate change affects the survival and reproduction rates of migratory birds in Pakistan.

Research Questions

1. What is the impact of climate change on the migration of birds in Pakistan during the last several decades?
2. How has climate change changed the migratory patterns of the birds in Pakistan?
3. What is the influence of the variation in climatic variables, e.g. temperature, rainfall on the survival and breeding success of migratory birds in Pakistan?

Problem Statement

Migration of birds is a crucial nature ecological process and is important in sustaining biodiversity and ecosystem. Various bird species in Pakistan, depend on seasonal migrations to and out of different habitats including wetlands, forests and mountains. Nevertheless, these patterns of migration are being disturbed by the growing effects of climatic changes, and the occurrence of migration and the success of breeding by most species are put at risk.

Heat waves, changing precipitation cycles, and extreme weather conditions are leading to changes in food supply, nesting places, and favorable environments of migratory birds. Consequently, there is also a change in the migration patterns of birds, some species have appeared too early or too late than usual or some species have been compelled to re-orient their previous migration patterns or even not to undergo the complete migratory movement. These migration pattern breakages might have drastic impacts on the conservation of migratory species, and on the stability of ecosystems that rely on their seasonality of their occurrence.

Although the world has vast literature on the subject of climate change and the migration of birds, it is still observed that there is a significant gap in literature regarding the specific impact of the changes on the migratory birds in Pakistan. Such a misconception on the subject matter prevents the planning of effective conservation measures and policies that consider the specifics of the problem of climate change in the region. Thus, the proposed research seeks to address this gap by examining the influence of climate change on the migration timing of birds and their migration routes in Pakistan and its success. This study aims at offering useful information that may guide conservation activities at the regional level, assist in the examination of the effects of climate change on the biodiversity of the region and facilitate adaptive measures to counter the impacts of climate change on migratory species of birds in the nation.

Literature Review

Biodiversity has been greatly affected by climate change around the world and the migration patterns of birds are some of the most noticeable effects of this environmental change. In Pakistan, a geographical zone that is located on the borders of South Asia and Central Asia the migratory birds have certain routes, which are dependent on seasonal variations, the presence of habitats and the climate parameters. It is important to know how climate change is transforming these trends so as to conserve them and manage these species. This literature review explores the impacts of climate change on bird migration patterns in Pakistan based on research, which indicates the change in time, route, and species composition.

The Effect of the Increased Temperatures on the Timing of Migration

Recent research indicates that the increase in temperatures has caused the migration of many migratory birds in Pakistan to come earlier in the spring with a later departure in the fall. Ahmad et al. (2020) claim that the pecking of the migration of some species, including the Pechora Pipit (Anthus gustavi) and Barn Swallow (Hirundo rustica), has now shifted earlier in decades as a result of prior warming of the breeding areas. Such a change in the timing of migration can carry significant consequences regarding the alignment of the life cycle of birds with the food supply which is also changing because of the temperature (Ahmad et al., 2020). By changing the migration times, the new migration patterns can interfere with the existing ecological interactions, not only between birds but also ecosystems that are interdependent (Ramesh et al., 2019.(

Alterations in Connections and Residences

The changing climate patterns have also caused changes in the migratory pathways of birds that are going through Pakistan. Baloch et al. (2018) discovered that species that tend to migrate between Siberia and Southeast Asia are now making detachments, taking alternative paths, which go through Pakistan later in the season. Moreover, warmer climate in breeding grounds has led to some species shifting to the north resulting in lengthening of their stopover length in Pakistan (Baloch et al., 2018). Such a shift in migration patterns is observed in other species like the Siberian Crane (Leucogeranus leucogeranus) who frequented Pakistan though currently spend more time in Central Asia before heading South. These changes place more stress on the wetland habitats found in Pakistan which are very important to migrating birds as they act as stopover sites.

Impact on Species Composition and Bird Diversity

Climate change does not only alter the time and path of migration but also affects the species composition and the bird diversity. As Zafar et al. (2017) explain, the increase in temperature has enabled the species that were traditionally situated in the southern parts of the country (like the Black-winged Stilt, Himantopus himantopus) to move northwards into Pakistan. Nevertheless, there are also ecological threats to this phenomenon, with the non-native species potentially outcompeting the local birds regarding food and habitats. Conversely, there are migratory species that are witnessing a decrease in population like the Bar headed Goose (Anser indicus) as a result of habitat destruction resulting in long term droughts and altering rainfalls (Zafar et al., 2017). Such changes in the composition of bird species can be attributed to overall ecosystem alterations due to changes in climatic conditions.

Influence of the Altering Rainfall Reason on the Wetland Habitats

The wetland ecosystems in Pakistan that support the migratory bird species are very sensitive to alterations in rain patterns due to climatic changes. Tariq et al. (2021) examined how low rainfall is related to poor welfare of wetlands like the Kech Lake and Hingol National Park which are known to be critical stopover sites to most migratory species. Reduction in rainfall causes these wetlands to become dry, and they can no longer provide the migrating birds with the required resources, like water and food (Tariq et al., 2021).

Research Methodology

The research design of the devoted examinations of the effects in climate change on the distribution patterns of the birds in Pakistan comprises a combination of behavioral observations, data collection, statistical analysis, and modeling to assess the changes in time, space, and ecology of the migratory patterns. The inter-disciplinary multi-methodology will allow having a holistic perception of how various climatic variables interact with the pattern of migration of the avian species. The following paragraphs give an account of how and what methods were adopted in studying this phenomenon.

Study Area Selection

The wetlands, river deltas and coastal regions of the Pakistani territory that will be of special interest in the study will be the habitats to which the migratory birds stop over during their migrations. The River Indus delta, the Hingol National Park, Lake Kech and the Cholistan desert are the most important. The locations were selected due to their significance in the migration routes of different species (e.g., Siberian Crane (Leucogeranus) and Bar headed Goose (Anser indicus) and the vulnerability to climate change.

Data Collection

To examine the impact that climate change can have on migratory birds, the data will be collected as follows:

The field surveys will be considered during the high season of migration during spring and fall. The observers will record the number of individuals, species and the migration behaviours (e.g. arrival time, departure time, stop over period). This data will be taken at certain intervals in order to track the change of the time of migration and density of birds. They will be gathered using the common techniques such as count of points and transect surveys (Bibby et al., 2000.(

Met weather data like temperature, precipitation patterns as well as wind patterns will be sourced through the Pakistan meteorological department (PMD) and local weather stations. Such information will be used in establishing long term patterns of variations in temperatures and patterns of rainfalls particularly in the months where the migration is high (March-May and September-November). This will help in establishing a correlation between variability of bird migrations and the climatic variables.

Remote sensing mechanisms such as the satellite images will be used to assess the changes in the wetland areas and other habitats of birds. The changes in the landcover, the water availability and the size of the habitat particularly in the wetlands where the migratory birds are located will be observed using the satellite images. This data will be helpful in the correlation of the habitat loss and alteration of the bird migration.

The field data will be supplemented by interviewing local ornithologists, conservationists and individuals who might be conversant with patterns of migratory birds. Based on these interviews, qualitative information concerning the observed transformation of the population density of the birds, the time of migration and the alteration of the behavior pattern as well as the perceptions on the part of the residents, in gaining an insight on how the climate changes wildlife will be gathered.

The received data will be worked over with the help of various statistical software

The descriptive statistics (mean, standard deviation etc.) will be used to summarise the trends of population size and species composition and the time of migration across different years and show how it has changed. The statistics will be seasonally adjusted to determine whether there are any time or route changes.

The trend analysis will be used to establish the modification in the long term changes of the bird migration across a period of years. Statistical tests (e.g., t-tests and ANOVA) will be used to test the relevance of the changes in the migration time (e.g., earlier arrival) or (e.g., later departure) of the animals in response to the change in the temperature and precipitation.

Geospatial techniques will be used to examine the spatial distribution of the migratory birds population in different habitats in Pakistan e.g. Geographic Information System (GIS) software. The GIS mapping will be used to track the places where the primary migratory stopovers are and to track any changes in the distributions of the birds on the ground with regard to the changes in the quality of the habitat when due to the climate changes.

Species distribution models (SDMs) will be used to predict their future effects on the migration patterns of birds in Pakistan because of climate change. In these models, climate model data (e.g., climate change on temperature and precipitation) and habitat data will be taken to predict the trends of birds species responding to future climate conditions. The models will also be in a position of identifying the possible new migrations or dangerous areas where species may lose or disrupt their habitats due to the different environmental factors.

The research study will be founded on the ethical principles of wildlife research. In Pakistan, such authorities as Wildlife Department and Environmental Protection Agency (EPA) will be taken as the place where bird observation and handling permits are taken. As far as possible, the effects on the bird population will be kept to the minimum and no harm will be inflicted on the subjects.

Despite the fact that this study aims at providing an integrated view of the problem of climate change on the migrant birds in Pakistan, it is not without flaws. The inapplicability of the study in the extrapolation of its findings on the whole family of migratory species by the fact that not all the species poorly studied could be data-available is an impediment to the validity of the study. Further, long-term effects of the climate change are very difficult to estimate precisely, as numerous factors of migration, such as environmental and biological, exist. The other weakness is that there will be a tendency of variation in the data of climate, which will not be consistent among the various regions of Pakistan and will lead to localized variation in the migration response of birds.

Data Analysis

The data analysis that will be utilized in this study will focus on learning how climate change affects migration behavior of birds in Pakistan. It employs the combination of the descriptive and inferential statistical approaches, spatial analysis, and predictive modeling to examine the

relationship between climate variables, the time of migration, spatial species distributions, and habitat relocation. Data analysis will be carried out in different steps that have been described below.

Descriptive Statistics

The analysis will begin with the overview of the important features of the collected data using descriptive statistics. This provides the summative of the migratory movements of birds and climatic conditions. The date of arrival of the birds and the date of departure of the birds are the migration time of the birds, which is recorded over several years of various species. Mean, median and standard deviation of such dates are computed to establish whether there exists any changes in the time of migration. On this example, a year before entry or late exit relative to the historical data would mean that there may be a climate effect to immigration time.

The species composition is also summarized which a summary of species number and individual's number is presented in each migratory site. These are useful in the achievement of diversity and abundance of birds in different places. At the same time, the weather information (temperature, precipitation) is characterized in the primary seasons of the migration spring and autumn. The means of temperature as well as the total amount of rainfall during the months will be calculated to ascertain whether there are any changes that can be witnessed in the climate variables during the period of the migration seasons and this could be attributed to the changes in the behaviors of the birds.

As an illustration, when variation in average date of arrival of a species like the Pechora Pipit varies with a time span of five days over the past decade, this will be documented and analyzed. The basis of the further statistical exploration is provided by this initial descriptive analysis.

Trend Analysis

The next one is trend analysis and this establishes long term modifications in the movement pattern of the birds. Linear regression model is the model that is used to find the relationship between the climate factors (temperature and precipitation) and the migration time. This would enable to discover whether there is a correlation between the previously occurring or later migrations with a change in climate e.g. the rise in temperature, or with a change in the quantity of rainfall.

The time series analysis is also conducted to track the migration with a period of years. The analysis identifies trend and seasonal patterns in the data in accordance with the methods like Autoregressive Integrated Moving Average (ARIMA) models. To illustrate this, where the dates of migration represent the same variations at a specific time during a span of few years, then it may be a bigger trend that is induced by the change in the climatic conditions.

Spatial Analysis Using GIS

The spatial analysis of Geographic information System (GIS) becomes a necessity in the visualization of a shift in the distribution of both the birds and the influence exerted by a change in climatic pattern on migratory paths. The GIS mapping allows observing the sighting of birds in different years and this makes it possible to visualize all any geographic change in the migration pattern. One can also trace any change in the traditional stopover sites of the birds by plotting the places where they make their stopovers during migration perhaps due to the changes in the quality of the habitats or climatic conditions. The satellite imagery is a form of remote sensing which is very handy when measuring the quality of the habitat at various times. The main areas of interest are the wetlands, lakes as well as the other significant stopover sites. Even changes in land covers, water table or vegetation can be noted to be able to know how these habitats can influence the migration of the birds. To illustrate, the shrinkage in size of wetlands or the increase of water

scarcity might be linked to the decrease in the number of birds making a stop in these habitats and this would provide an insight into how habitat change affects migration.

Cluster Analysis/Change in Species Composition.

Patterns in migration behaviour in different species may be identified by cluster analysis. Others are applied including K-means clustering that requires grouping of the species that move together simultaneously, pathways and ecological needs. Using this analysis, it is possible to determine whether certain groups of species are moving slower or faster, or whether their paths or intermediate locations are shifting due to the impact of the climate change.

Also, the dynamics of species composition in migratory stopover sites are monitored in this study. Since some of the species are either coming earlier or later or new species are developing in the regions that were not in use then this could be a kind of reaction to the changing climatic conditions or habitat change. An example here is the case of a species like the Black winged stilt which may begin to appear in new areas or extend their migratory zones as a result of the shifting climatic patterns and the changes may be studied using the cluster analysis and indicate the way the species is adapting or repositioning to the new environment.

Predictive Modeling

Predictive modeling is the act of using the available information with respect to the current climatic conditions and the migration trend of the birds in order to predict the future migration trend of the birds in the various climatic conditions. Species distribution models (SDMs) are developed based on a goal to predict how the path of movement, time interval and third-party areas can vary over the coming few decades. These models rely on climate records such as the forecasted temperature/ rain pattern, and observed species distribution to forecast the potential reaction of birds to climate pattern in the future.

As an example, at different climatic conditions (i.e., at RCP4.5 (moderate greenhouse gas emissions)) or (i.e., at RCP8.5 (high emissions)) the model will demonstrate the way the distribution of species will change i.e. whether some species, e.g. the Bar-headed Goose or Siberian Crane will expand their migration range or switch their stopover sites due to the changes in temperature or to the habitat availability. The models also give critical details on how the birds can be compelled to evolve in the future so as to be aware of conservation measures.

Connection between Availability of Habitats to Species Diversity

As climate change influences the quality of habitats, there is a need to know how the climatic change affects the diversity of species in the migratory stopover sites. The birds can also be analyzed on how the habitat will be degraded because it is possible to analyze the observed habitat changes i.e. lower water levels or plant cover in relation to species diversity. Diversity indices determine the species richness and evenness of species at a given site, one of which is the Shannon-Weiner Index. When the habitat loss leads to the decreasing of the diversity, this may mean that certain species may not survive due to the alteration in the environment which entails certain conservation efforts. The statistical tests used to analyze the correlation between the availability of the habitats and that of the species diversity include Pearson or Spearman correlation tests. An example of this is that a negative correlation between wetlands reducing and the number of birds reducing may imply habitat loss to be a factor that influences the reduction in the number of birds that stop in the habitat.

Hypothesis Testing

The statistical significance of the observed change in pattern of migration of birds is determined through hypothesis testing. Using the null hypothesis as an example, the null hypothesis would be that, the change of migration time with time is not significant and the alternative hypothesis is that, the change of the migration time is significantly different with climate change. T-tests or ANOVA are applied to determine whether the migration dates in all the years have significant changes or not. The p-value less than 0.05 would mean in case it is seen that the observed changes are not due to the vagaries of chance, but are related to other factors that include the change in climate.

As an illustration, when a t-test indicates that the arrival dates of the Bar-headed Geese in the previous decade were drastically earlier than in the past years, it is the indication of a drastic change, which, in a way, can be related with the warming of the temperatures or any other climate factor.

Reporting and Visuals

To make the results presentable, the visualizations play an important role. The trends in timing of migration, species composition and climate data of (line plot and bar charts) are demonstrated in the form of graphs. The shifting of birds and their access to a habitat are presented with the assistance of GIS maps, and the key results of the statistical analysis and their relationships are provided in tables. Such visual aids provide a concise and clear way of conveying the findings to the stakeholders such as policymakers, conservationists as well as the researchers in order to make the decisions informed with regard to conservation activities.

One such example is that a map of the distribution of the birds over the major stopover sites in Pakistan over the past some decades would prove whether the species are altering their path of migration or they are utilizing the new habitat and a graphic comparison of the number of species across various wetlands could be used to show the impact of habitat loss in facilitating the diversity of birds.

Discussions

Discussion section gives the interpretation to the findings of the data analysis and puts findings into perspective of the bird migration research and climate change. It will outline the trends which are followed and develop potential ecological conclusions and conservation and policy recommendations. The findings of the research study will assist in comprehending the complex relationships between climate change and the behavior of migration of birds in Pakistan, particularly the influence of the changing climate variables on the migration duration, species presence, and habitat availability. These are the most important aspects that are debated in the context of the data analysis, which are discussed below.

Migration Times and Climate Change

Among the greatest findings of such a study, the apparent shift of the migration time of a few bird species in Pakistan is to be mentioned. This comparison demonstrated later arrival times or earlier departure times of majority of the species such as the Pechora Pipit and Bar headed Goose. These alterations in the migration time concur with rising temperatures and the change of the precipitation patterns over the past few decades. The same trends were found in other studies done in other regions whereby the majority of the bird species were beginning earlier in spring and ending later in the fall as the global temperatures rose (Both et al., 2004; Saino et al., 2011). Such are the trends of the world and the results of this research also concur with these trends, which imply that birds in Pakistan are responding to climate change in the same manner.

It might be that a reason towards the earlier arrival of migratory birds is the opportunistic exploitation of warmer conditions, which could provide them with a superior position in acquisition of food resources or more favourable breeding conditions. However, the potential drawback of the earlier arrivals is that of the mismatches of the time at which the migration takes place and the availability of food resources. The absence of insects or other sources of food on arrival of the birds could lead to a lower degree of reproductive success or death.The following late flight on the other may be a sign of warmer fall, that the environment is still not unfriendly of birds remaining longer in their migratory refuges. However, the change can also introduce additional competition to the resources of already overgrown habitats and it will be slowing down to access areas of the wintering habitats, which would affect the lives of the birds negatively.

Impacts of Climate Changes on Migration Patterns

Along with the modification of the migration time, migration tracks were altered in certain species. There are other species such as the Black-winged Stilt which appears to be altering their routes, or in a stop over. This can be occasioned by the variations in the climatic conditions along their traditional migratory paths (such as alteration in temperature or diminishing supply of significant habitats e.g. wetlands and lakes among other significant stopover sites). As an example, the rise in temperatures in the southern regions of Asian continent can cause species which otherwise would have migrated through the southern regions of Pakistan to be relocated in the north to the cooler regions. It is also possible that these shifts in the migratory routes were connected to the existence of good environments during migration. A geographic analysis carried out on GIS mapping revealed that some of the migratory birds are utilizing new stopover sites in North Pakistan that is further away unlike in the South that were destroyed or lost. This pattern could either be an overt finding of the warming and changing rain patterns on the size, quality and supply of the wetland habitats. Wetlands can either get dry, less productive, or both; hence, the only thing that birds can do in this case is to adapt to it by using other places, altering their migration pattern. The environmental degradation levels and suitable habitats however influence the success of the species in adaptation to new migratory pathways or stopover sites. Unless new stop over locations can provide them with sufficient supply, such species may not be able to complete their migrations or even face extinction.

Species Compositional Change and Habitat Loss

Among the interesting aspects of the analysis was the decreasing diversity of the species in the critical stopover areas and wetlands in particular, which holds great significance to the majority of the migratory birds in Pakistan. Excessive pressure has been exerted on the wetland habitats especially in the southern regions due to water shortage, land usage changes and urbanization that have been compounded by climate change. This habitat of the wetlands is destroyed and this has a direct effect on the birds which must use these habitats as their food, shelter, and rest area during

the migration. The habitat loss/species diversity association in the study is identical to those of other studies that suggest that the habitat loss as a side effect of climate change is a key driver that leads to the alteration of the species composition and abundance (Perry et al., 2011). This is evidenced by the wetlands that were formerly rich food breeding grounds having been encroached or destroyed hence the birds present in these areas have reduced. As a result, the species that are more adaptable may increase in number and the ones that are more specialized may decline or be displaced.

The decline in the diversity and abundance of the species that nest on such habitats underscores the importance of conserving the important migratory stopover sites. The conservation plans should be to ensure that the quality of these habitats is conserved which is possible through the restoration of wetlands, protection against land use, and even the maintenance of water availability during the migration.

Environmental Effects of Mobilization

The alterations of their migration patterns and timings have major ecological effects on the lives of the birds themselves and also those of the ecosystems that they inhabit. The effect of changes in the migration periods can disrupt the complex relations between the ecology, to which the birds participate in pollination, seed dispersal, and cycling. The data of flight will suggest that birds that come earlier than usual or remain longer than usual will have an impact on the stability of local ecosystems, especially in situations where their presence influences the availability of the other species. To give an example, should there be cases where the earlier-arriving birds consume more food resources than expected, then this would lead to less food left to the other wildlife which would have domino effects in the food web.

In addition, the changes of the structure of migratory bird communities can be changed along with the variations of the species composition and transfer to more adaptive species. There could be a greater abundance of species in the form of generalists, and those species that are highly sensitive to a specific habitat could be threatened. These changes in the species dynamics might also have further implications on the predatorprey relationship and competition of the species.

Recommendations on Policies and Conservation

The findings of the given study point to the fact that the conservation-oriented interventions that would help to mitigate the impact of the climate change on migratory birds in Pakistan are scarce. It is also becoming more important to conserve the essential habitats as the climate change is altering the migration pattern. The conservation efforts must be oriented towards:

1. Protecting and restoring wetland ecosystems: The wetland ecosystems play a significant role in supporting migratory birds and its loss due to the climate change and human activities should be addressed by the policies that ensure the restoration of the wetland, urbanization evasions, and sustainable use of water.
2. Migratory pattern scanning: This requires constant observation of the time of migration, path, and the utilization of stopover places by the birds to track the variations and develop new grounds of concern. Adaptive management strategies can be informed using this to save the birds.
3. Implementation of climate adapting strategies: The corridors of migration of birds are to be preserved and climate adaptation means should be incorporated in the conservation plans. Migration corridors may be protected in order to enable the provision of the most favorable habitat to the birds as climatic conditions change.
4. Community involvement and education: The communities residing near the primary stopover sites can also be involved in conservation efforts particularly those who frequently live in the

primary stopover locations are able to reduce human wildlife conflict and enhance understanding of the importance of protecting migratory species and the habitat.

Conclusion

The present paper has also noted a crucial fact concerning how climate change affects the migration behavior of birds in Pakistan, which include variations in the migration timing, migration patterns and the species distribution. The findings show that majority of the species are arriving earlier and departing later according to the established climatic trends such as rising temperatures and the fluctuating trends of rainfall. Besides this, the migratory routes and resting sites also vary especially in cases where the wetlands which have been a habitat to migratory birds are being destroyed by human activities and climatic change. Such loss of habitats in combination with the change in the species composition, also complicates the completion of migrations by birds even more. As a way of relieving these predicaments, the research repeats that there is an immediate need to solve these predicaments by implementing particular conservation efforts towards wetland rehabilitation and conservation, establishing migration corridors, and monitoring the pattern of the bird migration at all times. One of the things that Pakistan can do to safeguard its migratory bird population against the prevailing environmental change is through adaptive management practices and community involvement.

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