SC209 - Environmental Science
B.Tech 2018 - 2020

Study of ecological connectivity for the migratory bird species. (Case study: Chilika Lake, Odisha)

Group 8

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Introduction

This report is about the study of ecological connectivity for the migratory bird/animal species in Chilika Lake, Odhisha. About 193 species migrate to Chilika every year. The species that is the subject of our research is the Bar- Headed Goose (*Anser Indicus*). Geese generally breed in central asia and winters in south-east asia and for that they might have to cross the world's highest mountain range-the Himalayas. This report gives an idea about the nature of the bird, its migratory and breeding patterns.

The Bar-Headed geese migrate to many sites in South-Asia. For the purpose of our research, we have focused on their migration to Chilika Lake, India. Chilika Lake is a brackish water lake and a shallow lagoon with estuarine character. It is spread across the districts of Puri, Khurda and Ganjam in the state of Odisha in eastern India. The water spread area of Chilika is fed by 52 rivers and rivulets and varies between 900 to 1165 sq. km. during summers and monsoon respectively. Our report provides details of several reasons as to why it serves as an ideal habitat for the several birds migrating there. We mapped out the route of migration and came up with a predictive model. 1) The model uses human observation data and predicts the number of birds that may be found in the different regions within 4 categories (0, 0-50, 50-100, >100). 2) An energy-based route optimization model maps out the optimal route for migration of the bar-headed geese. The report will give you a thorough idea of Chilika lake as the hub or habitat for the bird species as well as the in-depth study of the bird species Bar-headed goose (*Anser Indicus*)

Chilika Lake

Chilika lake of Odisha is the largest inland saltwater lake. It is located on the east coast of India and covers an area of over 1100 sq. km. It is the largest brackish water lagoon in Asia as well as the largest wintering ground of migratory birds in the Indian subcontinent. More than 193 species of migratory birds migrate to the Chilika Lake from October till March when they begin to fly back to their home countries. The birds are from Russia, Mongolia, central and Southeast Asia, Ladakh, the Himalayas, Caspian Sea, Lake Baikal, and Aral Sea. Chilika was designated as the 1st "Ramsar Site" of India because of its rich biodiversity and ecological significance.

Unfortunately, human practices like illegal prawn farming, overcrowding by tourists and illegal bird poaching affect the biodiversity of Chilika. Chilika Development Authority carried out one of the best executed restoration projects of the lake. The ecological system was restored to an extent and the number of migratory birds increased. Migratory birds come to Chilika as it is a hospitable habitat compared to the extreme freezing conditions in their natural habitats in Siberia, China, Japan and other countries in the northern hemisphere. The birds frequent open wetlands which have enough fish, prawns, frogs, snakes and molluscs.

Habitat (Characteristics)

The bar-headed geese migrate to Chilika Lake to spend the winter, flying over the Himalayas. The modern winter habitat of the species is cultivated fields, where it feeds on barley, rice and wheat, and may damage crops. Bar-headed geese are mainly vegetarian. They feed primarily on grasses, roots, stems and other plant parts, as well as on grains, tubers and occasionally seaweed. All of this is available in Chilika during the winter

months. The ecosystem of Chilika lake and the surroundings serves as an ideal environment for the bar-headed geese for wintering.

Lagoons are extremely productive environments largely due to high nutrient inputs from surrounding land drainages, as well as efficient nutrient recycling. This high productivity supports lagoon fisheries for both fish and shellfish. Lagoons are ephemeral environments (on geological time scales) evolving rapidly into other types of semi-aquatic habitats (marshes, swamps). This process is simultaneously accompanied by a gradual shift from high salinity conditions to freshwater. Human activities within lagoon watersheds often serve to increase the succession rate of lagoons towards their ultimate terrestrial end-state. The highly productive lake ecosystem with its rich fishery resources sustains the livelihood of more than 200,000 fisher-folk who live in and around the lake.

Virtually all of the following general processes appear to be currently operating within Chilika Lake.

- [1]the high degree of shelter from tidal and current action
- the relatively stable salinity gradients
- the soft mud and/or sand substrates
- the well-mixed nature of the water column through wind action
- extreme shallowness
- organic richness
- rapidity with which they change (over geological time scales)
- a seasonal variation in salinity and/or water level

[1] "Environments." *Environments | Chilika Development Authority*, www.chilika.com/environments.php.

Geology and Topography

Chilika Lake is an estuarine lagoon in a transitory environment, shallow throughout its spread. It is the largest wetland along the east coast of India. The lake is a convergence of marine, brackish and freshwater ecosystems with estuarine characters. The lake water is alkaline with the pH ranging from 7.1 – 9.6 with total alkalinity matching the salinity. Salinity levels have wide temporal and spatial variation because of a blend of freshwater discharge, evaporation, wind condition and tidal inflow of seawater .

The salinity level is 0 parts per thousand near the Daya River mouth and goes to a hyper-saline level of 42 ppt in the outlet channel during the dry period, showing the brackish nature of the lake. The dissolved oxygen values were between 3.3–18.9 mg/l. Phosphate phosphorus (0–0.4 ppm), nitrate nitrogen (10–60 ppm) and silicates (1–8 ppm) are high in the north and northwest part of the lake where most of the rivers discharge into the lake with large amounts of silt and nutrients. Based on the salinity value, the lake

is broadly divided into four zones : southern, central, northern and outer channel. During monsoon, the tidal influx of seawater is arrested by an influx of a large amount of fresh water from the northern and central zones. Even during the monsoon, brackish water conditions in the southern zone prevail due to low water exchange. Salinity in the southern zone decreases in the post-monsoon period and in winter as northern winds facilitate mixing of water with the rest of the lake. During the summer, intrusion of salt water from the outer channel into the lake increases since the water level of the lake is at its lowest level. This causes an increase in the salinity of the central and northern zones while the salinity in the southern zone does not rise appreciably.

The western and southern margins of the lake are fringed by the Eastern Ghats hill range. The catchment area of Chilika lake has a rock, sand and mud substratum. It contains a wide range of sedimentary particles such as clay, silt, sand, gravel and shell banks but the major part of the catchment area is silt. The inland rivers which bring silt into the lake, control the northern end of the lake. Around 1.6 million metric tons per year of sediment is deposited in Chilika lake by rivers Daya and several streams. The longshore sediment transport along the coast of Bay of Bengal tends to shift the lake mouth opening to the sea every year. The spatial and temporal salinity gradients resulting from the freshwater flow from the drainage basin and the seawater influx, give it the unique characteristics of an estuarine ecosystem, having a continuous influence on its biota.

Water depth of the lake varies from 0.9 ft (0.3 m) to 2.6 ft (0.8 m) in the dry season and from 1.8 m (5.9 ft) to 4.2 m (13.8 ft) in the rainy season. It is theorised that a rise in worldwide sea levels over the last 6,000–8,000 years occurred with a pause in the rise of sea level about 7,000 years ago. This might have resulted in the formation of a sandy beach near

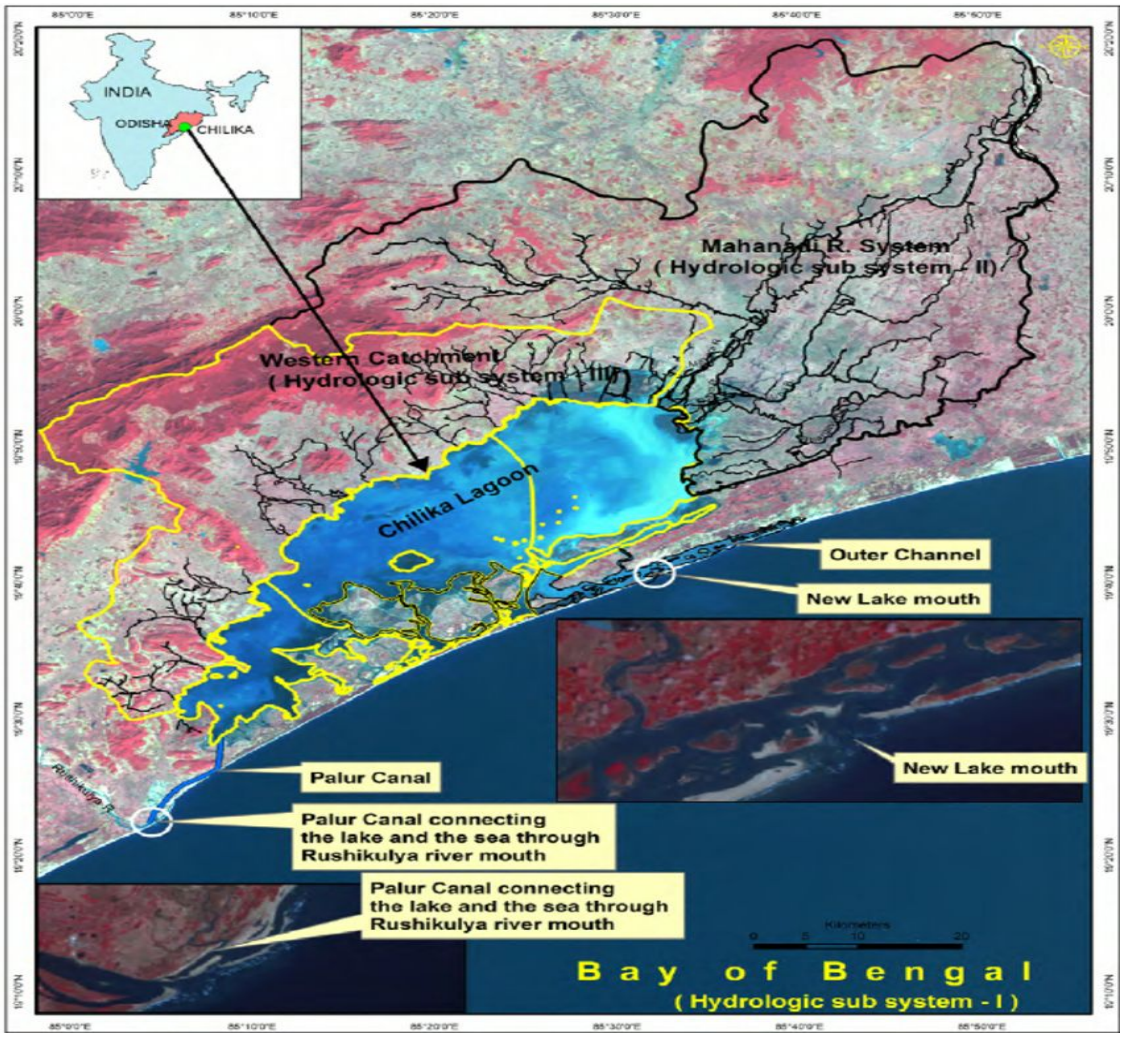
the coast in the Southern sector. With the rise in the sea level, the sand beach grew gradually, progressed seaward to the northeast and formed the spit of Chilika. A fossil unearthed from the southwestern edge of the spit indicates that the lake was formed about 3,500–4,000 years ago. The abrupt change in the direction of the coast north of the lake, strong winds shifting sand to the shore, longshore drift (littoral drift), the presence or absence of strong river and tidal currents in different areas are the reasons attributed for the growth of the spit.

White bands of coral in the southern sector, at a height of 8 m (26 ft), above the present water level, shows that the area was once marine and that the water was much deeper than present. The chronological development of the outer barrier spit of the lake has been dated by Optically stimulated luminescence studies of minerals. This was done on sixteen samples of the lake bed. The studies indicated doses of between 153 ± 3 mGy and 2.23 ± 0.07 Gy, corresponding to ages from 40 years at the top of the spit to 300 years at the bottom. The youngest ages are consistent with the age of the overlying vegetation. A clearly defined period of > 4.0 km (2.5 mi) of barrier construction 40 years ago is identified. Prior to that the deposition rate was relatively constant for 300 years.

Hydrology

Hydrological system of Chilika Lake has three subsystems. Land based system comprises the distributaries of the Mahanadi River on the northern side, 52 river channels from the western side and the Bay of Bengal on the eastern side. Two of the three southern branches of the Mahanadi River feed the lake and contribute about 61% (850 m^3/s (30,000 cu ft/s)) of the total freshwater inflow into the lake.

The second drainage system which is non–perennial accounts for 39% (536 cubic metres per second (18,900 cu ft/s)). The important rivers of this drainage system are the Kansari, the Kusumi, the Janjira, and the Tarimi rivers. The annual total surface freshwater input to the lake is estimated to 1.76 cubic kilometres including direct precipitation over the lake contributing 0.87 cubic kilometres. All the inland river systems have an annual flow of about 0.375 million cubic metres of freshwater which is estimated to carry 13 million metric tons of silt into the lake. On the northeast, a channel connects the lake to the Bay of Bengal.



[2]

[2] (Mohanty, 2015)

Climate

The bar-headed geese visit Chilika during the winters. They arrive during November to December and depart from February to March. During this time chilika lake has a median temperature of 14 degree celsius which suits the birds. The region normally has a tropical climate with an average annual maximum temperature 39.9° C, minimum temperature of 14.0° C. The lagoon experiences South-west monsoons during June to September and North-east monsoons during November to December respectively. The Western disturbances in North India during December and January cause cold wave conditions for a couple of weeks. This cool climate is ideal for the bar headed geese. The climate is drier in the inland hilly tract. There is higher temperature during the hot months and slightly cooler temperature in winter. The hot summer season is from March to May. December to February is the winter season. The period from June to September is the monsoon season while October and November months are the post monsoon transition months. The average rainfall in the catchment is 1238.8 mm with 72 rainy days. The rainfall generally decreases from northeast to southwest. About 75% of the annual rainfall is received during the monsoon months from June to September. The Krushnaprasad Block receives the lowest rainfall of about 107.5 cm, the lowest in the State.

The wind speed is high during the month of March to July and it is low during the winter season. The wind speed is mostly from North and north easterly direction. During monsoon month it is mostly from southerly and southwesterly direction due the influence of the South-west monsoon and the wind speed varies from 5.3 to 16.0(Km/Hour).

Bar-Headed Goose(Anser indicus)

 [3]

Description

- Life-span: 10 - 25 years.
- Size: 28-30 inches
- Weight: 1.87-3.2 kg
- Common Name: Bar headed goose,indian goose
- Category: Goose
- Family: Anatidae
- Scientific Name: Anser indicus
- Conservation Status: Least Concern
- Wingspan: 55-62 inches
- Total population: 97,000-118,000(70% of it in india and china)

[3] "Bar-Headed Goose." *Wikipedia*, Wikimedia Foundation, 19 Nov. 2006, en.wikipedia.org/wiki/Bar-headed_goose#/media/File:Bar-headed_Goose_-_St_James's_Park,_London_-_Nov_2006.jpg.

The bird is pale grey. Like all waterfowl ,the bar headed goose has a triangular, spatulate shaped bill,and the bill is bright orange with a contrasting black nail. Genders are similar though males are slightly larger and heavier than females.In flight, its call is a typical goose honking. Goose breeds in Central Asia in colonies of thousands near mountain lakes and winters in South Asia(as far as peninsular india).

Behaviour

These birds gather in large flocks and will mix with other waterfowl, particularly other types of geese. They are powerful fliers and have larger, more efficient lungs than many other bird species, adaptations that ornithologists believe are essential for their demanding, high-altitude migration. While migrating, they typically form *V-shaped* or *J-shaped* formations, with lead geese falling back when exhausted. On land, they walk well and graze continually.

Habitat and Distribution

These geese prefer freshwater habitats such as bogs, open marshes, marshy lakes, or river wetlands, as well as wet grassy fields or flooded agricultural areas. They are found in much of Asia, and migrate seasonally.

Diet and feeding

Bar-headed geese are primarily herbivorous and gaze on a wide range of plant materials, including grasses, grains, roots, stems, seeds, and berries. They will also eat a limited amount of mollusks, insects, small fish, and crustaceans, which meets the protein needs of their diet. While foraging, they may graze on land or nibble at aquatic plants at the surface of the water.

Nesting

These are monogamous geese that may mate for life, though there are recorded occasions of polygamy when females significantly outnumbers males on the breeding grounds. The nest is a shallow scrape lined with down, but occasionally bar-headed geese will nest in trees.The eggs of bar-headed geese are plain, dull white or a pale buff, and there are 3-8 eggs.Young females may lay their eggs in an older, more established female's nest, though such parasitic eggs rarely hatch.The female parent incubates the eggs for 27-30 days, and the goslings(i.e young goose)are capable of a high degree of a independent activity immediately after hatching hence they leave the nest within a day or two of hatching. Both parents guard and guide the chicks, which are capable of their first flights at 53-55 days old but are not fully independent until 65-80 days after hatching. Juvenile birds typically stay in a loose family group throughout the winter and only venture off on their own after returning to their breeding grounds the following spring. Bar-headed geese are not sexually mature until they are three years old.Only one brood is raised each year.

Breeding Ecology

The bar-headed goose breeds at high altitudes in *central asia.* Many geese visit breeding lakes prior to the spring in april. Breeding birds remain at the nest site and nearby feeding areas during the nesting period. Females incubate the eggs while males remain vigilant nearby, but pairs may share nesting islands with *gulls* and *cormorants*. Clutch size averages 3–4 eggs, and incubation lasts 27–30 days. Smaller numbers of geese nest on river islands, or nests in trees, or on cliffs where nest survival may be higher. They use a variety of nesting substrates,including pondweed, sand and soil. Bar-headed Geese forage on natural wetlands, including freshwater and

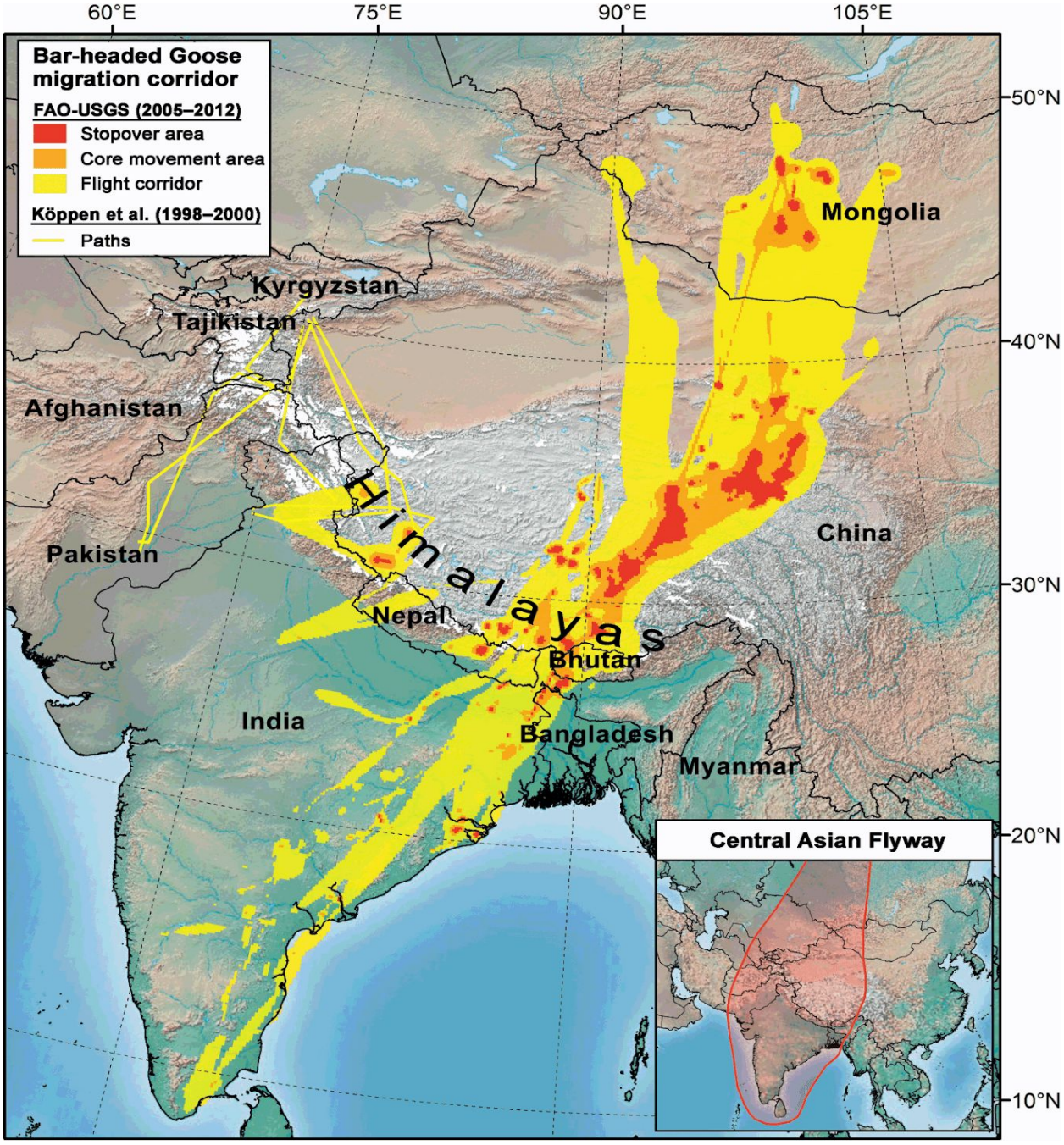
brackish lakes and riverine habitats. Goslings feed on lake edges with their parents and typically reach 400–500 g body mass within one month. Families are thought to remain together throughout the autumn migration(The goose in autumn migrates from its winter feeding grounds in lowlands of india to its nesting grounds in tibet) and the winter. Subpopulation of Geese who came to *south east india* to *winter* spent breeding season at Western Mongolia, Terkhiin tsagaan lake, Sagsai river valley, Tuul river, Qinghai lake, Lhasa river valley(almost 30% population winters here also to avoid crossing Himalayas), in Bhutan near Brahmaputra river.

Wintering numbers and ecology

Bar-headed Geese spend most of the winter on grasslands, pastures or agricultural areas, but they also use habitats in nearby natural wetlands, rivers and lakes.The largest wintering population in China appears to be in Southern Tibet near *Lhasa river valley*. Other wintering sites include watersheds of the *Yarlung zangbo* river in china and *Nyang river* in tibet. Number of distinct subpopulations may suggest distinct wintering areas.

Migration routes and stopover sites

They migrate long distances between *southern wintering* areas and *northern breeding grounds* in asia. This flyaway is uniquely defined by 200-400 km wide barrier of the *himalayan mountain range* that extends 2300 km from *nanga parbat* in pakistan in the west to *Namche-barwa* in china in the east,rising to an average elevation of 6100 m above sea level. The Himalayas present an obstacle to migration of waterbirds wintering on the Indian subcontinent from northern breeding grounds . Only two populations of true geese numbering in the thousands, the *Bar-headed Goose* and the



eastern population of the *Greylag Goose,* regularly winter on the Indian subcontinent.They followed the route - southeast to western Tibet crossing the Himalayas to wintering areas in Northwest India, including the Ravi, Degh and Chenab river valleys. Not all subpopulations of geese crossed the Himalayas, however and of them wintered in southern Tibet. In fact, there

may be a trade-off for geese wintering north and south of the Himalayas; geese wintering in Tibet must withstand harsher winters but offset this cost with a shorter migration distance and earlier arrival at the breeding grounds. Geese wintering in the milder climates of central and southern India migrate longer distances and cross the highest mountain barrier on the planet to winter in *Chilika lake, Odisha India*.

Bar headed Geese marked in southern and eastern coastal india followed a 3000-5000km leapfrog migration past Qinghai lake, crossing the Himalayas, the Qinghai-Tinetian plateau and the Gobi desert to breeding areas in Mongolia. For these geese, Dochen Lake and wetlands south east of Lake Como Chamling were the first spring stopovers north of the Himalayas . Almost 70% of the geese crossed the Himalayas through Nathu pass on the border between Sikkim, India, Tibet and China.

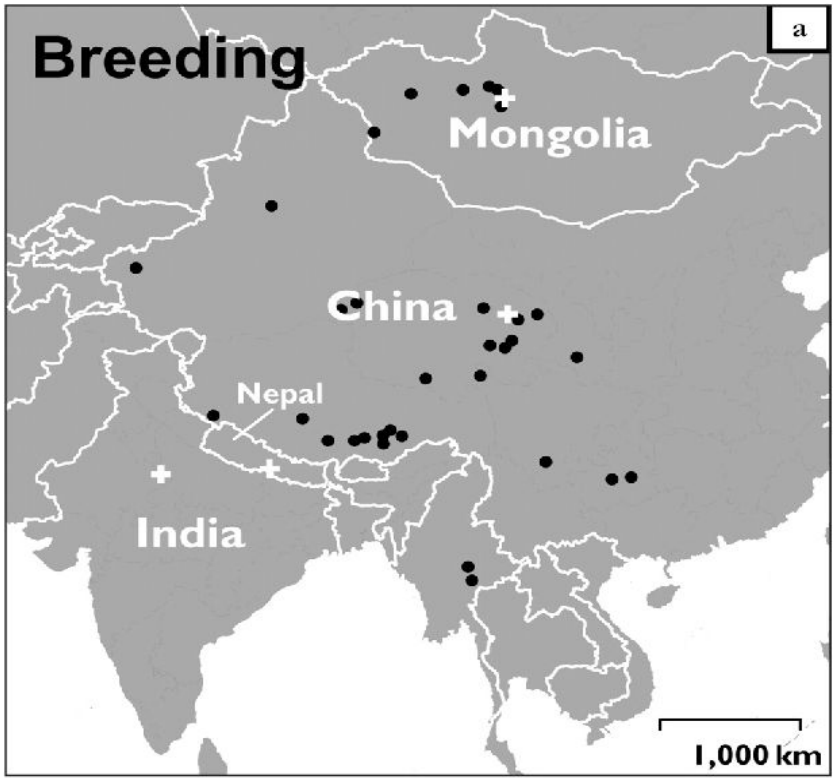
Northern flight to Himalayas

Bar-headed geese make one of the highest and most iconic transmountain migrations in the world. Some populations of geese that winter at sea level in India are capable of passing over the Himalayas in *1 day*, typically climbing between 4,000 and 6,000 m in *7–8 h.* They strategically avoid higher speed winds during the afternoon, thus maximizing safety and control during flight. Large birds may find such barriers particularly challenging as the sustained climbing rates of birds scale negatively with increasing body mass. Their most passes are at altitudes greater than 5,000 m, where the air density and partial pressure of oxygen are only about half of those at sea level. However, bar-headed geese have adapted in a variety of ways for living and flying at high altitudes . Their skeletal and cardiac muscles are better supplied with oxygen, having greater capillary density, more homogenous capillary spacing, a higher proportion of

mitochondria in a subsarcolemmal location, and a greater proportion of oxidative fibers than other waterfowl. Bar-headed goose hemoglobin is also highly effective at oxygen loading compared with many other bird species.These can enhance their climb rates or flying speed by selecting favorable wind conditions. Large mountainous areas are characterized by daily slope winds that occur due to predictable changes in daily solar radiation and thermal conditions. Geese generally matched the underlying terrain during their climbs and were most frequently located within 340 m of the ground (containing 80% of locations) and thus avoided climbing any steeper than was necessary. They crossed the Himalayas Southward in max 4.5 hour and min 3 hour.

Relatively early flight times, for both southerly and northerly migrating individuals, may be suitable because the air is likely to be colder and with lower wind speeds, which could be beneficial in a number of ways. Early flights would avoid the potential heat load of flying at low altitudes in India during the hottest time of the day, whilst cooler nighttime and early morning temperatures could help dissipate metabolically produced heat from the body. Early morning and midnight flights may save them from turbulent or stormy weather more prevalent in the afternoon.

After crossing the world's highest mountain range,Geese divide into four major wintering sites in India. 1) Pong dam, Himachal pradesh; 2) Chitwan national park,Nepal; 3) Chillka lake,Orissa; 4) Koonthankulam lake,Tamilnadu.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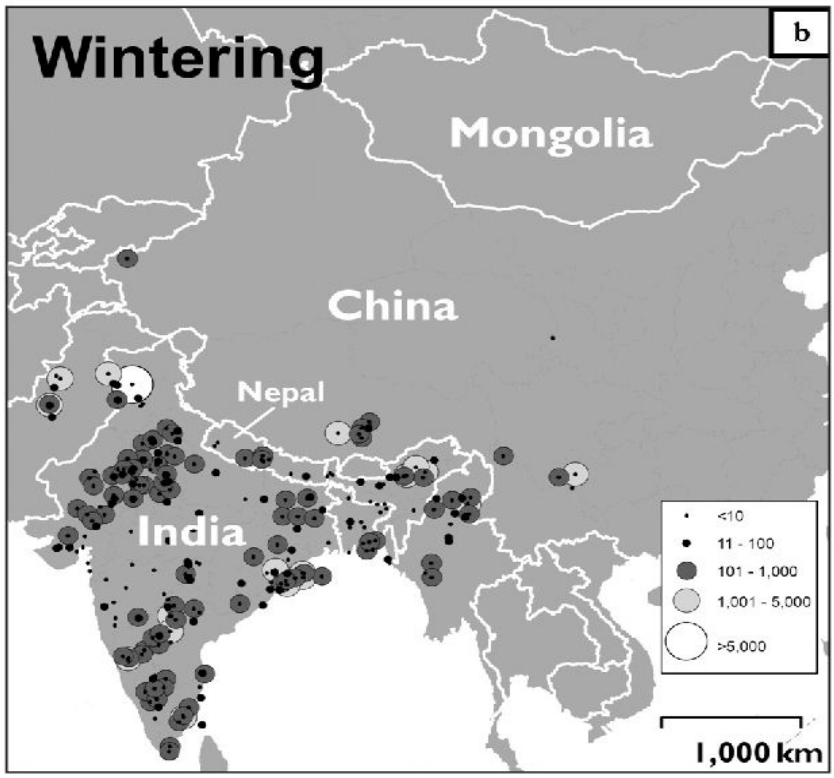
Breeding
Mongolia
China
Nepal
India
1,000 km


b
Wintering
Mongolia
China
Nepal
India
<10
11 - 100
101 - 1,000
1,001 - 5,000
>5,000
1,000 km

Observations

The general movement patterns of individuals within each subpopulation were similar, while the overall migration routes between subpopulations differed.There is at least three subpopulations of Bar-headed Geese characterised by their primary use of distinct wintering areas and breeding grounds: India–Nepal, China, and Mongolia.Variation among subpopulations is of critical importance for a species to be resilient to environmental change, demographic stochasticity, and disease. Sub-populations may possess behavioural, morphological, and physiological adaptations unique to their specific wintering and breeding habitats and migration pathways.

Population threats

Bar-headed Geese may be vulnerable to population declines as a result of wetland loss in over-wintering areas, changing land use patterns, severe damming of rivers for electricity generation, climate change-induced habitat alteration on portions of their breeding range , hunting pressure , and susceptibility to emerging infectious diseases such as highly pathogenic avian influenza H5N1 .

Land use change

In many areas across the range of Bar-headed Geese, riverine habitat is being lost to channelization. In Tibet, hydroelectric development threatens to disrupt river flows and alter important roosting and feeding areas.Powerlines from these projects are already a major source of injury and mortality to geese in some areas, including along the Yarlung River in Tibet, which is part of a large wintering area in the flyway. Elsewhere, power lines near roosting sites and migratory corridors are a significant threat. Availability of

agriculture may have resulted in geese short-stopping in this region rather than following traditional migration routes crossing the Himalayas . Wetland reclamation, urbanization and water pollution have led to population declines in wintering areas in Guizhou Province. Illegal gold mining, overgrazing, poaching and other anthropogenic disturbances have also degraded goose habitats and may have decreased breeding success in the Altun Mountain Nature Reserve.

Climate change

Changing climatic conditions are evident in the Qinghai-Tibetan Plateau, where temperature increases have been greater than Northern Hemisphere and global averages and are more pronounced during the winter. In the northern Qinghai-Tibetan Plateau and Mongolia, higher temperatures and decreased precipitation coupled with higher water demand by local communities have altered semi arid habitats in recent decades. In the southern Qinghai-Tibetan Plateau, warming temperatures and higher humidity have led to an increase in vegetative cover . Breeding phenology of Arctic nesting geese has been sensitive to climatic variation during the spring and the summer . In single-brooded species such as the Bar-headed Goose, a temporal mismatch between the brood rearing period and peak food availability could negatively affect reproductive success.

Disease threats

Bar-headed Geese are susceptible to outbreaks of highly pathogenic avian influenza H5N1 virus. The largest recorded wild bird outbreak at Qinghai Lake killed 3282 Bar-headed Geese in May2005.It is found that geese experimentally infected with H5N1 virus survived up to eight days. Thus, during the asymptomatic period, infected geese could fly hundreds of kilometres and disseminate the virus.

Mathematical Model

Description:

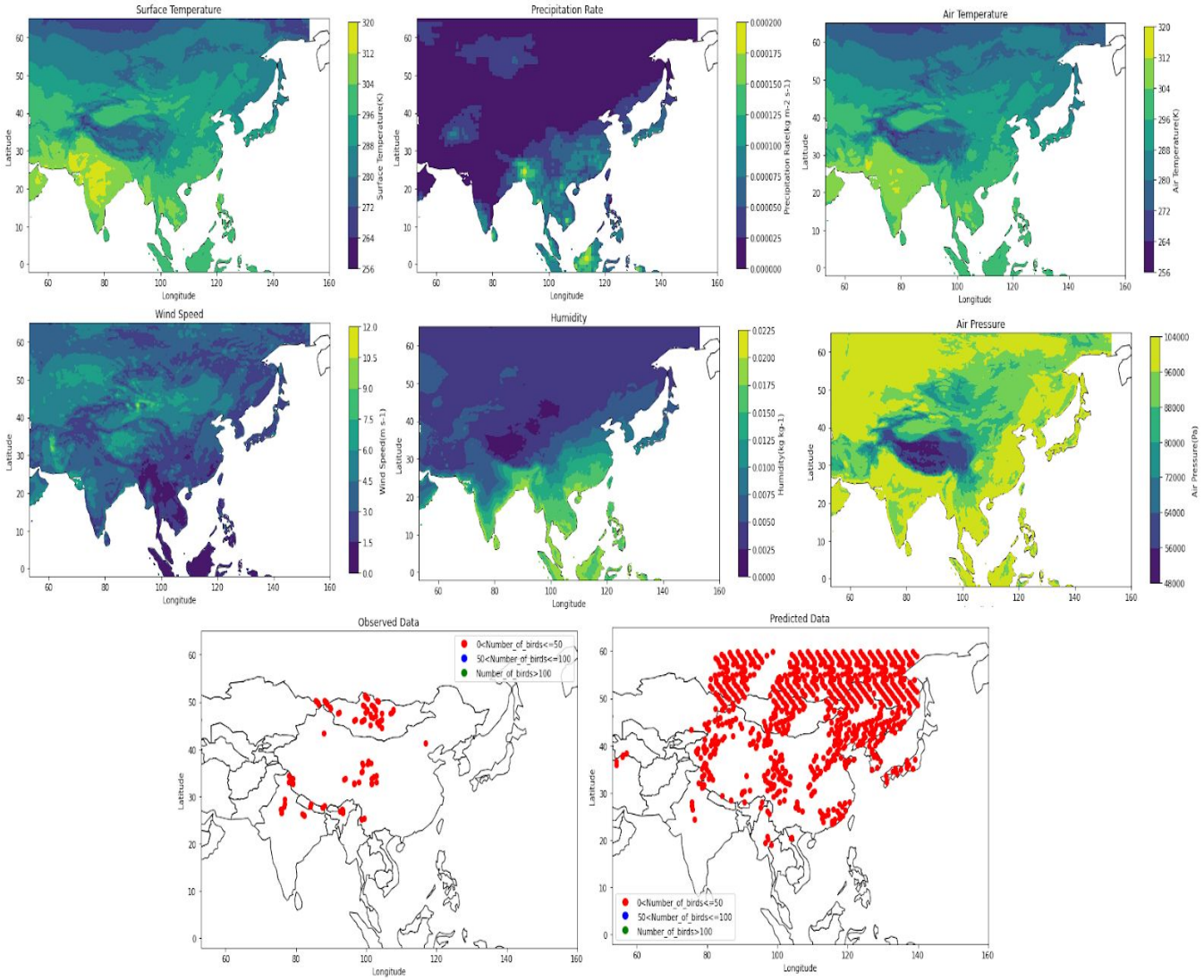
We modeled the distribution of bar headed goose in 4 different categories. We took six factors into consideration for modeling. They are Surface temperature, Air temperature, Humidity, Precipitation rate, Wind speed, Air Pressure. We took data of human observations for birds and we categorized that data into four categories. We resampled this data by applying Undersampling and Oversampling algorithms. We got data for environmental variables from NASA's project GLDAS. We used ANN(Artificial Neural Network) in order to make models predictive. We prepared 4 hidden layers of each having 16 neurons. We predicted for 4 different categories. We trained the model and were able to achieve 85% of accuracy.

Preparation of data:

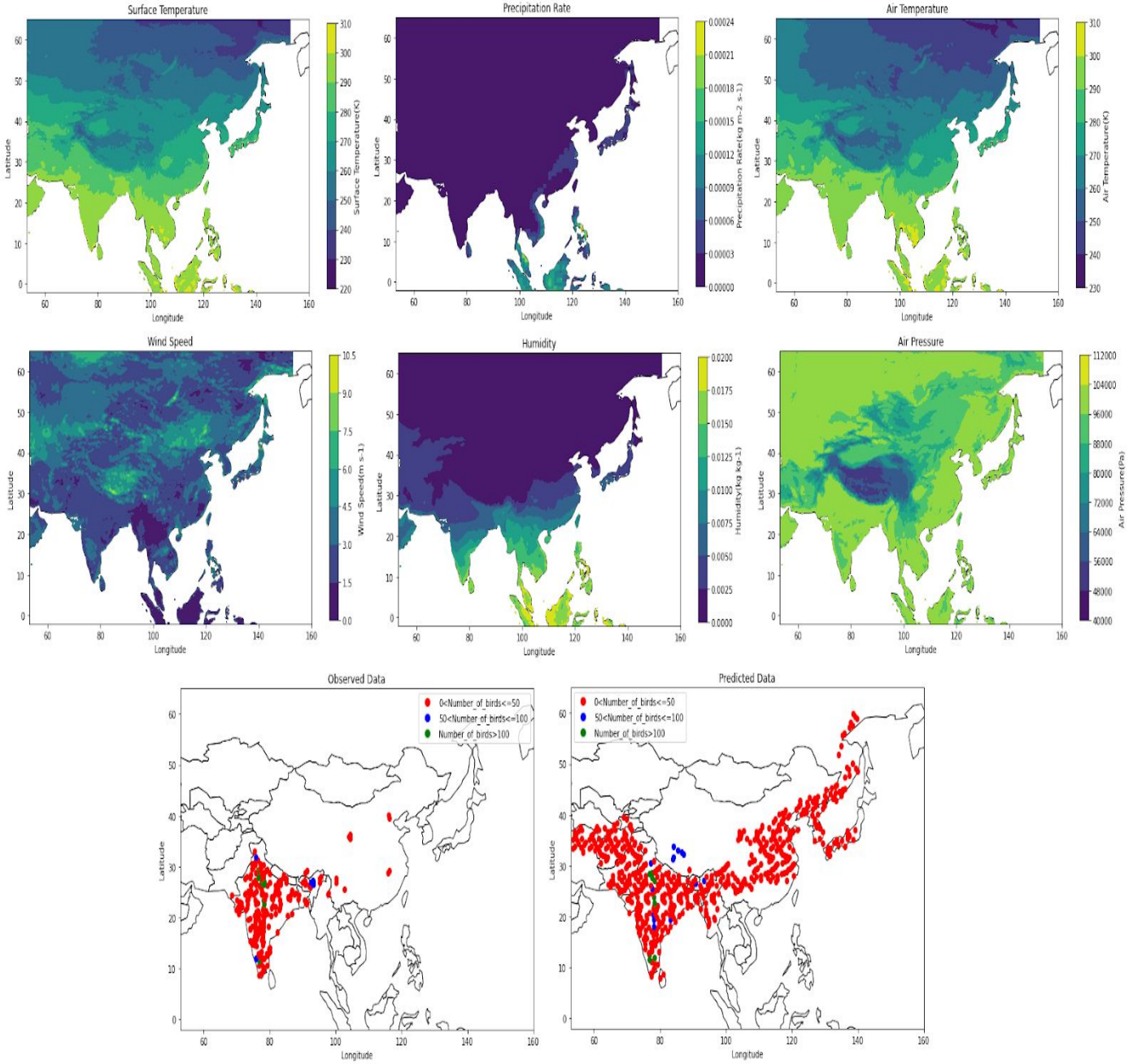
To train the model, we used data of the years from 2000 to 2017. We compared its predictions with actual observations of year 2018. To predict the number of birds for a particular month, all the coordinates where geese were observed during 2000-2017(of each month) will become presumptive coordinates. After inserting data of all the six factors for that particular month, the model will predict the coordinates where geese can be found for that month. The coordinates which are not predicted out of presumptive coordinates, will be categorized as zero. We got the number of birds by rounding off the coordinates of locations where the birds were observed. This data was very much imbalanced because the number of samples of zero category was very high than others. We balanced this data by applying the sampling algorithm on zero category data and over sampling on others.

Site	Arrival Period	Departure Period
Breeding Areas	*Late April To Early May*	*September To November*
Wintering Areas	*Mid October To Early December*	*Around mid march*

Breeding period(May)



Wintering Period(Dec)



Route Optimization Model

Description

The model uses the energy consumed by the birds during their flight from one point to another, and the amount of energy regained by them during a spot over sight which included factors like their breeding pattern, eating pattern and availability of materials at a stopover sight.

This model utilizes technology like MATLAB which gives you freedom to input your values and plots a graph(route) of the bird moving from one place to another based on different factors like temperature, precipitation and vegetation index.

This model is based on energy. We approximated the energy units gained by the birds at the different stop-over sites. Taking into consideration the distance between the stop-over sites and breeding sites, we approximated the energy utilized to travel between each pair of sites. So for a specific route, the total energy would be equal to the energy consumed by the bird during the flight minus the energy regained by the bird during all the stopover sites in that route. And the route in which less amount of energy is utilized turns out to be the most optimized route for migration.

Calculation : For the purpose of our study, we considered the routes terminating in Northern India and/or leading to Chilika Lake. Four routes were mapped out on the basis of the stop-over sites in between. They are as follows:

1) Terkini Tsagaan Lake (Mongolia) - Qinghai Lake (China) - Tibet - Nepal - Pong Dam(India)

2) Terkini Tsagaan Lake (Mongolia) - Qinghai Lake (China) - Tibet - Nepal - Keoladeo National Park (India)
3) Terkini Tsagaan Lake (Mongolia) - Qinghai Lake (China) - Tibet - Nepal - Chilika Lake (India)
4) Terkini Tsagaan Lake (Mongolia) - Qinghai Lake (China) - Tibet - Bhutan - Bangladesh - Chilika Lake (India)

Observation

Route #1

Route #2

Route #3

Route #4

Observation :

The optimised route for bar headed geese is predicted to be route 4, which is : Terkini Tsagaan Lake (Mongolia) - Qinghai Lake (China) - Tibet - Bhutan - Bangladesh - Chilika Lake (India). This route includes more stop over sites compared to the other routes, the energy regained by the birds is more in this route. Secondly, they will not have to suffer from harsh weather conditions of the Himalayas during their migration period. Routes 1, 2 and 3 force them to cross very high mountain ranges, which utilizes a lot of their energy and many birds perish. Based on our research, the majority of the birds do not winter in China as there was an outbreak of a H5N1 avian flu influenza in China in the bar headed geese. Hence, if they breed at stop-over sites in China, some birds stay back to care for the young while most of the others continue on the route.

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