INTRODUCTION

Contents

Understanding Wildlife Conservation
Taxonomy and Classification
Diversity of Flamingos
Population and Distribution
Breeding in Lesser Flamingo
Why Are They Important on Global Map?
Lacunae in Knowledge

Wildlife Conservation

Wildlife conservation consists of using scientific knowledge and practices to use, preserve, protect, conserve, enhance, and control wildlife resources. Conservation is an effort to maintain and use natural resources wisely in an attempt to ensure that those resources will be available for future generations.

Status of Avian Conservation

The beauty and grace of birds has long captured the human imagination, just as their sound and color can grab our attention at any moment. More than 1200 species of birds inhabit India for at least part of their lives, meaning that few people have failed to be captivated by the glimpse of a particular bird. They inhabit our forests, grasslands, deserts, wetlands, coastlines, and urban areas. Though they are everywhere, there are species that are declining at rapid rate and are on the verge of extinction (e.g. Great Indian Bustards, White-rumped Vulture etc.). However, birds and their habitats are threatened, principally as the result of human activities. Habitat loss and degradation, resulting from activities such as extensive development, industrial agriculture, energy production, and natural-resource extraction present major challenges to bird populations. Invasive

species pose threats, too, by altering habitats, increasing predation and competition for food and nest sites, and introducing diseases.

General Introduction to Flamingo

Flamingos are unmistakable birds, due to their remarkably long neck and legs and their distinctive pink plumage. They are large birds standing up to 90-155 cm tall. The neck and legs are longer relative to body size, than in any other group of birds. The long legs allow them to wade to greater depth, while the long neck facilitates feeding from the mud at the bottom. The pink plumage with black flight feathers is characteristic of all the flamingo species. The reddish/pinkish coloration comes from the carotenoid pigments, which are synthesized by algae that forms an important part of the flamingo's diet. Their half-curved bill possesses lamellae that filters its food and disallow larger food particles to be swallowed in.

The flamingos form one of the most ancient bird families, and there are fossils of present day genera from the Oligocene period, about 30 million years ago, while more primitive forms have been traced back to the Middle Eocene, more than 50 million years ago (Lanyon, 1992). Some fossils have been turned up in parts of Europe, North America and Australia where flamingos are not found today indicating that their past distribution was wider than at present (Rasmussen et al., 1986).

Taxonomy and Classification

The classification of flamingos has puzzled taxonomists for years. Flamingos have characteristics in common with a number of bird groups, and it remains unclear to which group they are most closely related. Flamingos are sometimes placed in the Order Ciconiiformes but it is now generally accepted that flamingos should be placed in their own Order, Phoenicopteriformes.

The proper phylogenetic position of the Phoenicopteridae has long been a perplexing problem in avian systematics. Because of the conflicting nature of the taxonomic evidence presented so far, the relationships of these birds

have never been satisfactorily resolved (Olson and Feduccia, 1980). Flamingos or flamingo like birds are well documented in the fossil record, extending well back into the late, and perhaps early Cretaceous (Brodkorb, 1963); however to date the fossil record has failed to provide any conclusive evidence concerning the relationships of this enigmatic group.

Flamingos are most often placed with storks, herons, and ibises in the order Ciconiiformes. This assemblage consists of large, long-legged waterbirds having a long neck, "desmognathous" palate, and usually altricial young (Sibley and Ahlquist, 1990). While Hagey (1990), based on the behavior patterns, webbed feet and water proof plumage similar to geese especially those of chicks, placed them closer to geese (Jhonson et al., 2006).

Sibley et al. (1969), in reviewing the classification of the flamingos, listed 15 separate taxonomic treatments. In each case, the flamingos were placed somewhere near the anseriformes (ducks, geese and swans) or the ciconiiforms (storks, ibises, and herons). Sibley et al. (1969) stated that, "The question is, are the flamingos most closely related to the herons and storks and merely convergent to the anseriform birds in certain characters or were they derived from the ducks and geese and later converged toward the ciconiiform birds?" Alliance with the ducks and geese has been based primarily on the structure of the bill and feet, voice, development of the young, and the mallophagan parasites, while general anatomical similarity has been used to indicate alliance with the Ciconiiformes.

On the basis of the protein evidence Sibley et al. (1969) concluded that the flamingos (Phoenicopteriformes), Ciconiiformes, and Anseriformes are related to one another and that the flamingos and Ciconiiformes are closer to one another than either is to the Anseriformes. These are conclusions similar to those of many authors, but Sibley et al. (1969) cautioned that, "A third possibility is that they were derived from some other group and are similar to both geese and herons by convergence."

In the early 1980s, a new hypothesis claimed that flamingos have common ancestors with some of the waders, including oystercatchers, avocets and

stilts, and should, therefore, be included as a separate family within the Charadriiformes (Olson and Feduccia, 1980). This proposal was based on fossil evidence and on similarities, in both anatomy and behavior, between flamingos and the Australian Banded stilt (*Cladorhynchus leucocephalus*), while the resemblance with storks, herons and waterfowl were put down to convergent evolution (Olson, 1979).

Olson et al. (1980) examined the evidences supposedly showing a relationship between flamingos and either storks (Ciconiiformes) or ducks (Anseriformes) in light of the recent hypothesis deriving flamingos from shorebirds of the order Charadriiformes. Anatomical characters used to indicate relationship between flamingos and storks are shown to consist entirely of primitive "non-anseriform" traits found in several other orders, including Charadriiformes. Most of the presumed anseriform characters of flamingos also occur in the Charadriiformes, as do all of the characters of flamingos that do not occur in either Ciconiiformes or Anseriformes. The distinctive life history and behavior of flamingos is demonstrated as being very similar to that of the Recurvirostridae (Charadriiformes), particularly the Australian Banded Stilt *(Cladorhynchus leucocephalus)*, but is unlike that of storks or ducks (Olson et al., 1980). Sibley et al. (1988), using DNA-DNA Hybridization analysis techniques, concluded that flamingos are most closely related to storks, ibises, shoebill, pelicans and New World vultures. Recent genetic data suggests that the closest living relatives of the flamingos are the grebes (van Tuinen et al., 2001; Hackett et al., 2008), as does a sister relationship between their ischnoceran lice (Johnson et al., 2006), and most recent authorities now place these two very ancient groups next to each other in any taxonomic listing. Both have no close living relatives.

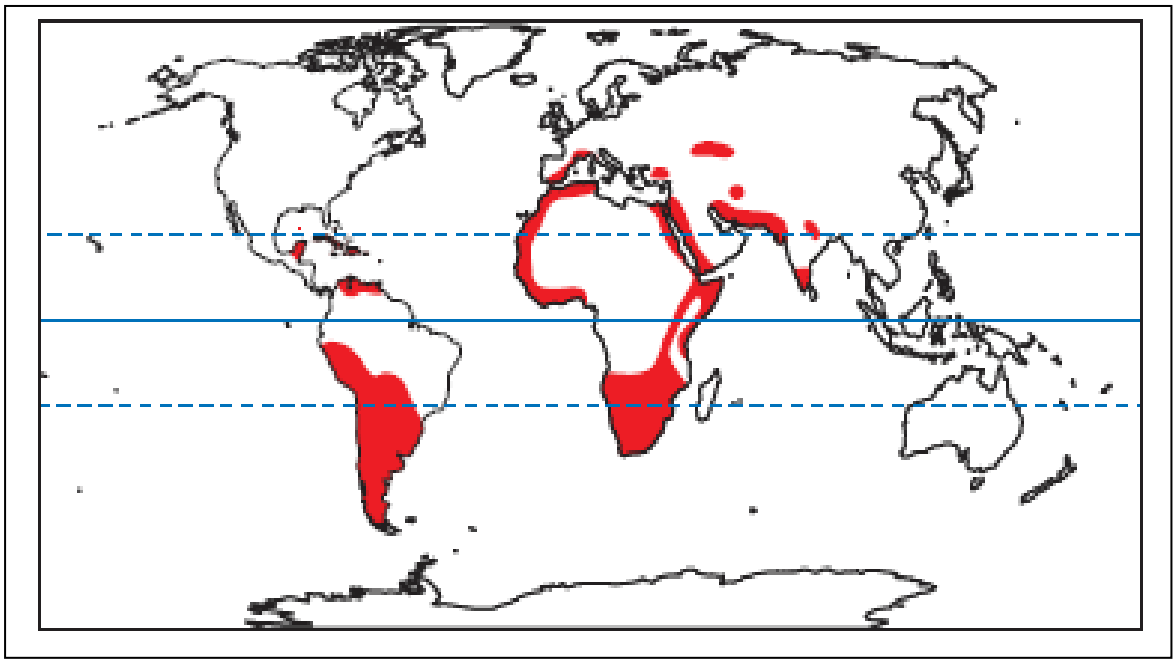
The IUCN-SSC group and Birdlife International currently support the view that the flamingos are their own family (Phoenicopteridae) within the order Ciconiformes (IUCN 2004; Birdlife International 2000).

The classification scheme for the Lesser Flamingo is as under.

Phylum	Chordata
Class	Aves
Order	Ciconiiformes
Family	Phoenicopteridae
Genus	*Phoeniconaias* (Geoffroy Saint-Hilaire, 1798)
Species	*Phoeniconaias minor* (Geoffroy,1798)

Flamingo species of the World

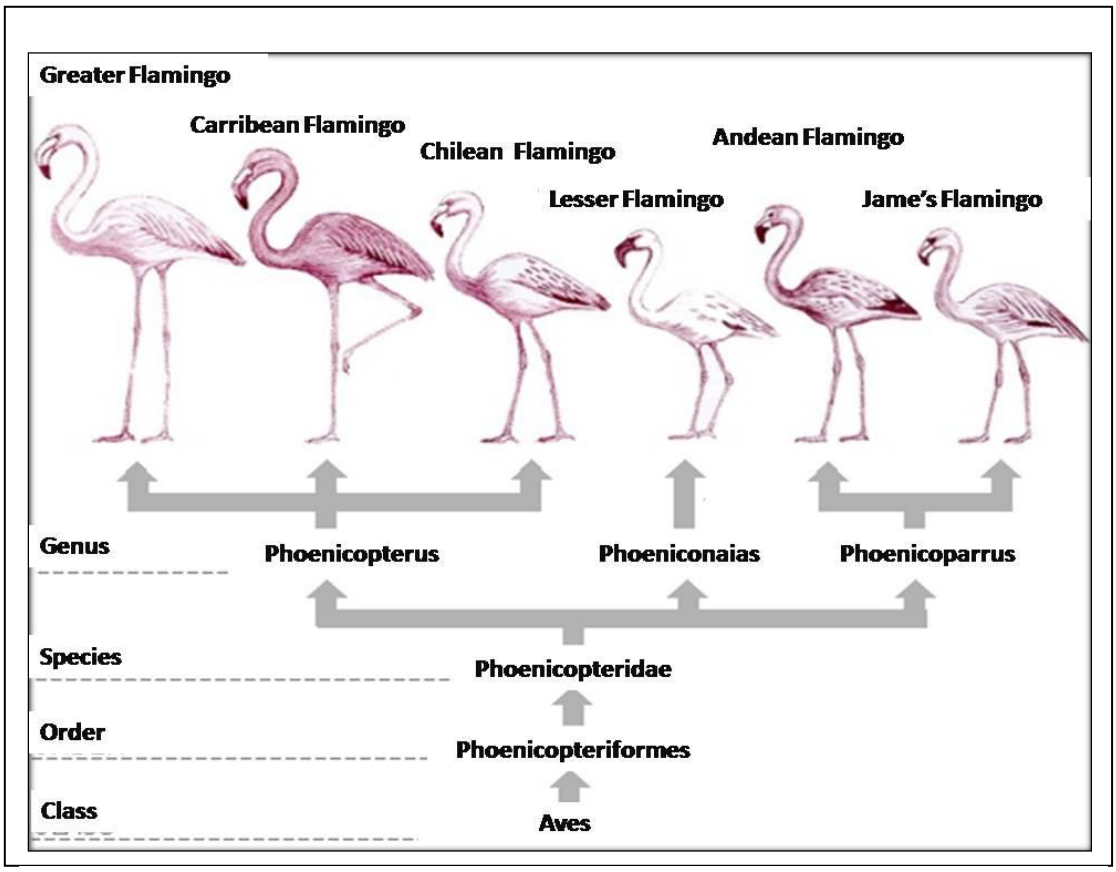
Six species of Flamingos are known, all in the family Phoenicopteridae. These six species of Flamingos occurs in Africa, Asia, Europe, North America and South America (Fig. 1).



Source: Birds of the World (II)

Fig 1: Distribution of Flamingo species of the world (sites marked Red)

The existing six species are placed in three genera that are separable into two groups on bill morphology: (1) Phoenicopterus, which has a more primitive filtering apparatus, (2) Phoenicoparrus and (3) Phoeniconaias, which are more specialized in their feeding and habitat requirements (Jenkin, 1957). The largest species is the Greater Flamingo, standing up to 120 cm to 150 cm (3 ft 11 inches to 4 ft 11 inches) tall and weighing up to 3.5 kg. The smallest species is the Lesser Flamingo, standing up to 80 cm (2 ft 7.5 inches) tall and weighing 2.5 kg. Both these species are found in the Old World while Caribbean, Chilean, Andean and James's Flamingo are found in the New World (Fig 2) (Allen 1956, http: //www. flamingoatlas.org).



They occur in fresh, brackish, and salt water habitats: shallow lagoons, alkaline lakes, and estuaries. All the flamingos are filter feeders.

Fig 2: Flamingos of the World (classification and size)

Flamingo Species of India

Two species of Flamingos are found in India, The Greater Flamingo (*Phoenicopterus roseus*) and the Lesser Flamingo (*Phoeniconaias minor*). Both these species of Flamingos are resident species and breeds in the Little Rann of Kachchh in Gujarat. When not breeding, the former occurs in majority of the coastal states of India and some inland wetlands, while the latter has restricted distribution and mainly confined to the western coast of the country (Gujarat and Maharashtra).

Greater Flamingo (*Phoenicopterus roseus*)

The Greater Flamingo, *Phoenicopterus roseus* is the largest, palest and most widespread of all the flamingo species. It is found in parts of Africa, southwest Asia, southern Asia and southern Europe (Birdlife International 2012). Formerly the species *Phoenicopterus ruber* was considered a single species (Sibley and Monroe, 1990, 1993) but later following the studies by Knox et al. (2002), contra SACC (2005), the species has been split into *P. roseus* (Greater Flamingo) and *P. ruber* (Caribbean flamingo). It is distinguished from all other flamingos by its large size (averaging 120 - 150 cm) in combination with its pale plumage.

This species is regularly seen from West Africa eastward throughout the Mediterranean to South West and South Asia, and throughout sub-Saharan Africa. The Palearctic population (including West Africa, Iran and Kazakhstan) is estimated to number between 205,000 and 320,000, the South West and South Asian populations combined at 240,000, and the sub-Saharan African populations between 100,000 and 120,000 (Delany and Scott, 2006). The Palearctic population appears to be increasing, while the Asian and sub-Saharan African populations appear to be stable (Delany and Scott, 2006).

Lesser Flamingo (*Phoeniconaias minor*)

The most numerous of the world's flamingos, the (*Phoeniconaias minor*) was classified “Near Threatened” in the 2006 IUCN Red List of Threatened Species, indicating that it is considered likely to qualify for a threatened

category in the near future. The species is also listed in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) Action Plan, Appendix II of the Bonn Convention (CMS) and Appendix II of the CITES Convention. The Lesser Flamingo is an itinerant species adapted to respond to changes in local environmental conditions by moving among wetlands, and thus depends on a network of suitable sites (Childress et al., 2007).

Population and Distribution

The Lesser Flamingo due to its intrinsic habitat requirements and colonial feeding and breeding habits is a restricted range species and its major populations are concentrated at just four major sites in the world. The largest population, estimated to be 1.5 - 2.5 million individuals, occurs on the alkaline-saline lakes of the Great Rift Valley in East Africa. In other parts of Africa, it is estimated to be 55,000 - 65,000 birds in southern Africa and 15,000 - 25,000 birds in West Africa (Wetlands International, 2006).

Smaller populations occur in the Rann of Kachchh in western India, estimated to be approximately 390,000 birds. Population declines have been recorded for much of the Africa, but it is difficult to clarify due to wide scale movement within the continent. Increasing numbers of vagrant Lesser Flamingos are sighted each year in the Middle East and the Mediterranean region (Childress et al., 2007).

Lesser Flamingos during non-breeding season occurs in majority of the sub-Saharan countries and from the Arabian Peninsula to India (Birdlife International, 2000). In south Asia, Lesser Flamingos are found at a variety of mostly coastal sites between Yemen and Bangladesh (del Hoyo et al., 1992; Mundkur, 1997).

The Lesser Flamingo occurs regularly in 29 countries from West Africa, across sub-Saharan Africa and along the south-west Asian coast to South Asia, and occurs as a vagrant in 25 additional countries. Though, its global population is concentrated in10 primary range states and confirmed regular

breeding is confined to just five sites in four of these countries: Makgadikgadi Pans in Botswana, Etosha Pan in Namibia, Lake Natron in Tanzania and Zinzuwada and Purabcheria salt pans in India (Childress et al., 2007). Of these confirmed breeding sites, only Etosha Pan and the two sites in India are officially protected (Fig 3).

The Lesser Flamingo is a non-migratory nomadic species with flocks constantly moving between different feeding sites (Childress et al., 2004) (Fig 4). The normal Lesser Flamingo flight speed is approximately 60-65 km/h (Mc Culloch et al., 2003; Childress et al., 2004). The movement is sometimes in response to changes in local environmental conditions (Tuite, 1979).

The abundance of food supply does not necessarily attract the bird (Vareschi, 1978), but the decline in the food sources will cause the birds to abscond a site (Vareschi, 1978; Tuite 1979). It is a highly itinerant species (Evans 1985), moving frequently and impulsively from lake to lake within the Great Rift Valley (Brown, 1975; Vareschi, 1978; Tuite, 1979; Brown et al., 1982; Tuite, 2000), and between salt pans and other wetlands in southern Africa (Borello et al*.,* 1998; Mc Culloch et al*.,* 2003), but returning to the same breeding sites. Traditionally, the frequent inter-lake movements have been thought to be associated with fluctuation in food abundance (Vareschi, 1978; Tuite, 1979).

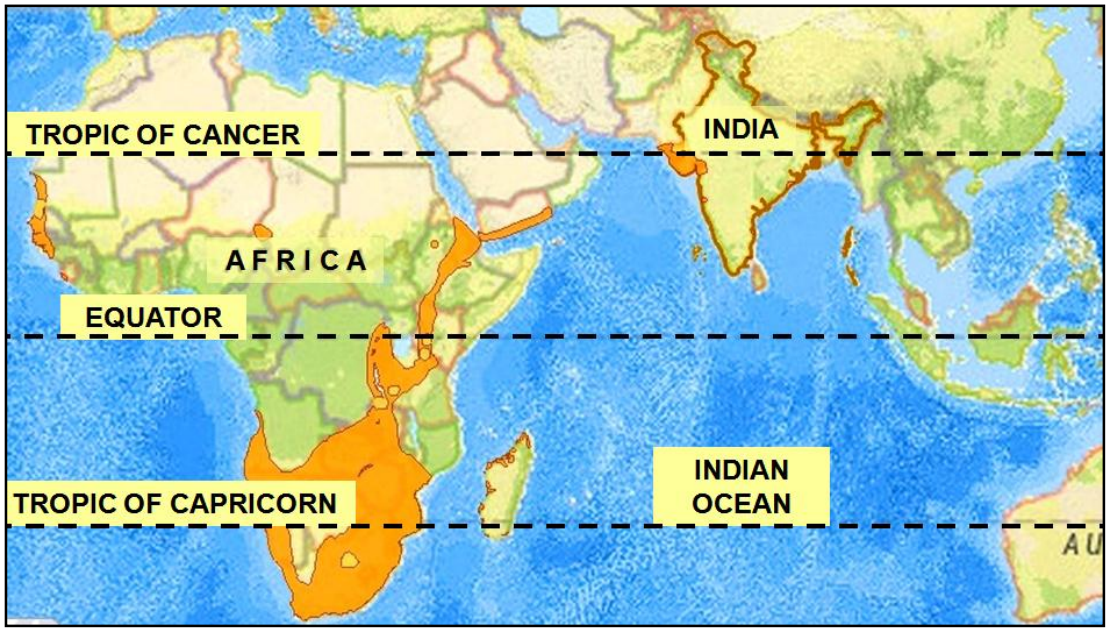
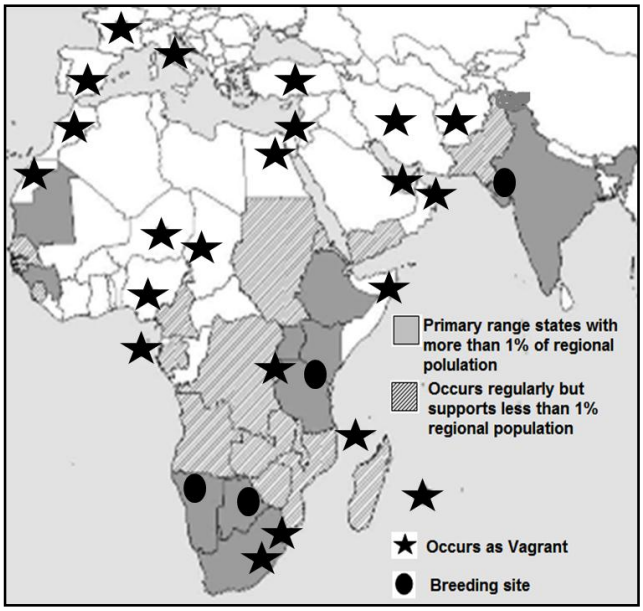


Fig 3: Map showing distribution of Lesser Flamingos in the World (orange colored sites). (Source: http://maps.iucnredlist.org)



(Source: Joint Nature Conservation Committee (JNCC, UK) Reports, No. 381)

Fig 4: Lesser Flamingo distribution Map.

Distribution in India

In Indian Subcontinent, Lesser Flamingos occur mainly in the states of Gujarat and Rajasthan in North-western India (Jadhav and Parasharya 2004). There are smaller populations in southeastern Pakistan, along the border with India, and along the southern coast of Arabian Peninsula in

Yemen and Oman (Mundkar 1997). In India, the Lesser Flamingo mainly occurs in the coastal intertidal mudflats and saline pools along the shore, and in the Great and Little Rann of Kachchh in Gujarat (Jadhav and Parasharya, 2004). Lesser Flamingos have been observed throughout the year in Sambhar Lake during 1997 (Sangha, 1998) and during 1995-96 both the species of Lesser Flamingos have been reported to bred in Sambhar Lake, Rajasthan (Varu and Khacher, 1998). Lesser Flamingos were also observed in Anna Sagar Lake in the city of Ajmer, Rajasthan (Shivakumar, 2004). Lesser Flamingos are also observed regularly during non-breeding season in Sewri mudflats of Mumbai, Maharashtra (Sunjoy Monga, personal communication).

Distribution in Gujarat

Gujarat is one of the strong hold states of the 'Near Threatened' Lesser Flamingo (*Phoeniconaias minor*) in India. Major congregations of Lesser Flamingo are found in Gujarat. The portion of Gulf of Khambhat (GoKh) near Dholera-Roniyo bet in Ahmedabad and Bhavnagar districts, the coastal areas of Bhavnagar, Jamnagar and Kachchh are major congregation sites for flamingos in non-breeding season. Whereas Gulf of Kachchh (GoK) near Surajbari (along the Surajbari creek), Little Rann of Kachchh, Great Rann of Kachchh in Kachchh district are well-known areas where breeding congregations have been reported (Tere, 2005; Mundkar et al., 1989).

The overall status of Lesser Flamingo for Indian subcontinent is migrant, with resident population in Gujarat as they breed here. In fact the Little and Great Rann of Kachchh are the only breeding sites for Lesser Flamingos in the entire Indian Sub-continent with major part of the population being restricted to western region in India and majority in Gujarat.

Diet and Feeding

Lesser Flamingos are filter feeders, feeding on microscopic cyanobacteria (Spirulina spp., Oscillatoria spp. and Lyngbya spp.) and benthic diatoms

(Navicula spp., Bacillariophyceae) found only in alkaline lakes, salt pans and saline lagoons and estuaries (Ridley et al., 1955; del Hoyo et al., 1992). The species have also been observed to take small aquatic invertebrates such as rotifers (Brachionus spp) (del Hoyo et al., 1992).

Breeding in Lesser Flamingo

The species is known to breed in only five sites, two in southern Africa (Makgadikgadi Pans in Botswana and Etosha Pan in Namibia), one in East Africa (Lake Natron) and two in India (Zinzuwada and Purabcheria salt pans). Of these breeding sites, only Etosha Pan and the two sites in India are officially protected. The Lesser Flamingo in East Africa does not show regular breeding season, nor does the species breed every year, however, the large breeding congregations have been recorded to develop there between October and February (Brown and Root, 1971). Lesser Flamingos do not breed every year, even when climatic conditions or the state of the mudflats would appear to be suitable. In 1955 there were very large numbers of flamingos on Lake Nakuru, in breeding condition on the evidence of enlarged gonads but no breeding took place. However, they did not; nor, apparently, did they breed anywhere else at that time, for no large numbers of recent young appeared on Lake Nakuru in 1955-56, as they normally do following successful breeding (Brown and Root, 1971).

Lesser Flamingos build mud-mound nests similar Greater Flamingos but are slightly smaller than those of the Greater Flamingo (Brown and Root, 1971). Lesser Flamingo nests in Magadi (East Africa) were from 24 to 8 inches (20.3 cm to 60.9 cm) high, and 15 inches (38.1) in basal diameter. At Lake Natron (Africa), on soft mud, the nests were 7 to 15 inches (17.7 cm to 38.1 cm) in height (Brown and Root, 1971). The Nest height as recorded by Tere (2005) was 6.4 to 18 cm at Purabcheria (Surajbari) nesting site and 10 cm to 29 cm in Zinzuwada nesting site in Little Rann of Kachchh. The circumference recorded was 105-184 cm at Purabcheria and 130-227 cm at Zinzuwada nest sites.

Usually one elongated oval, pale blue with thick chalky white outer layer is laid. Large numbers of birds tend to lay synchronously in particular parts of the colony (Brown and Root, 1971). Both sexes incubate, for about 28–29 days. Incubating birds are liable to desert en masse when disturbed. 70–90% of eggs hatch, usually about 85%. Larger colonies are more successful than smaller, and birds that lay out of phase with others tend to desert without hatching (Brown and Root, 1971).

Breeding in Gujarat

The history of flamingos in India dates back to 18th century, when the first certain record of breeding of Flamingos in India was reported by the Maharao Khengarji of Kachchh. One of his officials identified a place near Khadir where the Flamingo eggs were found during October 1893 and he received about 20 eggs and two recently hatched flamingos (Lester, 1894). From this evidences, it was concluded that the flamingoes lay eggs in September and October. The men who picked up the eggs found numerous nests in one place in the Rann (Lester, 1894). However, it was not specifically mentioned that the eggs belonged to either Greater or Lesser Flamingo. They noted that the nests; which were built of earth while the earth is wet; were not made on any particular island, but the birds seem to select ground slightly higher than the surrounding country. These were covered with shallow water on all sides to a considerable distance from the spot selected, evidently so as to be free from danger from jackals, wolves, etc (Rao Khengarji, 1904).

Lester (1904) was the first to presume that Lesser Flamingos might have bred somewhere in Rann of Kachchh. Later on, Salim Ali (1954) observed 1,00,000 adults and juveniles of Lesser Flamingo in Rann of Kachchh and agreed to the presumption of Lester. Later, in 1974 Salim Ali gave the authenticated proof of breeding of Lesser Flamingo in Flamingo city along with the Greater Flamingo. About 2000-5000 Lesser Flamingos were estimated breeding with Greater Flamingo in January 1974 (Ali, 1974). A new nesting site was discovered in Cherwari (a fishing village) on the north

bank of Hadkiya Creek in July 1987 where 288 nests of Lesser Flamingos were observed (Mundkur et al., 1989). Shri Uday Vora gave first authentic record of the species breeding in Little Rann of Kachchh in December, 1984. A colony of 10,000 nests was recorded near Koprani village (Vaishnav et al., 2005). In June, 1998, H.S. Singh, (IFS, Gujarat Forest Department) had recorded 30,000 nests and 25,000 eggs of Lesser Flamingos in Little Rann of Kachchh about 20 km from Vachchhraj Beyt, west of Jalandhar beyt (Times of India, 14.10.1998). In 1998 large colony of nesting Lesser Flamingos was recorded by Shabbir Malik at 7.5 km south of Vachchhraj Solanki Beyt. A colony of 25000-30000 nests and 25,000 chicks was recorded (Singh et al., 1999). An unsuccessful nesting attempt was also recorded from Porbandar city during 1991 (Khacher, 1994).

No published record of Lesser Flamingo breeding in the state was reported from any of the traditional breeding sites of the species till 2002. Later, in November 2002, about 9,200 nests were recorded near Zinzuwada in Little Rann of Kachchh (Parasharya and Tere, 2006), about 8,100 nests in September 2003, and about 4,000 nests were recorded in 2004 and 10,000 nests were recorded in 2005 (Parasharya and Tere, 2006). At Purabcheria site, unsuccessful nesting was recorded in 2006, wherein a total of 1100 nests were observed deserted. Large breeding congregations of Greater and Lesser Flamingo (5,00,000 – 10,00,000 birds of both Greater and Lesser Flamingos) have been reported sporadically in the Greater and Little Rann of Kachchh (Ali, 1945; 1954; 1960). The birds have a well-established breeding location (locally known as ‘Flamingo City’), and census numbers at this location are highest during the breeding season (Jadhav and Parasharya, 2004). Lesser Flamingos have been observed throughout the year in many salt pans along the coast of Gulf of Kachchh (Mundkur 1997) and the Gulf of Khambhat (Jadhav and Parasharya, 2004). About 3,72,800 Lesser Flamingos were counted from different sites in Gujarat during January 2003. They occurred exclusively on coastal wetlands, with 80% of the Lesser Flamingos in the Gulf of Khambhat (Jadhav and Parasharya, 2004). During October, 2003 total 6,65,920 Lesser Flamingos were counted from Gujarat,

the highest count of Lesser Flamingo ever recorded in India (Parasharya and Tere, 2006).

Why Are They Important on Global Map?

Due to its erratic breeding nature and very few known breeding sites, the population of Lesser Flamingo appears to be undergoing a moderately rapid decline (IUCN, 2001) and thus classified as 'Near Threatened' Species. Considering the population of Lesser Flamingo in India, Gujarat is the major stronghold of the species harboring more than 95% of the total Indian population and providing the two known breeding sites in the country. The species has never successfully bred outside Gujarat.

Lacunae

Most of the populations of Lesser Flamingos generally exists in remote areas, and thus were not studied in detail until recently (Morrison, 1975). The remoteness of many colonies has further restricted research efforts because investigators often cannot remain on site for extended periods. Studies have now addressed all species of flamingos (Ogilvie and Ogilvie, 1986), but nearly all investigations have focused on the breeding portion of the annual cycle. Indeed, of 303 literature citations reported in the symposium entitled "Flamingos" (Kear and Duplaix-Hall, 1975), none specifically addressed the non-breeding period.

Flamingos represent a group of birds with special needs and requirements for future survival because their specialized habitat is not abundant throughout the world (Sprunt, 1988). Additionally, the rigorous habitat occupied by the flamingos has the capability of producing salt, and humans have exploited these naturally saline environments for centuries for the production of salt via the evaporation of sea water (Sprunt, 1975; Friedman and Krumbein, 1985). Historically salt production operations in many arid coastal regions were conducted at a small scale and with limited habitat alteration. Recently, however, many salt-producing areas have been

converted to large, mechanized, high-volume production centers (Sprunt, 1975), some of which are in areas traditionally used by flamingos.

Management of the system to conserve wetland habitat and associated wildlife resources is hampered by lack of knowledge relative to flamingo behavior, habitat selection, movements among habitats, population ecology and the function of the entire wetland complex. However, management programmes for the flamingo cannot be formulated without detailed investigations. Flamingos breed colonially and regularly aggregate in large feeding flocks in both the breeding and non-breeding seasons suggesting their need for specificity in a given habitat. Understanding characteristics of this variable habitat and how flamingo use it, it is necessary to secure survival of the Lesser Flamingo population in the region.

So far, studies on the Lesser Flamingos in Gujarat (India) have mainly focused on the breeding status, its distribution in the wetlands of Gujarat and its breeding distribution in the state. Informal attempts have been made so far to study its habitat characteristics during non-breeding season. Also no studies have so far addressed the behavioral pattern of the species both during the breeding and non-breeding cycle of the species. Thus taking into account lack of such information on such 'Globally Nearly Threatened' species, the present study was carried out in the coastal areas of Bhavnagar district bordering of Gulf of Khambhat and Little Rann of Kachchh (breeding ground).

Objectives

1. Study the habitat ecology of Lesser Flamingos at major sites of its congregation in Gulf of Khambhat: the non-breeding habitat.

2. Study behavioral ecology of Flamingo during breeding and non-breeding cycle.

3. Identify the threats to its key/ favorable habitats and conservation measures.

MATERIALS & METHODS

MATERIALS & METHODS

Contents

Population Survey
Behavioral Pattern Analysis
Habitat Characterization
Statistical Analyses

To study the habitat requirements and behavioral aspects during non-breeding period, coastal areas of Bhavnagar were selected for the present study. Within Bhavnagar district, Kumbharwada sewage area and coastal saltpans of Bhavnagar were selected for the study, as these two areas have been reported to support more than 25,000 birds in non-breeding season. Studies during breeding season were carried out in Little Rann of Kachchh, Cherwari in Surajbari creek and Great Rann of Kachchh.

Population surveys

The population estimation of Lesser Flamingo was done using point count method at various sites during the survey. The birds were counted using the block count method whenever large congregations were observed. The surveys at breeding sites were conducted from May to December when nesting congregations have been reported by previous studies. Surveys were carried out at their previously known breeding sites and considerable time was also spent in searching new breeding locations whenever the birds were not present at their traditional breeding sites. Whenever a breeding congregation was observed, the activity of the bird was monitored. The counts were made of number of birds present during early morning, afternoon and evening. The numbers of built nests, nests in construction, birds engaged in courtship display were also enumerated. Efforts were also made to identify new nesting colonies. These surveys were carried out at all the sites that were potential breeding habitats for the species as per the

literature survey. At non-breeding sites, the total number of birds present was counted in different time blocks (morning, noon and evening).

Flamingo numbers were estimated through censuses from one or several points from the edge of the salt-pans depending on the size and shape of the lake/pan, by using Nikon binoculars of 10 X 50 magnification and Nikon spotting scope of 40X magnification. For enumeration of larger flocks and accurate count manual tally counters were used. The observation points were recorded with a GPS and thus were the same in every survey.

At times when large congregations (>10,000 birds) were observed, different observers counted individuals in each habitat/saltpan at least twice so as to have an accurate estimate of the population. The counts were done independently and if their numbers varied <5% of each other, an average of the group was taken; if it was greater the count was repeated. Total count method was adopted for flocks smaller than 500 birds. For larger flocks (>500 birds), block count method was adopted wherein the birds were counted in estimated groups of 10, 20, 50 or 100s depending on the flock size (Bibby et al., 1992). If Flamingos were observed moving among sections/ habitats while scanning, sampling was terminated to avoid counting individuals twice at a given site. Data collected prior to termination were not used for analyses. Daily site totals were calculated by summing the number of birds observed in each section. Besides counting the total bird population at any area, neighboring areas, between which bird movements were frequent, were counted on the same day. However, those areas were not considered for data analysis.

Behavioral Aspects

Different habitats available to the flamingos and their behavior in relation to habitat types over the non-breeding portion of their annual cycle were characterized. Flamingo's diurnal activity pattern during breeding as well as non-breeding period was studied in detail.

Activity Budgeting

The activity budget study has been recognized as an important tool for understanding habitat use and niche separation (Rave and Baldassarre, 1989) and therefore has been used as an important tool for managing a bird's habitat. Behavioral observations were made at both breeding and non-breeding sites of Lesser Flamingos.

Activity behaviors were recorded using Focal Animal Sampling techniques (Altmann, 1974) because flock activities of waterfowls are often synchronized (Kahl, 1975). Thus, the activity of nearly all birds in a flock could be determined, which minimizes potential bias associated with selecting a focal individual for activity-budget sampling. Activity-budget data were collected during diurnal hours (sunrise to sunset). All observations were made using a 40 X Nikon spotting scope from a distance at which the bird's activity is not affected and all the birds in entire study area are visible.

Sampling was conducted for each site on three randomly selected days during breeding and non-breeding season, with each day divided into four time blocks of: (1) Early morning; (2) Late morning (9 am to 12 pm) (3) afternoon; and (4) late afternoon or evening. Each time period was then divided into equal 5-min blocks. Scan samples were stopped at 300 seconds and activities were recorded at every ten seconds interval. Thus, for a given bird, 30 activity events could be recorded in each 5 minute block. Activities were categorized as feeding/foraging (Rooth, 1976), resting, locomotion/movement (flying and walking), preening, and alert. Movement with head up while foraging was classified as movement whilst movement with head down while feeding was recorded as foraging.

For each bird while scan sampling, we recorded water depth, temperature, salinity, type of habitat used, flock size etc. to later correlate them with the activity of the birds.

A subpopulation of randomly selected birds from different flocks at Surajbari Creek, Littler Rann of Kachchh (during the breeding season) and

Kumbharwada site, New Port site, Vadgam, Little Rann of Kachchh (Non-breeding season) were studied in detail for time activity budget of the species. During the study period, a total of 1800 hours of observations were carried out to study diurnal activity pattern of the species.

Physical Characterization of Habitat

Studying habitat characteristics of a species plays a pivotal role in the conservation of a species. The data were collected on salinity, pH, and dissolved oxygen (DO) and water temperature whenever the Lesser Flamingos were observed. Salinity was measured at every location of Flamingo presence or absence. The salinity was measured by hand held digital salinity meter and salinity refractometer. Water temperature was also measured on site (Plate 4 A).

As per the classification, the water was classified as Freshwater, Brackish water, saline water and Brine and flamingo use of the entire habitat were studied.

Vegetation Cover

A quadrate frame of 100 x 100 cm was designed to estimate the grass cover on the ground. The quadrate was further divided into 10X10 cm smaller sub-quadrates and visual counting of each quadrate for the ground cover was made, and this was then further converted to % ground cover and % of bare ground. The quadrate was laid at every 20 meters for a distance of 300 meters (15 quadrates laid).

The vegetation cover sampling was carried out to correlate the spread of vegetation against the shrinking foraging habitat of the Flamingo at the

Kumbharwada site. Google earth images were also used to interpret data on vegetation cover. Open water areas, marshy areas and grass cover spread/shrinkage were analyzed using Google earth imageries.

Habitat area and vegetative cover changes

A time series of Google earth images from 2008 to 2013 were used to characterize the vegetation cover changes apart from manual data collection from field with quadrate sampling. These images were used to measure physical changes in the sewage pan habitat. Images were analyzed using Google earth pro area polygon tools and ground truthing was supported by quadrate sampling in vegetative areas.

Soil Sample Analysis

To know the nesting habitat characteristics of the species in Surajbari in the Little Rann of Kachchh and Flamingo Great Rann of Kachchh), soil from the nests and areas adjoining to the nests were collected and analyzed for its sediment structure.

Sediment composition

Sediment composition of the nests and adjoining potential nesting habitats were carried out to know the silt-clay-sand composition of the nesting habitats (Plate 4 B). Nesting soil from degraded/washed nests and soil samples from nearby mud-flats were collected to know if any marked difference in selection of nesting substratum was observed in flamingos. Sediment samples were collected weighed. Sediment sample were dried, powdered and treated with hydrogen peroxide washed with distilled water and supernatant was drained twice to remove the hardness due to salts which causes clumping of the grains. Later on sodium fluoride was added which serves as anti-flocculent and avoids clumping of grains. Mechanical dry sieving method was employed as described by Folk (1954). Sieves with standard ASTM 260 (BSS/ASTM 60) were used looking to the nature of the sediments to find the sand and silt/clay composition.

Habitat Selectivity Index

Foraging habitat selection was analyzed by the use of the Savage selectivity Index, wi = Ui/pi (Tella and Forero, 2000; Ursu´a et al, 2005). Ui is the proportion of observations in a given habitat and pi is the proportion of that habitat against the total available area. A Savage selectivity reading of 0 is the maximum negative selection; it has not been selected at all. An index value of 1 means there is no habitat selection. Statistical significance was calculated using Chi-square distribution.

Statistical analyses

To construct diurnal time-activity budgets, behavior was first expressed as the mean percentage of birds engaged in behavior of a particular category each hour.

The hourly data were analyzed in two ways. Firstly, the whole data set was inspected to determine the mean percentage time spent by Lesser Flamingos in each activity for the entire non-breeding season. Secondly, the data were re-analyzed to determine the mean percentage time allocated to different activities during the four time blocks from sunrise to sunset depending upon the season. Standard errors were indicated as (± SE).

Spearman test was used to correlate the relative abundances for each species with the following variables, waterbird richness, water depth, and salinity and other variables. For the New Port site, for some habitats/areas, only the January 2009 to June 2011 data were used, because Lesser Flamingos were absent from these lakes during after June 2011 due to the anthropogenic activities in the area.

Most of the statistical analyses were carried out in Microsoft excel, however, Minitab 14.0 and Graph-pad Prism 6.0 were also used to study correlation, regression, Multiple Regression Analysis and other statistical analyzes and to illustrate graphs and charts**.**

Limitations of the Present Study

As, discussed earlier, Lesser Flamingos being habitat and diet specialist species, the breeding of the species is erratic and does not necessarily occur every year. Thus, during the present study, no successful complete breeding cycle (displays → courtship → nest building → egg laying → chick rearing) was recorded. Also the species did not bred near Vachhraj Solanki beyt (its traditional breeding grounds Little Rann of Kachchh) from 2009 to 2012. Breeding, though occurred twice only during these years were in the remote areas of Great Rann of Kachchh which is under the direct control of the Border Security Force and therefore, the permission to visit the Flamingo City was given only once during the entire phase of the study (Plate 4 C).

However, regular breeding event (displays → congregations →nest building) were recorded at only one site (Cherwari near Surajbari Creek) during the year 2009, 2010 and 2011 and thus data collection has been restricted to nest building and egg laying stage of the species.

Flamingo being a selective filter feeder it was difficult to ascertain its exact food preference based on phytoplankton studies. Though, numerous sampling efforts were carried out and various phytoplankton, diatoms and zooplanktons, were identified to correlate the flamingo numbers with Phytoplankoton/Diatoms diversity. It was difficult to precisely demonstrate the any correlation or exact food preference of the species and therefore information on its food/diet were not further collected. Moreover, Lesser Flamingo being a “Near Threatened” species as per IUCN, it was not possible to collect gut content of the species without the consent of Ministry of Environment and Forests, GoI for precise understanding on its food preference.

STUDY AREA

STUDY AREA

Contents

Sites in Bhavnagar
Climate at local level
Little Rann of Kachchh
Surajbari Creek

The study area for the present study was classified into two different categories viz. breeding areas and non breeding areas. The breeding habitat includes Surajbari Creek in the Little Rann of Kachchh and other intermittent breeding sites in the Little Rann of Kachchh and Great Rann of Kachchh. The non-breeding ground includes Kumbharwada Sewage ponds, saltpans and Newport saltpans of Bhavnagar district.

Bhavnagar District

Bhavnagar district is on the coastal region of the Saurashtra peninsula abutting the Gulf of Khambhat. The district area is 11155 Sq. Km and total population as per 2001 census is 27, 50,430. Bhavnagar district has a coastline of about 152 km which is 9.5 % of total coastline of the state (source: State Population Data, 2001) Geographically, Bhavnagar district consists of diverse features like uneven, rocky (basaltic) land surface traversed by mountain ranges/ridges and trappean dykes. Most of the district is composed of weathered to hard and massive Deccan Trap formation, which is impervious. Mahuva, Talaja and Ghogha along Gulf of Cambay are made up of sedimentary formations like Ghogha bed, Clay and Milliolitic limestone (Groundwater Evaluation Report, October - 2006 District – Bhavnagar, Government of Gujarat).

The large part of Bhavnagar taluka bordering the Gulf of Cambay is made from alluvial deposited by the rivers like Kalubhar, Ghelo and Keri River. The large part of the taluka is flat plain made of sandy and clay soil. During high tide period large part of it gets submerged under sea water (Fig 5).

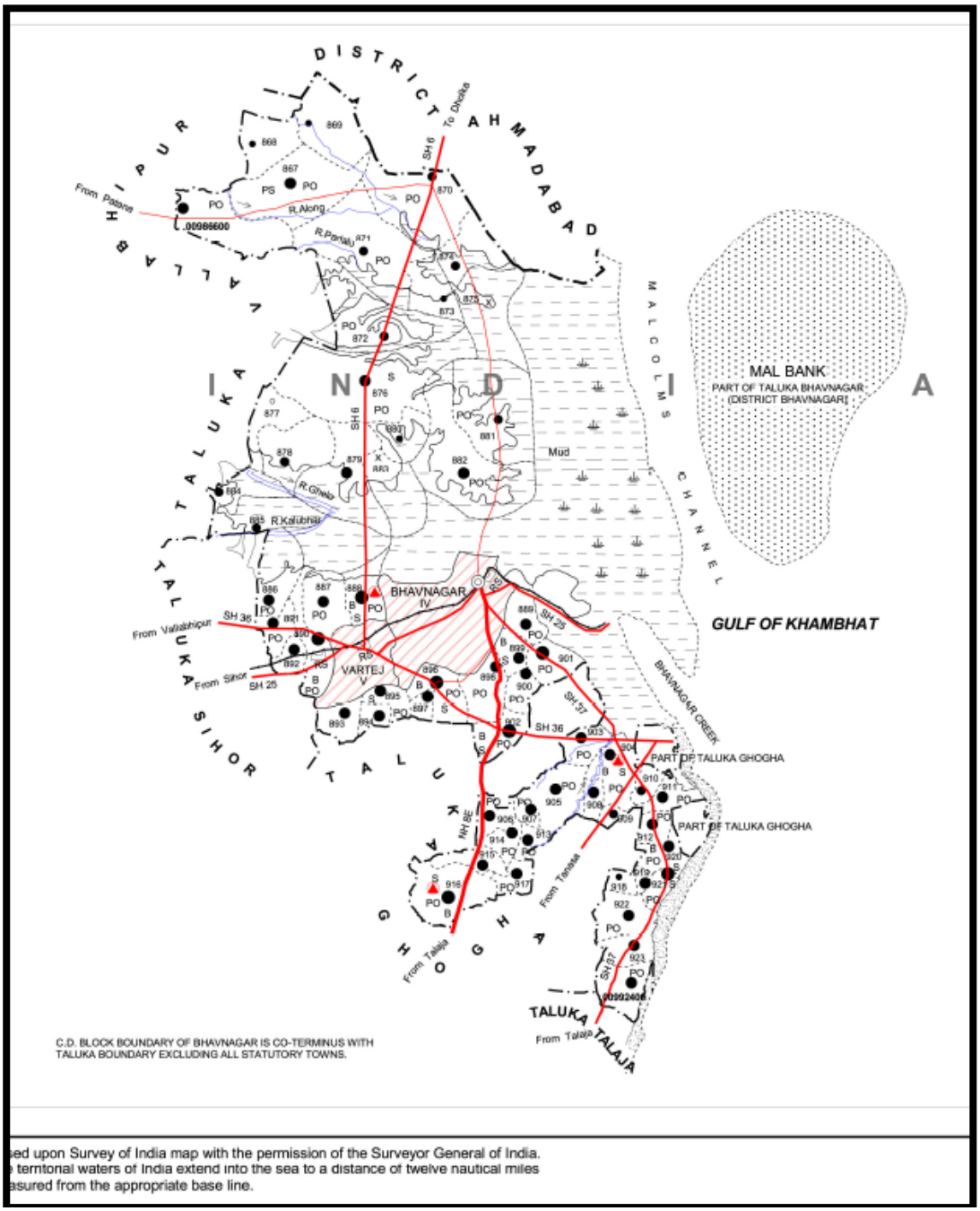


Fig 5: Map of Bhavnagar Taluka

Kumbharwada Site

Kumbharwada area lies in the northern boundary of the town of Bhavnagar. It is an admixture of saltpans, abandoned saltpans, sewage waste water and Freshwater and is generally less than 2 meters deep. The Kumbharwada Wetland complex together with the surrounding saltpans forms the largest wetland complex around Bhavnagar city. The wetland is recognized for its

outstanding waterbird diversity on the western shore of Gulf of Khambhat. Fresh water is contributed by receiving waste water from the urban households, precipitation and to a lesser extent by runoff (waste) from upland habitats of the Bhavnagar City (Fig 6).

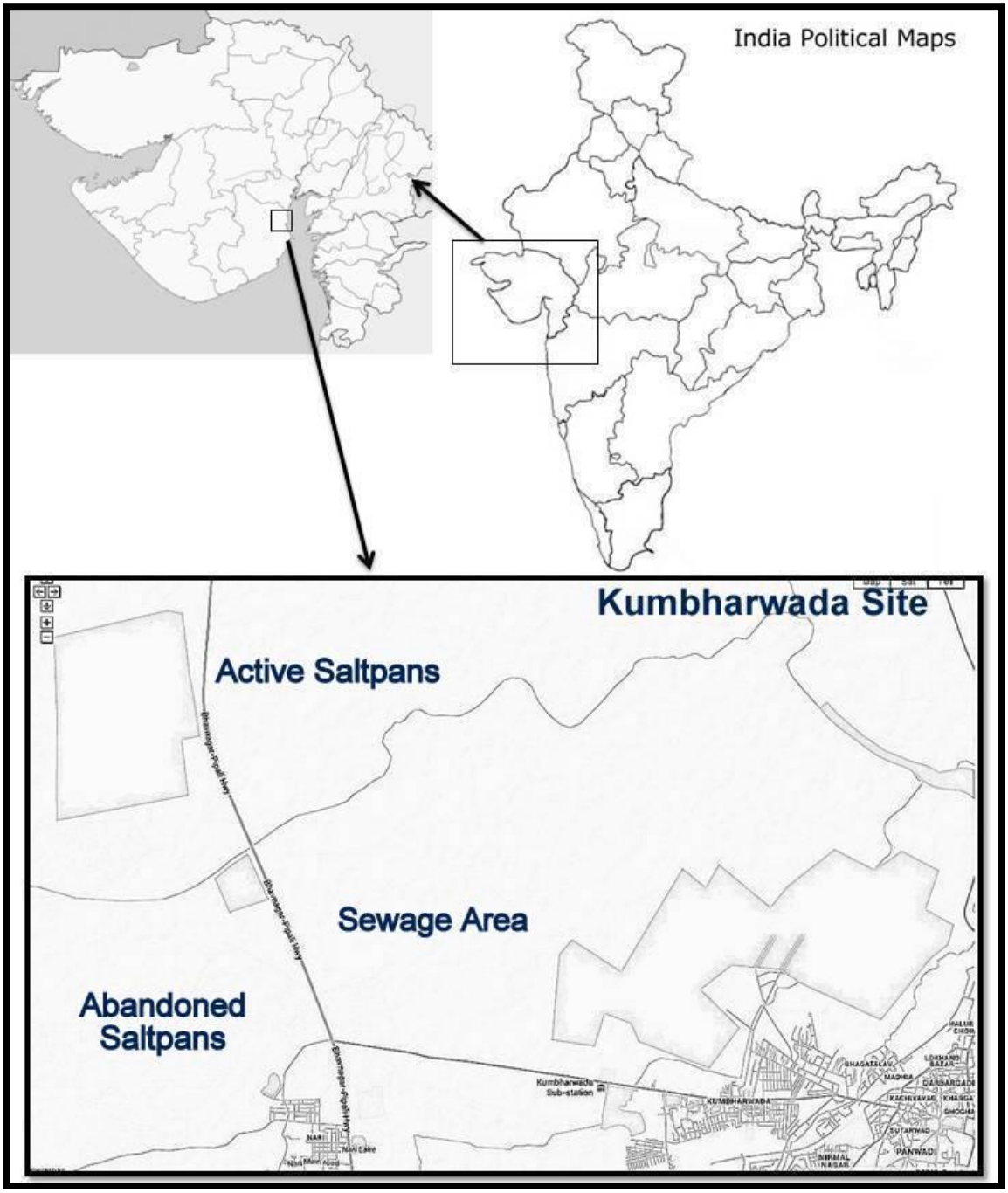


Fig. 6: Location map of Kumbharwada Area of Bhavnagar, Gujarat

The ground water is saline as the area is in close proximity to Bhavnagar Coast and thus the salt pan owners use ground water for salt farming. The

area also has few saltpans of which some are abandoned (not used) and some are active. This geomorphology and hydrology have resulted in a mixture of seasonal, semi-permanent and permanent wetlands of variable salinity .

Based on the habitat types, the entire habitat was classified into three broad categories viz. i) Sewage waste water areas (Sewage pans) ii) Active saltpans (Used Saltpans) area iii) Fellow Land and iv) Abandoned saltpan (Table 1). The areas have been differentiated based on vegetation type they support, amount of water they receive, the source of water and salinity. There is hardly presence of any vegetation except in the sewage water ponds which is interspersed with grass (*Porteresia coarctata* and *Aeluropus lagopoides*) and some shrubs of Prosopis (Plate 1 A,B,C).

As the area is on the outskirts of the city, there are also slum dwellers adjoining this area with poor sanitation facilities. The southern portion of Kumbharwada also receives waste water from the industries of the Bhavnagar Industrial Development Corporation (GIDC). Kumbharwada area being a mosaic of these habitat features supports a good diversity of water birds especially marsh birds (Fig 7).

The Natural fluctuations in salinity and water level caused by rainfall and the effluent/household waste runoffs in the area have created zones of vegetation with varying degrees of tolerance to salinity. These periodically inundated and shallow water habitats on the eastern shore are the favored haunts of wading birds.

The abandoned saltpans area is dominated by *Aeluropus lagopoides* grass and the sewage waste water area is dominated by *Porteresia coarctata* grass which is one of the common mangrove associates and has characteristic ability to grow fast and spread rapidly. The sewage waste water area is undulating forming the ridges or hummocks and is dominated by *Porteresia coarctata.* On the other hand, the abandoned salt pan area is

Fig 7: Google earth image of Kumbharwada Study Area of Bhavnagar

comparatively plain and interspersed with *Prosopis juliflora* shrubs. The saltpans that were used for salt manufacturing were devoid of any vegetation and were most of the time filled with high saline water.

Table 1: Kumbharwada study site divided into 9 sub-zones

Place		Code	Area (Hectare)
Kumbharwada	Sewage Pans	KW SP 1	40
		KW SP 2	15.5
		KW SP3	174.7
	Used Saltpans	KW USP1	136
		KW USP 2	111
	Abandoned saltpans	KW ASP 1	10
		KW ASP 2	05
	Fellow Land	KW FL 1	138
Total			492.2

Newport Saltpans

Newport saltpans on the other hand lie in the eastern boundary of the Bhavnagar town. It separates the Western Coastal Belt of Gulf of Khambhat along Bhavnagar coast from the mainland of the Bhavnagar city. The area is totally saline with high degree of salt production activity compared to Kumbharwada Saltpans (Fig 8). The area also has some abandoned salt pans which are not used for salt manufacturing (Plate 2 A, C). However, most part of the study area (379 hectares) is used for salt manufacturing. The area is totally devoid of vegetation except some outgrowth of *Prosopis* spp. on the periphery. The area also supports a good diversity of water birds especially coastal waders (Fig. 9).

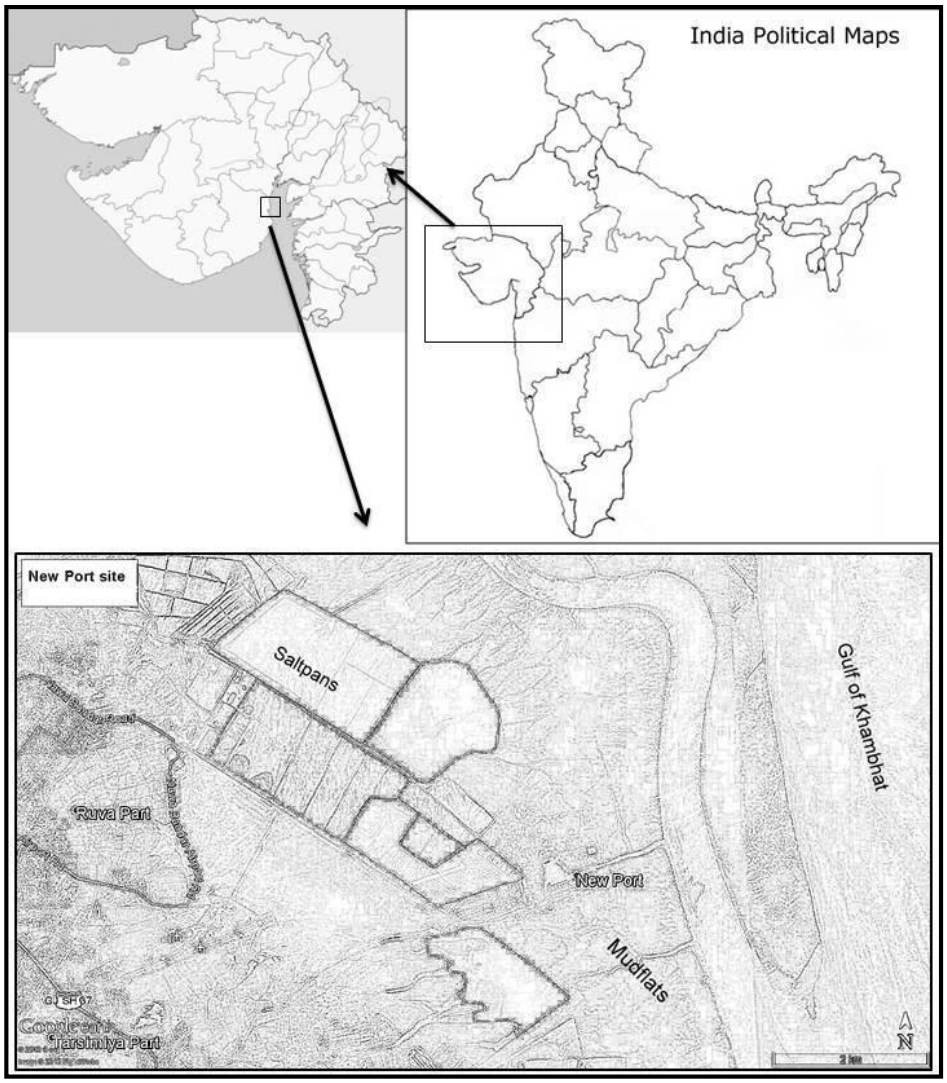


Fig. 8: Location map of Newport Area of Bhavnagar, Gujarat

Table 2: Area of Newport Site divided into 6 sub-zones

Place		**Code**	**Area (Hectare)**
Newport Saltpans	Used Saltpans	NP USP 1	256
		NP USP 2	123
	Abandoned saltpans	NP ASP 1	250
		NP ASP 2	28.8
	Mud flats	NP MF 1	123
		NP MF 2	167
Total (Hectares)			**947.8**

Newport area was also further divided into three zones based on the habitat/land use category and habitat features. The area was divided into i) Used Saltpans, ii) Abandoned salt pans and iii) Mudflats adjoining the creek areas of Gulf of Khambhat (Table 2).

The mudflats covered an area of about 290 hectares, whereas about 278 hectares of area was classified as abandoned salt marshes. About 379 hectares of land was under salt manufacturing. However, towards the end of the study period, the area classified under abandoned salt pans was later converted into salt production area and thus were abandoned by the species (Plate 2 B).

The only source of freshwater in New Port study site was monsoonal rains. Unlike the Kumbharwada site, where fresh water was received as industrial and house hold waste apart from rains. Mostly the inundation occurred due to release of extra ground water harvested by salt manufactures, and gulf water received through creeks during high tides.

Climate at Local level

The climate is typical on West coast of India: it is characterized by hot summer and general dryness, except in coastal region. The weather during summer season extending from March to May is humid which is followed by regular seasonal heavy rainfall due to South-West monsoon during the months from June to October. The post monsoon period extends further beyond October to November. The winter months are from December to February. Thus, in a year our seasons can broadly be classified into four distinct seasons. The winter period is from December to February; the pre-monsoon/summer is from March to May. The south-west monsoon is from June to September; the post monsoon period is from October to November. In the post monsoon months and to a lesser extent in May and June, storms and depressions from the Arabian Sea sometimes reaches the district and its neighborhood, causing gusty and widespread heavy rain. Thunderstorms have the highest incidence in June and to a lesser extent in the monsoon period.

Fig 9: Newport study site showing different habitat types

Rainfall

According to the Groundwater Evaluation Report October-2006 of District – Bhavnagar, Government of Gujarat, the average rainfall of district is 548 mm whereas as per Indian Meteorological Department, Government of India report on the Climate of Gujarat and Diu, Daman, Dadra Nagar Haveli, it is 593.2 mm (IMD). About 95% of annual rainfall in the district is received during the southwest monsoon months i.e., June to September and July being the rainiest month. Being a semi arid region, the variations in the rainfall from year to year are certain.

During the 80 year period 1901 to 1980 the highest annual rainfall amounting to 203% of the normal occurred in the year 1947. While 1918 was the year with the lowest annual rainfall which was only 23% of the normal. In the same 80 years period the annual rainfall which was less than 80% of the normal occurred in 22 years and two consecutive years of such low rainfall occurred twice and even three and four consecutive years of such low rainfall occurred once. The annual rainfall in the district was between 301 mm and 800 mm in 54 years out of 80 years. On an average there are 29 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. (Climate of Gujarat and Diu, Daman, Dadra and Nagar Haveli (India Meteorological Department)

Temperature

The period from March to May is the period of continuous temperature rise. May is generally the hottest month of the year; the mean daily maximum temperature reaches up to 39.6º C. Hot winds blow during the summer season and the day temperatures ranges between 40º to 43º C which is quite common. The heat particularly in the interior of the district is intense and some days the day temperatures may go up to 46º or 47º C in the summer.

With the onset of the southwest monsoon by about the middle of the June the day temperatures decrease a little. With the progress of the season however, the days become cooler. After mid-September, day temperatures

increase and a secondary maximum in day temperatures is reached in October. However the nights become progressively cooler. After mid-November both day and night temperatures begin to decrease till January which is the coldest month, when the mean daily maximum temperature is about 28º C to 30º C and the mean daily minimum temperature is 13º to 15º C. In association with cold waves which sometimes affects the district in the rear of western disturbances which pass across north India during the cold season, the minimum temperature in the interior of the district drops down to about the freezing point of water and frosts may occur.

The highest maximum temperature recorded at Bhavnagar was 46.7º on May 17 1912. The lowest minimum at Bhavnagar was 0.6º C on January 31 1929.

Humidity

During the southwest monsoon season (June - September) the relative humidity is generally high, being over 60% in the northern parts of the district and over 80% in the southern parts near to coast. Rest of the year the air is comparatively dry with afternoon humidity especially in the northern and interior parts of the district ranging between 20 and 30% and about 50 to 60 % in the coastal regions.

Cloudiness

Skies are heavily clouded to overcast on many days during the southwest monsoon season. During rest of the year, the sky is clear or partially clouded. Though, the sky becomes cloudy for few days in the winter season when affected by western disturbances passing across north India.

Winds

Winds are generally light and they become strong during the latter part of the summer season and south-west monsoon season. Winds blow mainly from two directions: between west and north during mornings and from north and east during afternoons in the months of October to April and mostly from the southwest or west during the southwest monsoon season.

Gulf of Khambhat

The Gulf of Khambhat is a south to north penetration of the Arabian Sea on the western shelf of India between the Saurashtra peninsula and mainland Gujarat. It is located approximately between latitude 20° 30' and 22° 20' N and longitude 71° 45' and 72° 53' E (Fig. 10). At its northern end between the Sabarmati and Mahi river mouths, the Gulf is barely 5 km wide and it opens out southwards like a funnel, reaching its maximum width south of Gopnath point. Its north-south length is approximately 115 km. It covers an extent of about 3,120 km^2 mainly of mudflats with some rocky (sandstone) intertidal area. The rocky beaches are common from Mahuva to Gopnath, reducing towards Ghogha and Bhavnagar. A few sandy patches are also observed intermittently. The Gulf is intercepted by several inlets of sea and creeks formed by confluence of major rivers such as Narmada, Tapi, Mahi, Sabarmati, Shetrunji and many minor rivers. All the major rivers form estuaries and their inflow carries heavy load of suspended sediments into the Gulf. A medium sized delta is present near Shetrunji between Gopnath and Ghogha. The ecosystems of the Gulf comprising mangroves, estuaries, creeks and vast intertidal mud flats are known to have rich biodiversity and a number of endemic flora and fauna.

In the interior of the Gulf, of Ghogha there is a small island viz. Piram Bet and further north there are large shoals which get exposed during low tide. A series of shallow banks run linear at the Gulf mouth, making it an ideal habitat for coastal birds and other fauna. The shoreline of the coast between Bhavnagar and Gopnath has provides an assemblage of erosional and depositional features related to tectonic and eustatic factors resulting in gaining of land in between Bhavnagar and Mahuva. Rapid development and heavy industrialization on the coast line of t he Gulf has resulted in the degradation of the environment and decline in biodiversity.

Physiography

The depth of the Gulf ranges from 18 to 27 m and is less than 20 move r most of its length. However, the depth at the head is as low as 5 m and in

the channel on the eastern side of the Piram Bet it is about 50m. The tides are of mixed semi-diurnal type, with large diurnal inequality and varying amplitude, which decrease from north to south. Because of its unique position (nearness to the Tropic of Cancer), Gujarat coast experiences very high tides; the highest anywhere along the Indian coast. Because of the funnel shape and the semi-enclosed nature at the head, the tidal height increases tremendously in the upstream. The mean tidal elevation during spring is 4.7m at Mahuva Bandar which rises to 6.5 m at Gopnath Point and 10.2 m at Bhavnagar. Because of the high tidal amplitude, especially in the upper Gulf, it has huge inter-tidal expanses of 1.5 to 5 km, perhaps the widest along the Indian coast.

Gulf of Khambhat receives 600-800 mm rainfall during the south-west monsoon. Out of the total cultivable land in the coastal area, irrigated land is estimated to be about 26%. Mangrove occupies a total of 53.95 sq. km (Hydrology Project-II, GoG).

About 668.87 sq. km area of the total area of GoKh is salt affected, 2587.73 sq. km (17.62 %) area is the mudflats and about 132.52 sq. km (0.90 %) land is under the salt cultivation (saltpans) (Dept. of Ocean Development, GoI., 2002).

Mudflats in Gulf of Khambhat

The Gulf supports a vast intertidal expanse of 3268 km^2, the maximum along the Indian coast, due to high tidal range. Owing to the conical shape, the intertidal mudflats of northern Gulf extend to about 5 km. However, the mudflats of the southern Gulf are restricted mostly towards eastern side (Plate 3 A). The mudflats of the Gulf have extended to an area of about 2, 588 km^2.

Gulf of Kachchh

The Gulf (Fig. 10) is an east–west oriented indentation north of Saurashtra Peninsula. It is about 170 km long and 75 km wide at the mouth, narrowing down abruptly with a distinct constriction at 70°20’ E at Satsaida Bet, and

dividing into a creek system often called the Little Rann of Kachchh. The Gulf has an area of 7300 km^2 and a volume of 220,000 Mm^3. Depth varies from 20m at the head (Kandla-Navlakhi) to 60m in the outer region. The average depth is 30m, the minimum 3m above chart datum in the inner creeks.

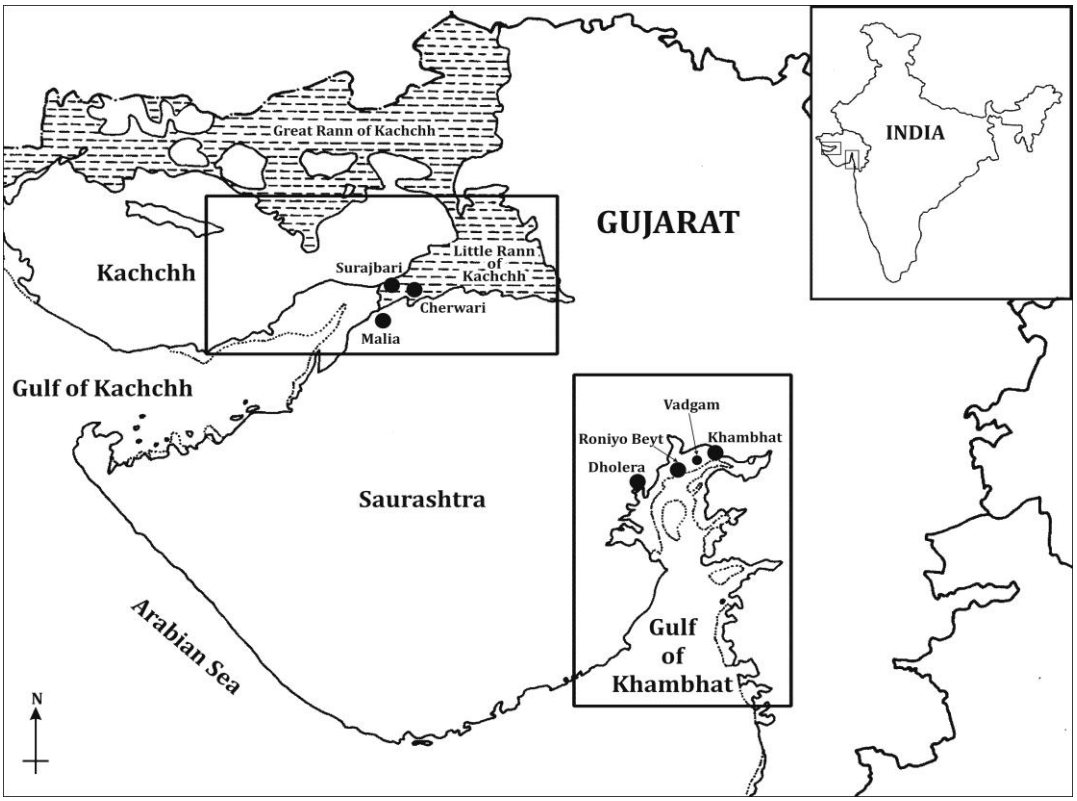


Fig 10: Breeding (Gulf of Kachchh and Surajbari Creek) and Non-breeding areas (western Gulf of Khambhat) under present study

The Little Rann of Kachchh gets flooded during the south west monsoon establishing short term connection with the creek sat the head of the Gulf. The vast mudflats that get inundated during high tide consist of thick deposits of very soft marine clay up to a depth of 12-15m underlain by calcareous sand and highly weathered, weak sedimentary rock formations comprising of compacts and, silt stone, clay stone and sandstone.

Climatic conditions

The Gulf area is generally termed as semi-arid region. The weak monsoonal rains and high rate of evaporation not only make the land area arid but also

influence the seawater salinity to increase. The region experiences four main seasons namely winter, summer, south-west monsoon and post-monsoon seasons. The winter season (December to February) is characterized by chilly winds from the N-NE due to high pressure zone in the north of Himalayan ranges. Summer season (Marchtomid June) is characterized by high temperature and high humidity with the maximum air temperatures often reaching 40-45°C. South-west monsoon (mid-June to mid-September) has weak monsoon mainly due to monsoon low centered on Kachchh district making it a rain shadow zone; but strong winds with S-SW directions are often experienced. Post-monsoon season (mid-September to November) is a transition period between monsoon and winter when the climate is pleasant with relatively calm periods.

The air temperature of the region varies from 10°C to >36°C over the year. January is the coldest month with night temperatures falling below 10°C and May and June are the hottest months with mean maximum temperature of 36°C during day and mean minimum of 26°C during night. The relative humidity is generally high during monsoon months and range from 70 to 80%. Rest of the year, humidity ranges between 55 and 70%.

Surajbari Creek system

There is a network of creeks and alluvial marshy tidal flats in the interior part of the Gulf and the Little Rann of Kachchh is inter-connected through many other large and small creeks. The three desert rivers, Banas, Rupen and Saraswati, drain its water to the Little Rann that gets flooded during the south-west monsoon period establishing short term connection with the creeks at the head of the Gulf. The creek receives negligible fresh water inflow during the dry season. Hence, the evaporation exceeds precipitation leading to salinities higher than that of typical sea water (35-36ppt).

Cherwari Village in Surajbari Creek

Cherwari is a village just off the Surajbari creek on the bank of Hadkiya Creek. Fishermen community principally dominates the village are engaged in prawn fisheries. Cherwari has a landing site for prawns and fish on the northern bank of Hadkiya creek which joins further north with Little Rann of Kachchh. The area is frequently inundated with tidal water and during the period of low tides, vast stretches of mudflats amongst the small creek channels are exposed (Fig. 10 and Fig. 11).

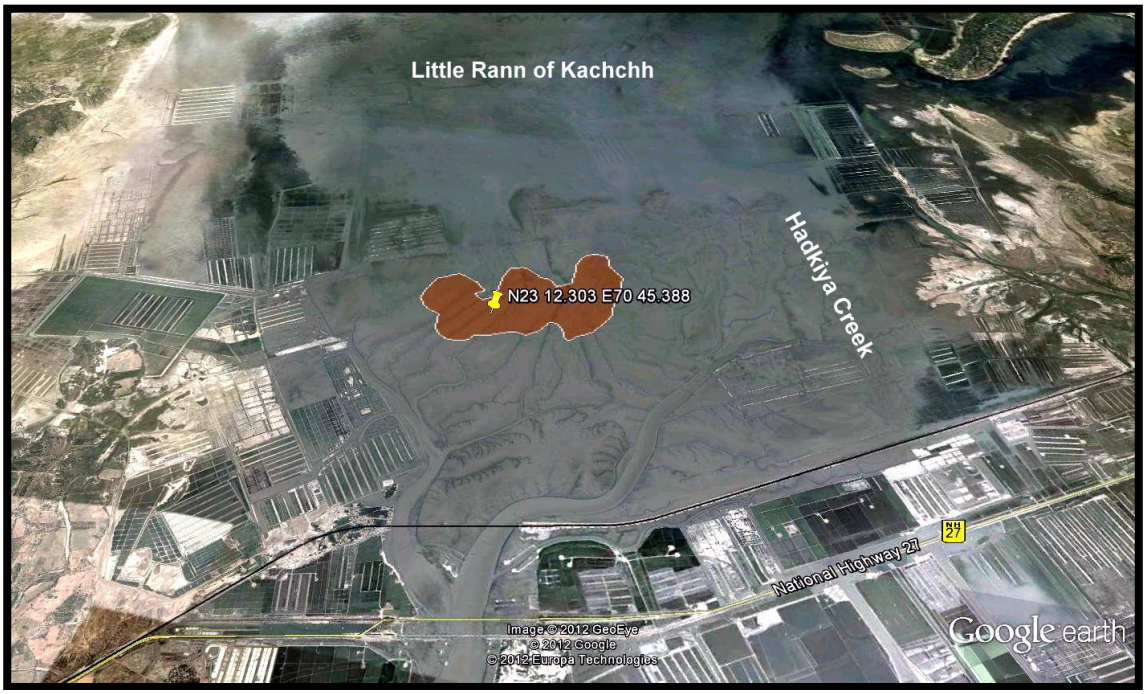


Fig 11: Google Earth image of Surajbari Creek nesting site

These mudflats from June to October acts as breeding grounds of the species where large congregation is followed by nest building and egg laying (Plate 3 B).

Little Rann of Kachchh

Little Rann of Kachchh (LRK) is a unique landscape comprising saline mudflat and marshes, which in during the monsoon gets charged by freshwater is transformed into a very large seasonal wetland with good

diversity of invertebrate taxa. This large saline mudflat has been the traditional breeding ground for the Lesser Flamingo since time immemorial (Plate 3 C).

Climate

The climate is tropical monsoonal and recorded wide fluctuations in inter and intra-annual temperatures and rainfall. In general terms, the landscape recorded the regions with arid and semi-arid climates. In the entire landscape, the average annual temperature hovers between 12°C in winter to around 44°C in peak summer. Inside the Little Rann of Kachchh area, temperature sometime reaches as high as 50°C and also drops near to freezing point.

Little Rann of Kachchh was selected as one of the breeding sites of the species to study the breeding behavior of the species. However, during the entire study period (2009-2011), no successful breeding of Lesser Flamingo was recorded in Little Rann of Kachchh.

Flamingo City

Flamingo city has been the traditional breeding ground of the species since its first visit by Dr. Salim Ali in 1945. It is a small island amidst the Great Rann of Kachchh. The surrounding area of the Flamingo city gets inundated by the waters from Banas and Sarswati during the monsoon and creates ideal breeding site for both Lesser and Greater Flamingo. The site was selected to study breeding aspects of the species in Great Rann of Kachchh.

Plate 1

A. Saltpan Habitat at Kumbharwada site

B. Sewage Pan Habitat at Kumbharawada site

C. Abandoned Saltpan Habitat at Kumbharwada site

Plate 2

A. Saltpan Habitat at Newport site

B. Mudflats Habitat at Newport site

C. Abandoned saltpan Habitat at Newport site

Plate 3

A. Roniyo beyt in Gulf of Khambhat

B. Nests of Lesser Flamingos at Surajbari Creek

C. Lesser Flamingos feeding in Little Rann of Kachchh

Plate 4

A. Salinity measurement on site

B. Nest diameter measurement

C. Nesting survey in LRK during monsoon