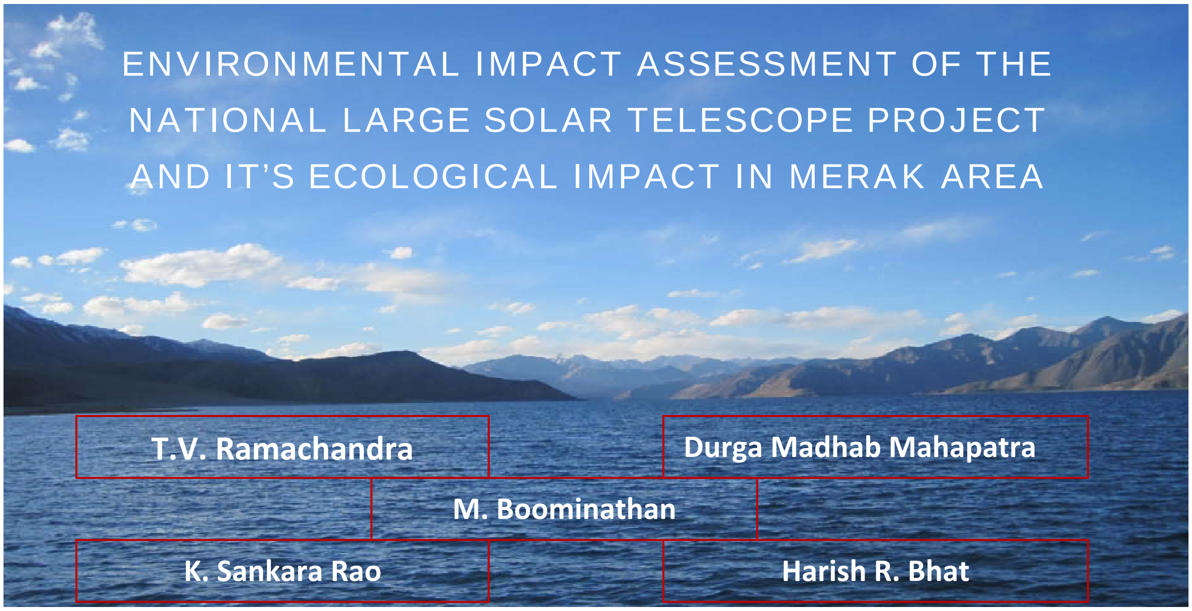

ENVIRONMENTAL IMPACT ASSESSMENT OF THE NATIONAL LARGE SOLAR TELESCOPE PROJECT AND IT'S ECOLOGICAL IMPACT IN MERAK AREA

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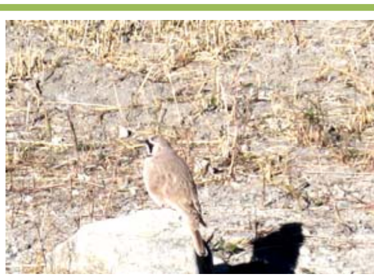





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Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

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Executive Summary

A 2-m state-of-the-art telescope (National Large Solar Telescope - NLST) aimed at understanding the fundamental processes taking place on the Sun has been proposed at Pangong lake site at Merak due to the optimum atmospheric properties (the number of sunshine hours, sky brightness and good atmospheric window enabling observations over long periods). This unique facility with the innovative design and backend instruments will enable observations with an unprecedented high spatial resolution that will provide crucial information on the nature of magnetic fields in the solar atmosphere and also night-time astronomy. This being a multi-purpose telescope, with state of the art post-focus instruments will permit Indian scientists to carry out cutting edge research towards understanding the fundamental processes taking place on the Sun.

The proposed NLST would involve the construction and operation of a modified reflecting Gregorian-type telescope that would deliver images of small part of the sun (300” ×300”) onto instrument stations mounted on the telescope and on a rotating platform located below the telescope. The facilities would include: the observatory facility, which includes the telescope (kept at a height of nearly 26 m), its pier, and the rotating instrument platform, the telescope enclosure, the telescope building with a diameter of approximately 15 m and an aluminizing chamber at a separate location sufficiently far off from the site.

Constitution of the team: The current study was undertaken by a multidisciplinary team of scientists and engineers that comprised of ecologists, environmental engineers, , GIS and remote sensing experts, botanists, zoologists, soil and water scientists, and wildlife experts. The team visited the site and carried out field work during 25-28th September 2010.

Aspects/Facets of the study:

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area. This involves land use analysis and investigations of flora and fauna

Landscape: Land use, Land cover analyses; Biodiversity; Aquatic ecosystem: Soil, water and sediment characterization, impacts of the proposed work, proposed environment management plan to mitigate the likely impacts

Study Area: The proposed location for commissioning a 2 m state-of-the-art telescope class telescope (National Large Solar Telescope (NLST) is at Merak, close to the Pangong Tso Lake and inside the Changthang Wildlife Sanctuary. Changthang Wildlife Sanctuary is a habitat for endemic, endangered species, vulnerable, and near threatened species. The area is of adequate ecological, faunal, floral, geomorphological and natural significance, and also link one protected area with another. The area of Pangong Tso Wetland is one of the Wet-site of the Changthang Wildlife Sanctuary. The area of 4000 Sq.Kms stands notified as Wildlife Sanetnary since 19-03-1987. The same wet-site is protected under the overview of J&K Wildlife Protection Act 1978.

Methods:

- **Land use analysis:** Remote sensing data along with collateral data
- **Ecology and Biodiversity**: Field visit, consultation with the local forest department officials and published literature
  a) Documentation of the existing flora in the proposed corridor
  b) Documentation of animal paths (bird migratory paths, if any)
  c) Documentation of endemic species
  d) Assessing the Environmental Impacts
  e) Arriving at environmental management plan to achieve the least disturbance to the existing flora and fauna
- **Development of Environment Management Plan:** This is based on the understanding of ecological and environmental impacts (if any) – quantification was done based on the detailed field visit.

Significant Findings:

1. The Pangong Tso wetland (at elevation of 4258 m), is the longest lake in Ladakh, with about 50 km stretch within Indian territory and over 100 km long stretch in the Tibetan plateau of neighbouring China. It is fed by glacial waters and is well known for its deep blue colour. Over the years, the outflows got blocked and the lake became mildly brackish. Therefore, except for the locations of fresh glacial waters, the lake does support marine life evident from under-water plants and algae. The lake is said to be in a seismically safe zone. It runs between two mountain ranges in the NW to SE direction which steadily widen towards south of south-east, before bending eastward into China
2. The Pangong Tso Wetland is home to a wide range of fauna ranging from migratory birds to mammals of various species. The black-necked Siberian crane, bar-headed geese and waterfowl are recorded at the lake. Many cranes sp. (i.e. species) such as red crowned crane, bar headed goose and the high souring raptors cross high ranges to enter India and finally leave towards Africa during the winter. The Siberian birds do also enter the country through the north eastern Himalayan ranges and traverses through the Western Ghats and southern parts of India before leading to Africa.

3. During the construction phase, there is likelihood of local disturbance on the silent and pristine ecosystem. Movement of vehicles and the transfer of raw materials and consequent noise and vibration would disrupt the local fauna habitat. The salinity of the water is around 10, 000 mg/l. Special care should be taken for the metals like Fe and Cu, which have ample chances of a very high corrosion.
4. Earlier studies indicate of increasing water levels and there is gradual submersion of some elevated regions along the beaches of the lake. The proposed site (incursions into the lake) has mixed origins which are parts of sedimentary deposits. These necessitate appropriate structure through geotechnical investigations.
5. During the operation of the telescope, highly focused and concentrated reflected light attract the birds. The very reflection and glare might disturb the birds passing by the region. This excessive or obtrusive artificial light which hinders the movement of organisms is referred as photo pollution or luminous pollution. This reflected light from the mirror can confuse animal navigation and cause physiological harm. Birds have tendency to get attracted to the intense light energy, and hit the mirror which might even damage the mirror.
6. The field investigations and subsequent synthesis of field data indicate that the proposed project has minimal impact on the environment and appropriate mitigation measures would help in addressing these impacts.

Environment Management Plan:

- Suppression of dust during the movement of vehicles –operation phase
- Construction work and movement of vehicles only during the day time so that the fauna are not affected during the night.

At site:

- Shadow plate covering the primary mirror protects it from the vision of birds.
- The mitigation measure involves change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections.
- Use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre.
- Planting of native species of flora would aid as heat sinks
- Setting up science centre and primary health centre for the employees and local public (part of the social commitment)

Merak near Pangong lake is the most suitable site for commissioning and operation of National Large Solar Telescope. The activities will involve minimal environmental impacts. Setting up of NLST would boost the region as it would provide employment opportunities, and associate benefits (like medical facilities, education, etc.) to the local people. This also gives visibility to the region in the global perspective and might prevent further land encroachments. Bird's death is reported in migratory path sue to Sky scrapers which are constantly lit (high intensity illumination).

Reports reveal that about five million birds, representing about 250 species (most of them are nocturnal migrants), fly through Chicago twice a year get confused with the night time lights of high rise buildings. These birds either crash into high intensity reflection of these buildings or get disoriented causing them to circle around and around, finally setting exhausted in a street tree or bush. These birds tend to fly into glass windows as they fly towards a reflection. Mitigation measures adopted by local residents are to dim or turn off decorative lighting late at night and to minimize the use of bright interior lights during migration season.

In this context, considering the proposed building height of NLST building and implementation of the suggested mitigation measures **(-** Shadow plate covering the primary mirror protects it from the vision of birds; change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections and use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre) would minimise the impact on birds.

II Project Description

Description of project rationale: A 2-m state-of-the-art multi-purpose National Large Solar Telescope (NLST) at Merak with state of the art post-focus instruments has been proposed to carry out cutting edge research with an aim to understand the fundamental processes taking place on the Sun. It's innovative design and backend instruments will enable observations with an unprecedented high spatial resolution that will provide crucial information on the nature of magnetic fields in the solar atmosphere. This would be the largest solar telescope in the world and fills the longitude gap between Japan and Europe. NLST will be a telescope, which will be equipped. This would represent a continuation and extension of the tradition of solar studies established at Kodaikanal more than a century ago.

The selection of a site with optimum atmospheric properties, such as the number of sunshine hours and good "seeing" over long periods are critical to the successful implementation of NLST. In this regard site characterization has been conducted at locations such as Hanle, Merak and Devasthal. The data obtained so far suggest that the Pangong lake site at Merak has excellent "seeing" conditions suited for a 2-m class solar telescope.

Site survey, selection criteria and reasons for selecting the proposed site at Pangong Lake: Critical to the successful implementation of NLST is the selection of a site with optimum atmospheric properties. Absence of clouds is one of the primary criteria. Another is the presence of good seeing over long periods of time with clear skies. The diffraction limit of a 2 meter solar telescope at 500 nanometers is 0.06 arc sec which corresponds to about 40 km on the solar surface. With the use of adaptive optics, features on the sun can be resolved nearly up to the above limit provided the atmospheric 'seeing' conditions of the site where the telescope is located are very good, say in the range of 1" or better for significant periods of time. This forms a major requirement for the site. Reconnaissance surveys were carried out in Ladakh. Hanle was chosen for evaluation due to the advantage of logistics of already existing stellar observatory there.

Among the lake sites, the Pangong lake appeared more promising than Tso Morari or other major lakes in Ladakh, due to the following advantages; its 30 km stretch within India, the several land incursions into the lake, the almost east – west elongation, the wind ducting from east to west, and the large flat land at the southern shore allowing good access to the southern declination, necessary for solar observations at this latitude of about 34 degree north. The essential parameters monitored were total annual sunshine hours, sky brightness, atmospheric seeing at various heights of up to tens of meters above ground, micro thermal conditions, meteorological parameters such as precipitation, wind speed, wind direction, humidity, irradiance, temperature range, aerosol distribution at site and etc. Regular observations of seeing and other related parameters were carried out by IIA at Hanle for over two years, at Merak for over one year.

The Pangong lake site at Merak appears to be very promising - it provides excellent spells of continuous sub arc second periods of seeing (Figure 1). The wind speeds of a few meters per second for most part of days help to stabilize the thermals. The total annual sunshine hour is comparable to Hanle, being in the range of 1700 hours. However the afternoons in Hanle have periods of strong winds.

Illumination

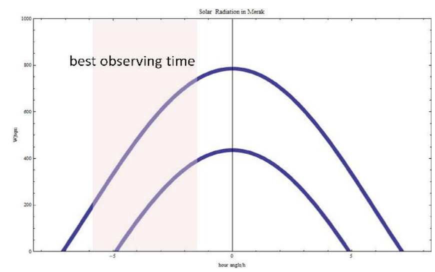


Figure 1: Intensities of solar radiations at Merak

Need for a 2 m Telescope: A 2-m class telescope with a sufficiently large aperture, is required to observe processes occurring on spatial scales of tens of kilometers (as crucial physical processes like vortex flows, dissipation of magnetic fields and the generation of MHD waves can occur efficiently on length scales even as small as 10 km). Telescope operating at its diffraction limit is required in order to resolve structures with sub-arc sec resolution in the solar atmosphere as well as to carry out spectropolarimetry. Good angular resolution with a high photon throughput is necessary for spectropolarimetric observations to accurately measure vector magnetic fields in the solar atmosphere with a good signal to noise ratio. In order to resolve structures with sub-arc sec resolution in the solar atmosphere as well as to carry out spectropolarimetry, a sufficiently large aperture telescope is required. Resolving structures observationally is of utmost importance to study and improve our understanding of the different physical processes involved. This helps in understanding the interaction of magnetic fields with plasma for interpreting various processes in the atmosphere of the Sun. Unfortunately apertures needed to resolve solar features to this level at visible wavelengths limit even the largest current solar telescopes. Presently, the best spatial resolution that the existing generation of solar telescopes can attain during moments of good seeing and using adaptive optics is limited to about 0.13 arc sec corresponding to nearly 90 kms on Sun. NLST would provide a superior platform for performing high quality solar research and aid as an unique research tool for several talented solar astronomers and is expected to bring in enormous growth in scientific development for the local region and the state. This would demand great technological challenges, give several spin-offs both direct and indirect to the country.

NLST is a 3-mirror, Gregorian on-axis telescope with a 2-m aperture primary mirror and a final f/40 focal ratio. NLST has a high throughput, which is highly desirable for polarimetry and speckle interferometry. The telescope has a high-order adaptive optics (AO) system to ensure diffraction limited performance. A 2-m parabolic primary mirror M1 (f/1.75) forms an image of the solar disk with a diameter of 33 mm at the prime focus F1. Here a cooled heat stop rejects and dissipates all the energy which does not pass through the stop. The primary mirror is cooled from below to keep it close to the ambient temperature. A beam, providing total field of view (FOV), passes through the centre hole with 3.4 mm diameter. An elliptical mirror M2 creates f/7.7 beam and forms a secondary focus F2 at a distance of ~600mm in front of M1 and about 200 mm above the elevation axis. Here a FOV of 200 arc sec corresponds to a scale of 15 mm. The modulation and calibration of the polarimetric package is kept here to exploit the symmetry property. A weak negative field lens is also situated here (see Fig. 2). The F2 image is sent to another elliptical mirror M3 which changes the f-ratio to f/40 in the beam that produces a final image at F3 where we have the desired image scale of 2.5 arc sec mm^{-1}. Additional specifications are listed in Table 1.

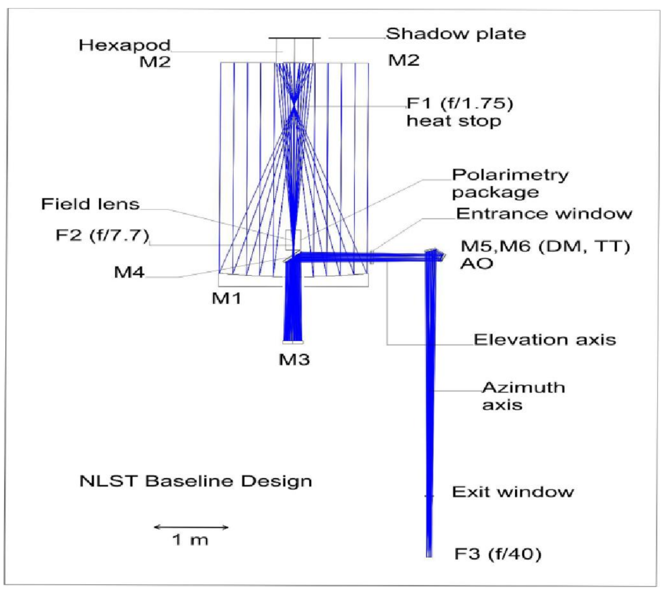


Figure 2: Optical layout of NLST

M4 is a flat mirror with a central hole that reflects the beam into the elevation axis. The mirror group M5/M6 reflects the beam into the azimuth axis which in our design is by the side of the primary mirror. By means of the field lens in F2, the pupil is imaged on M6 which can serve as the tip tilt mirror of the AO. M5 is a deformable mirror. F3 is about 6200 mm below the elevation axis which allows for convenient access of the focus points in the building. A mechanical turntable behind the telescope moves the whole post focus assembly which compensates for the rotation of the image due to the alt-azimuth telescope system. NLST has a mounting which is optimized for natural air flush in order to minimize mirror seeing. Heat near the primary focus is taken out of the system with a heat stop.

NLST is housed in a building which is optimized aerodynamically in order to minimize turbulence above the telescope. The telescope has an open design with a simple retractable dome that will cover the telescope during the period when there are no observations.

Basic principles:
Solar constant outside atmosphere: 1360 W/m2
Solar radiation at surface is given by the following equation:

$$I = I_0 \cos(Z)$$
$$Z = \arccos(\sin\delta \sin\phi + \cos\delta \cos\phi \cosh)$$
$$\delta = Declination$$
$$\phi = latitude$$
$$h = hourangle$$

Precautions have been taken to mitigate the likely impacts of reflection from the mirror and likely impacts on birds. These include:

- Shadow plate covering the primary mirror protects it from the vision of birds.
- Change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections (figure 3).
- Use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre.

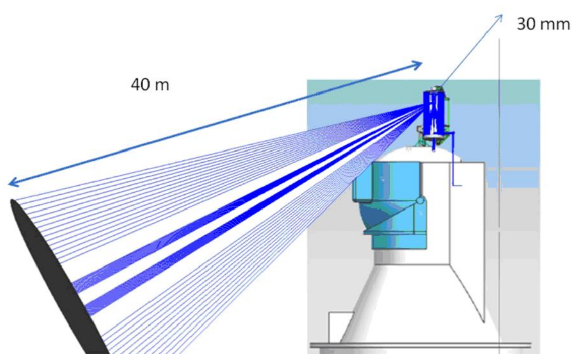


Figure 3: Beam Geometry

The Merak site at Pangong lake has sky conditions which are comparable to that of the Big Bear Solar Observatory lake site, combined with the advantages of the high altitude desert. It certainly appears to be well suited for locating a two meter or even a larger solar telescope for optical and near infra red observations. The following major criteria were used for preliminary selection:

- Annual number of clear sunshine hours (in the range of 2000),
- Significant number of 1 hour spells with median Fried parameter (r_0) of 7 cm or better and 30 min spells of r_0 better than 10 cm,
- High altitude for excellent transparency & dry conditions for NIR observations, &
- Lake sites with winds of 4 to 8 mps, as they are known to be good for day skies.

Table 1: Optical Specifications:

Aperture (primary mirror M1)	: 2 metre
Focal length	: 4 metre
Optical configuration	: 3 mirror, Gregorian on axis
Aberration free Field of view	: 200 arc sec
Final focal ratio of the system	: f / 40
Image scale	: 2.58 arc sec mm^{-1}
Optical quality	: 80 % of energy to be within circle of 0.1 arc sec or less over the entire field of view of nearly 3 arc min diameter at 5000 Å.
Wavelength of operation	: 3800 Å to 2.5 microns
Polarization accuracy Scattered light level within telescope	: better than 1 part in 10,000 : < 1 %
Active and Adaptive optics	: to realize near diffraction limited performance; Strehl ratio >0.5 within Isoplanatic patch
Spatial resolution	: < 0.1 arcsec at 5000 Å.

Consideration and evaluation of project alternatives: The exploratory surveys were carried out in Hanle, Devasthal and Pangong Tso (Figure 4). The mountain desert conditions of Ladakh provide good number of sunshine hours with minimal precipitation and have the additional advantages of high altitude desert, such as excellent transparency and low humidity. Therefore, Hanle, at an altitude of 4500 m in the Great Himalayan range in Ladakh, with demonstrated good conditions for astronomical seeing for the night sky, having median of 1.07 arc sec, which was selected through a survey of the region during 1995-2000, was chosen as one of the sites for evaluation.

Similarly, Devasthal, at an altitude of 2540 m in the Shivalik Hills of the Central Himalayan range and has been shown, through a survey during 1980-1990, to have good night sky conditions with medians of 1.1 to 1.4 arc sec (Sagar et al 2000), was chosen for detailed evaluation since it provided an alternative topographical environment in the Himalayan range. Besides, these two sites would have the advantage of the logistics available in an existing astronomical observatory.

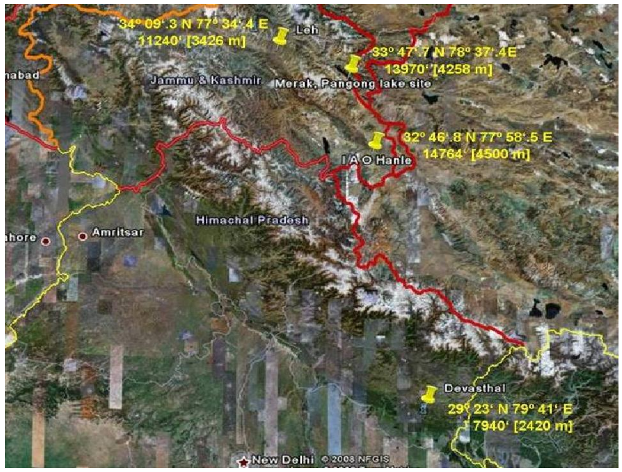


Figure 4: Locations of the three probable sites, Hanle, Devasthal, & Merak

Several lakes in Ladakh were examined for prospective sites. Tso Morari, Pangong Tso, Tso Kar, and Twin lake, in the altitude range of 4200 to 5000 m, were considered. The Pangong Tso lake, with a long stretch of about 50 km, was readily recognized to be the most promising lake site for detailed evaluation. The desirable land protrusion into the lake, the steady wind flowing over the water body for most part of the day, and the clear access to the southern sky, were found to be most favourable at a site along the shore near village Merak. This site was selected for detailed evaluation.

Description of the sites selected: Three sites Hanle, Devasthal and Merak were identified for the detailed investigations.

Hanle: This site was selected to be most prospective for night time astronomy, based on a detailed study of meteorological data, satellite imagery, and site reconnaissance trips to six high-altitude sites in the Great Himalayan Ranges. Site characterization starting 1995 proved that Hanle in the high altitude cold desert of south eastern Ladakh is among the best high altitude sites in the world for astronomical observations. A 2 m optical telescope, with remote operational facility from near Bangalore, started functioning in the year 2000 (Figure 5). A site adjoining the 2 m optical telescope, at 32° 46' 47" N, 78° 57' 50" E, and at an altitude of 4486 m, was selected for detailed study of the day time conditions.

Figure 5: NSO S-DIMM at Hanle

Devasthal: After a preliminary survey, carried out during 1982-91 and Devasthal turned out to be the choice in terms of the prevailing night time seeing, meteorological conditions, and also the logistics involved. A 1.3 m optical telescope has become operational in 2010, while a 3.6 m optical telescope, in collaboration with TIFR, Mumbai, is in an advanced stage of procurement. Both the telescopes are to be used for night time astronomy.

Figure 6. Devasthal site with instruments on towers and the observation hut.

Merak: The picturesque Pangong lake, at an elevation of 4258 m, is well known for the deep blue colour of its water body. It is the longest lake in Ladakh, with about 50 km stretch within Indian territory and over 100 km long stretch in the Tibetan plateau of neighbouring China. Fed by glacial waters, the lake once drained into the Tangshe river. Over the years, the outflows got blocked and the lake became mildly brackish. Therefore, except for the locations of fresh glacial waters, the lake does support marine life. The lake is said to be in a seismically safe zone. It runs between two mountain ranges in the NW to SE direction which steadily widen towards south of south-east, before bending eastward into China

Figure 7: The Merak site with the lake. Cluster of towers & instruments, and the observing hut are noticeable

The western shore of the lake has two villages, Spangmik and Merak. Following a survey of the entire shore, the land protrusion near Merak at 33° 47' 42" N, 78° 37' 08" E, was selected for implementing NLST. The prevailing wind is channeled over the water body for most part of the day, at a steady speed of a few mps, and this was readily recognized to be a major advantage of the site. The lake is well connected by road up to its starting point at Lukung, which is five hours drive from Leh via Chang La pass. A motorable mud road further connects Spangmik, Merak, and Chushul.

Methods used to identify, predict and assess impacts

- **Land use analysis:** Remote sensing data along with collateral data
- **Ecology and Biodiversity**: Field visit, consultation with the local forest department officials and published literature
  a) Documentation of the existing flora in the proposed corridor
  b) Documentation of animal paths (bird migratory paths, if any)
  c) Documentation of endemic species
  d) Assessing the Environmental Impacts
  e) Arriving at environmental management plan to achieve the least disturbance to the existing flora and fauna
- **Development of Environment Management Plan:** This is based on the understanding of ecological and environmental impacts (if any) – quantification would be done based on detailed field visit.

III Description of the Baseline Environment

The land protrusion near Merak at 33° 47' 42" N, 78° 37' 08" E, close to the Pangong Tso Lake and inside the Changthang Wildlife Sanctuary was selected for commissioning a 2 m state-of-the-art telescope (National Large Solar Telescope - NLST). Changthang Wildlife Sanctuary is a habitat for endemic, endangered species, vulnerable, and near threatened species. The area is of adequate ecological, faunal, floral, geomorphological and natural significance, and also link one protected area with another. The area of Pangong Tso Wetland is one of the Wet-site of the Changthang Wildlife Sanctuary. The area of 4000 Sq.Kms stands notified as Wildlife Sanctuary since 19-03-1987. The same wet-site is protected under the overview of J&K Wildlife Protection Act 1978. its 30 km stretch within India, the several land incursions into the lake, the almost east – west elongation, the wind ducting from east to west, and the large flat land at the southern shore allowing good access to the southern declination, necessary for solar observations at this latitude of about 34 degree north. The essential parameters monitored were total annual sunshine hours, sky brightness, atmospheric seeing at various heights of up to tens of meters above ground, micro thermal conditions, meteorological parameters such as precipitation, wind speed, wind direction, humidity, irradiance, temperature range, aerosol distribution at site and etc. The next sections will discuss of Himalaya (geological aspects, evolution), origin of lake as the proposed site is land incursion into the lake

Himalaya: Description

Being the highest mountain range in the world the Himalayas extends along the northern frontiers of Pakistan, India, Nepal, Bhutan, and Burma. Its origin was geologically driven as a result of the collision of the Indian subcontinent with Asia. This process of plate tectonics is ongoing, and the gradual northward drift of the Indian subcontinent still causes earthquakes. Lesser mountain ranges proceed southward from the main body of the Himalayas at both the eastern and western ends. The Himalayan system spanning about 2,400 kilometers in length and varying in width from 240 to 330 kilometers, is made up of three parallel ranges i.e. the Greater Himalayas, the Lesser Himalayas, and the Outer Himalayas and are sometimes collectively called the Great Himalayan Range.

The Greater Himalayas, or northern range, average approximately 6,000 meters in height and contain the three highest mountains on earth: Mount Everest (8,796 meters) on the China-Nepal border; K2 (8,611 meters, also known as Mount Godwin-Austen, and in China as Qogir Feng) in an area claimed by India, Pakistan, and China; and Kanchenjunga (8,598 meters) on the India-Nepal border. Many major mountains are located entirely within India, such as Nanda Devi (7,817 meters) in the state of Uttar Pradesh. The snow line averages 4,500 to 6,000 meters on the southern side of the Greater Himalayas and 5,500 to 6,000 on the northern side. Because of climatic conditions, the snow line in the eastern Himalayas averages 4,300 meters, while in the western Himalayas it averages 5,800 meters.

The Lesser Himalayas range from 1,500 to 5,000 meters in height and are located in northwestern India in the states of Himachal Pradesh and Uttar Pradesh, in north-central India in the state of Sikkim, and in northeastern India in the state of Arunachal Pradesh. Shimla (Simla) and Darjiling (Darjeeling) are the hill stations located in the Lesser Himalayas. It is in this transitional vegetation zone that the contrasts between the bare southern slopes and the forested northern slopes become most noticeable. The Outer or Southern Himalayas, averaging 900 to 1,200 meters in elevation, lie between the Lesser Himalayas and the Indo-Gangetic Plain. In Himachal Pradesh and Uttar Pradesh, this southernmost range is often referred to as the Siwalik Hills. The northernmost range, known as the Trans-Himalaya and is located entirely on the Qinghai-Xizang Plateau, north of the great west-to-east trending valley of the Yarlung Zangbo river. Although the Trans-Himalaya Range is divided from the Great Himalayan Range for most of its length, it merges with the Great Himalayan Range in the western section as the “Karakoram Range” where India, Pakistan, and China congregate. The southern slopes of each of the Himalayan ranges are too steep to accumulate snow or support much tree life; the northern slopes generally are forested below the snow line. Between the ranges are extensive high plateaus, deep gorges, and fertile valleys, such as the vales of Kashmir and Kulu. The Himalayas serve a very important purpose as they provide a physical screen within which the monsoon system operates and are the source of the great river systems that water the alluvial plains below.

As a result of erosion, the rivers coming from the mountains carry enormous quantities of silt that enrich the plains. The area of northeastern India adjacent to Burma and Bangladesh consists of numerous hill tracts, averaging between 1,000 and 2,000 meters in elevation, that are not associated with the eastern part of the Himalayas in Arunachal Pradesh. The Naga Hills, rising to heights of more than 3,000 meters, form the watershed between India and Burma. The Mizo Hills are the southern part of the northeastern ranges in India. The Garo, Khasi, and Jaintia hills are centered in the state of Meghalaya and, isolated from the northeastern ranges, divide the Assam Valley from Bangladesh to the south and west.

Evolution of Himalaya:

It is now widely accepted that the collision between the Indian Plate and the collage of previously sutured micro-continental plates of Central Asia occurred during the mid to late Eocene, at approximately 50-45 Ma (Million yrs. Ago) (Alleigre et al., 1984; Searle et al., I987). The timing of terminal collision of the two plates is deduced from (i) the ending of marine sedimentation in the Indus Suture Zone (ISZ), (ii) the beginning of continental molasse sedimentation along the suture zone, (iii) the ending of Andean-type calc-alkaline magmatism along the Trans-Himalayan (Ladakh-Kohistan-Gangdese) batholith and (iv) the initiation of the major collision-related thrust systems in the Himalayan Ranges. Palaeo-magnetic data indicate that over 2000-2500 km of southern (Neo) Tethys separated 55 Ma (Klootwijk, I979) and terminal collision at about 40 Ma (Molnar & Tapponnier 1975; Klootwijk & Radhakrishnamurthy, 198I). The northward relative motion of the Indian Plate decreased threefold at 40 Ma from average rates of 14.9 + 4.5 cm/a to 5.2 + 0.8 cm/a (Pierce, 1978). Seafloor spreading rates in the Indian Ocean also decreased drastically at anomaly 22 (given in the fig. below), which corresponds in time to ca. 50 Ma (Sclater & Fisher 1974; Johnson et al. 1976). Major directional shifts in the relative motion of the Indian Plate at anomalies 22 and 21 (given in the fig. below) (50-48 Ma) are also thought to indicate the onset of collision (Patriat & Achache, 1984). Another major shift occurred at anomaly 13 (36 Ma) after which India resumed stable northwards convergence with a constant rate of 5 cm a-' (Patriat & Achache, I984).

The post-collision crustal shortening in the Indian Plate can only be deduced from the restoration of balanced cross sections across the Himalaya. It is widely recognized that in general terms, southward-propagating thrust stacking had occurred across the Himalaya since the mid-Eocene collision and suturing (Molnar 1984; Mattauer 1986; Searle et al., 1987). The climax of crustal shortening and thrust stacking occurred during the mid-Tertiary in the High Himalaya and Zanskar Ranges, with thrusts propagating southwestwards from the Main Central Thrust (MCT) system to the Lesser Himalaya and the late Tertiary Main Boundary Thrust (MBT) system (Figure 8). The youngest thrusts occur along the southern boundary of the Himalaya, in the Siwalik molasse deposits of the Indian foreland basin, where the Main Frontal Thrust (MFT) terminates at tip lines below the Indo-Gangetic plains. Four major tectonic zones constitute the

Ladakh-Zanskar Himalaya. These are, from north to south, the Ladakh (Transhimalayan) batholith, the Indus Suture Zone, the Tibetan-Tethys (Zanskar shelf) Zone, and the High Himalaya. A generalized geological map depicting these zones is shown in figure 2. Figure 3 shows a late Cretaceous and Tertiary time chart for the Ladakh-Zanskar Himalaya (after Searle 1983, 1986) updated with all radiometric ages and stratigraphic time spans for the four tectonic zones.

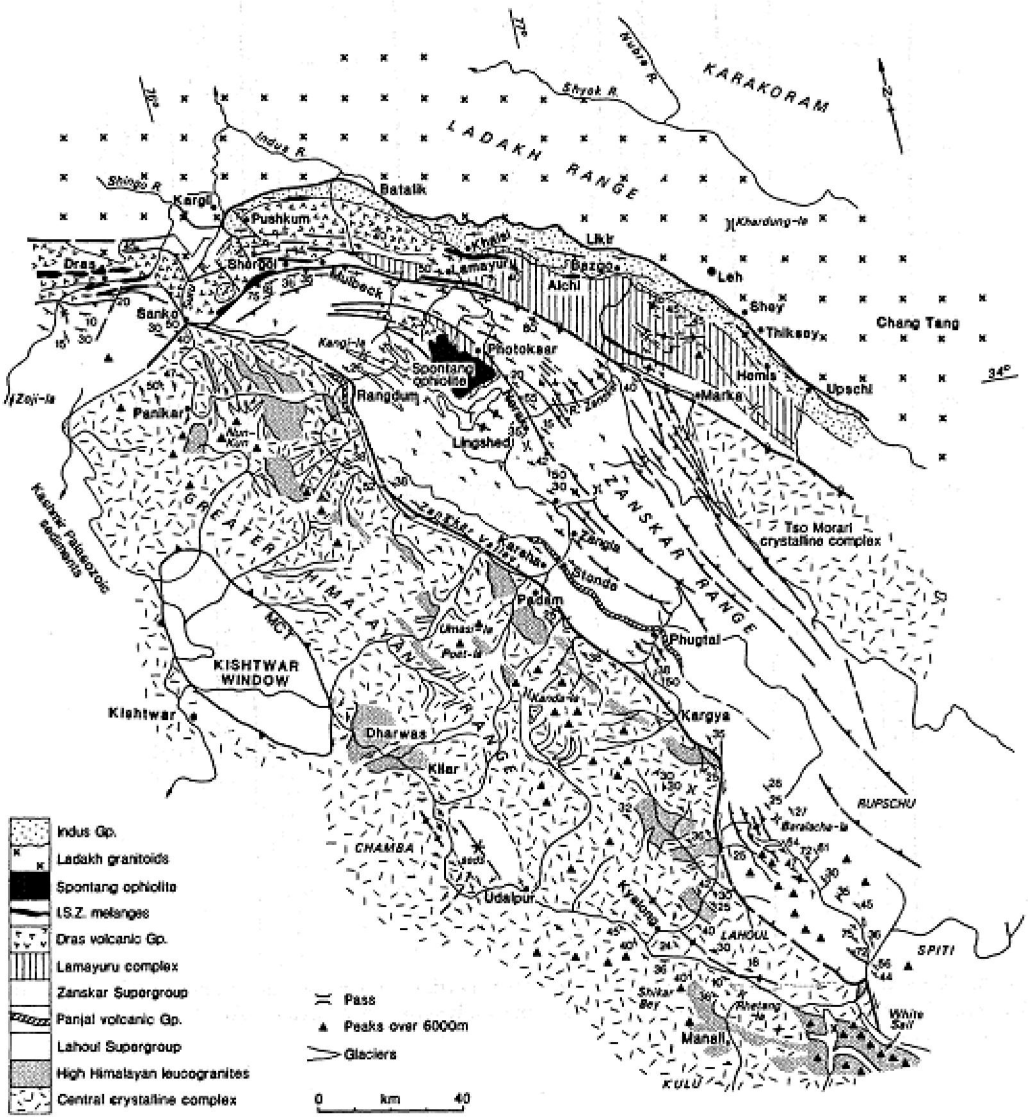


Figure 8. Geological map of Ladakh-Zanskar (After Searle 1983, 1986)

Ladakh Batholith: Batholiths are large emplacement of igneous intrusive (also called plutonic) rock that forms from cooled magma deep in the earth's crust. Batholiths are almost always made mostly of felsic or intermediate rock-types, such as granite, quartz monzonite, or diorite. The Ladakh batholith, a part of the 2000 km long Transhimalayan batholith, is situated to the north of the ISZ (Indus Srture Zone) in the Ladakh Ranges (figure 9). The Transhimalayan belt continues westward to include the Kohistan batholith in northern Pakistan (Petterson & Windley, I985) and eastward to include the Gangdese batholith in south Tibet (Alleigre et al., 1984; Tapponnier et al. 1981). The Ladakh batholith ranges in composition from olivine-norite (types of rocks) to leucogranites with grandiorites dominating (Thakur, 1981; Honegger et al., 1982). Olivine-orthopyroxene-bearing norites, gabbros, diorites, granodiorites, granites and leucogranites are all represented and collectively represent a continental, subduction-related batholith (Honegger et al. i982). The presence of granitic gneisses and meta-sedimentary sequences in the Ladakh Range provides evidence for the existence of precursory continental crust (Honegger & Raz, 1985). Furthermore, a substantial component of inherited lead in zircons extracted from samples of the batholith implies involvement of continental crust during ‘petrogenesis (Scharer et al., 1984).

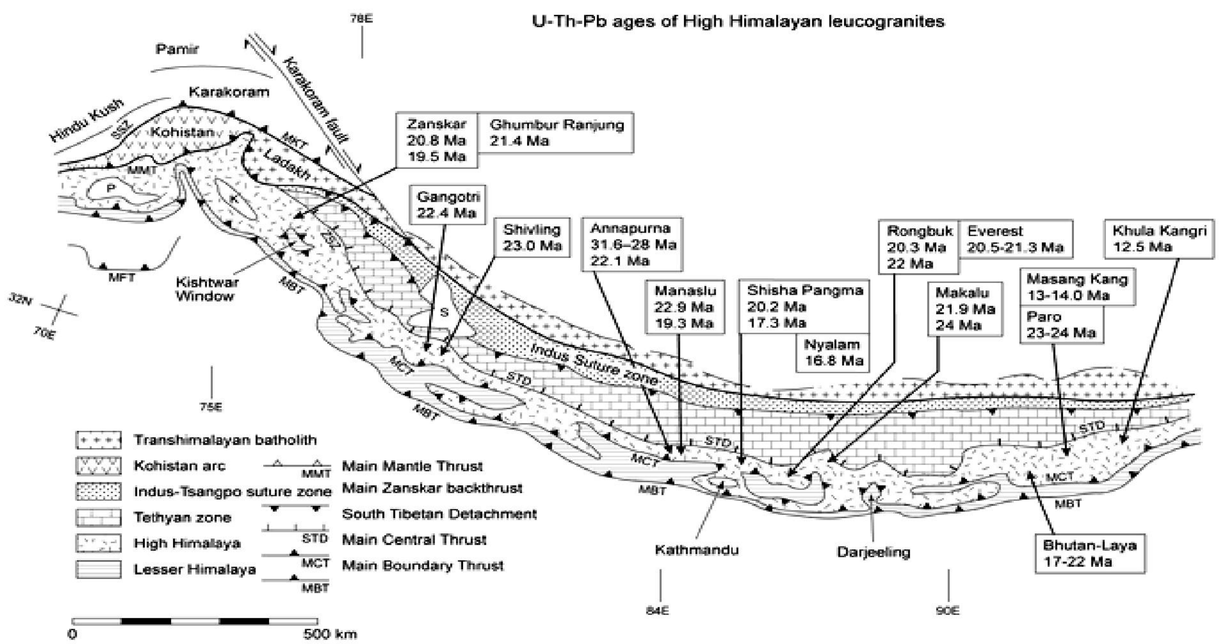


Figure 9: Origin and changes in High Himalayan Leucogranites

Initial 87Sr/86Sr ratios of around 0.704 (Scharer et al., 1984) and 0.705 (Honegger et al., 1982) are un-enriched, inferring a primary mantle that is a derivation of the magmas. The amount of isotopic enrichment due to the envisaged crustal component remains to be quantified. Available geo-chronological determinations indicate that the Ladakh batholith is composite and dominated by pre-collisional magmatic events. U-Pb zircon ages of 103$\pm$3 Ma (Honegger et al., 1982) and 101$\pm$2 Ma (Scharer et alt., 1984) from samples collected near Kargil refer to important mid-Cretaceous magmatism. A second U-Pb determination of monazite/allanite from a biotite-granite near Leh gave an age of 60.7$\pm$0.4 Ma, whereas a Rb-Sr isochron age of 73$\pm$2.4 Ma (Scharer et at. 1984) and a ^{39}Ar/^{40}Ar age of 82 $\pm$ 6 Ma (Sckirer & Allbgre, 1982) may indicate a continuity of magmatic activity for some 40 Ma, finally terminating with continent-continent collision (figure 10). Likewise, a span of K-Ar mineral ages of 50-40 Ma is considered to reflect a cooling period associated with uplift.

The termination of granitic magmatism in the Ladakh batholith is at the same time with the closing of Neo-Tethys along the ISZ and the change from marine to continental sedimentation. Clasts of granites, andesites and rhyolites are particularly widespread in the conglomerates of the Chogdo, Nurla and Hemis Formations of the Indus Group molasse, which unconformably, overlies the batholith. Volcanic rocks overlying the Ladakh batholith include andesites and rhyolites (Srimal et al., 1987). Late-stage garnet-muscovite leucogranitic dykes intrude the granite and may reflect a final phase of intracrustal melting after the 50 Ma collision along the ISZ. Granitoids of the Ladakh batholith intrude the Dras island arc volcanics and rocks of the suture zone around Kargil. This provides strong evidence that the Dras island arc was accreted to the Karakoram-Lhasa Blocks by the mid-Cretaceous and that the Shyok (Northern) Suture between the Ladakh and Karakoram terranes closed in the mid-Cretaceous (Coward et al., 1986; Pudsey, 1986; Searle et al., 1988) and not in the late Tertiary (Thakur, 1981, 1987). The Ladakh batholith has undergone an unknown amount of post-collision shortening evidenced by thrusting within the granitoids. Near Kargil, a number of late stage shear zones with mylonitized amphibolites and greenschists cut intrusive rocks of the batholith are found.

Source: http://www.scielo.org.mx/img/revistas/geoint/v46n1/a4f1.jpg

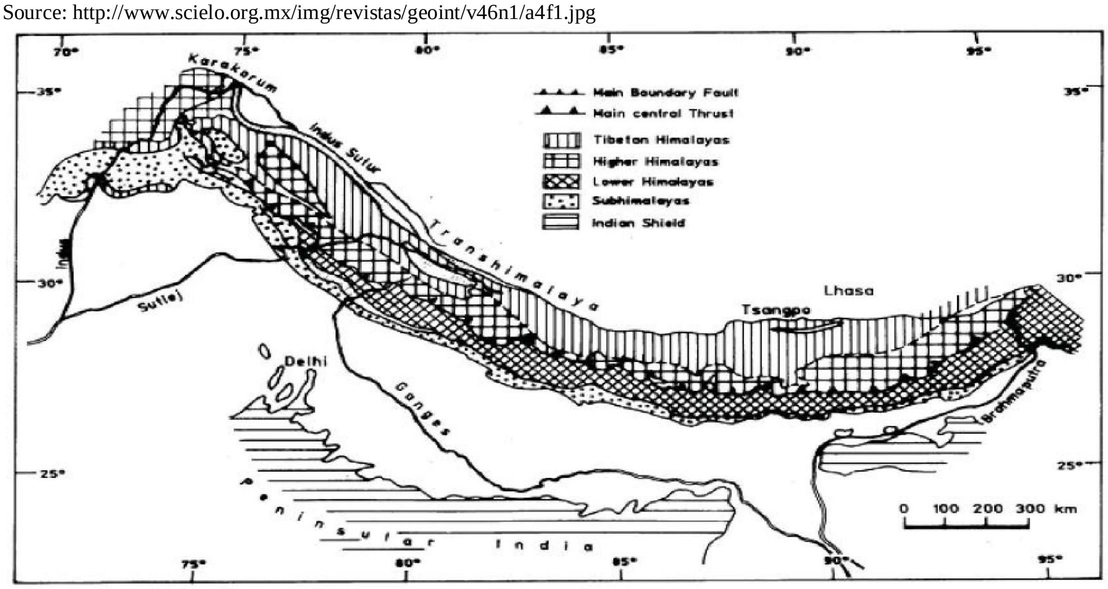


Figure 10. Tectonic map of Himalayas and its adjoining regions showing the major fault zones and lithotectonic regions (Gansser, 1964)

Indus Suture Zone (ISZ): The Indus Suture Zone (ISZ) defines the zone of the collision between the Indian Plate and the Karakoram-Lhasa Block to the north (Gansser, 1964, 1977; Allegre et al., 1984; Searle et al. 1987) and can be traced for over 2000 km from Kohistan and Ladakh in the east right across southern Tibet to the NE Frontier region of India-Burma. In Tibet it is commonly referred to as the Yarlung-Tsangpo Suture; in the western Himalaya it is the Indus Suture Zone. To the west of Ladakh, the ISZ is folded around the giant Nanga Parbat fold, a 35 km wavelength, upright anticlinorium that exposes Indian Plate gneisses equivalent to the Central Crystalline Complex in its core (figure 11). The ISZ has been offset by the late Tertiary culmination of Nanga Parbat and downfaulted west of Nanga Parbat along the Rakhiot Fault zone. It continues westwards as the Main Mantle Thrust (MMT) across southern Kohistan (Tahirkheli & Jan, 1979). In Ladakh, the Indus Suture is bounded to the south by the backthrust shelf sediments of the Zanskar Supergroup and the Tso Morari crystalline complex, and to the north by the Ladakh batholith. The geology of the ISZ has been described by Gupta & Kumar (1975), Shah et al. (1976), Andrieux et al. (1981), Fuchs (1977, 1979), Bassoullet et al. (1978, 1981), Frank et al. (1977), Baud et al. (1982), Brookfield & Andrews-Speed (1984a, b), Thakur (1981, 1987) and Searle (1983, 1986). The Indus Suture Zone in Ladakh consists essentially of three major linear thrust belts, the Lamayuru complex, the Nindam-Dras Volcanic Group and the Indus Group molasse. They are separated by major fault zones or ophiolitic melange belts (figure 7 a, plate 1). Figure 4 is a palaeogeographic reconstruction of the Neo-Tethyan basin showing the pre-Eocene stratigraphy of the rocks now preserved in the ISZ in Ladakh.

Indus Group molasses: The term “molasses” refers to the sandstones, shales and conglomerates formed as terrestrial or shallow marine deposits in front of rising mountain chains. A continental clastic sequence approximately 2000 m in thickness, comprising alluvial fan, braided stream and fluvio-lacustrine sediments, constitutes the Indus Group (Brookfield & Andrews-Speed, 1984 a,b; Van Haver, 1984). Clasts in the conglomerates were derived mainly from the uplifted and eroded Ladakh batholith to the north, but also from the suture zone itself (cherts, limestones, serpentinised peridotites) and from the Zanskar shelf carbonates to the south. Palaeo-currents show dominantly east to west basin axis-parallel sediment transport paths (Pickering et al., I987). Near Kargil the Indus molasse unconformably rests on the Ladakh granitoids along the northern margin of the ISZ. The collision of India with the Karakoram and Lhasa Blocks and the closing of Tethys at 50 Ma mark the initiation of Indus Group molasse sedimentation (Searle et al., 1987). The Chogdo Formation at the base of the molasse rests stratigraphically above late Palaeo.

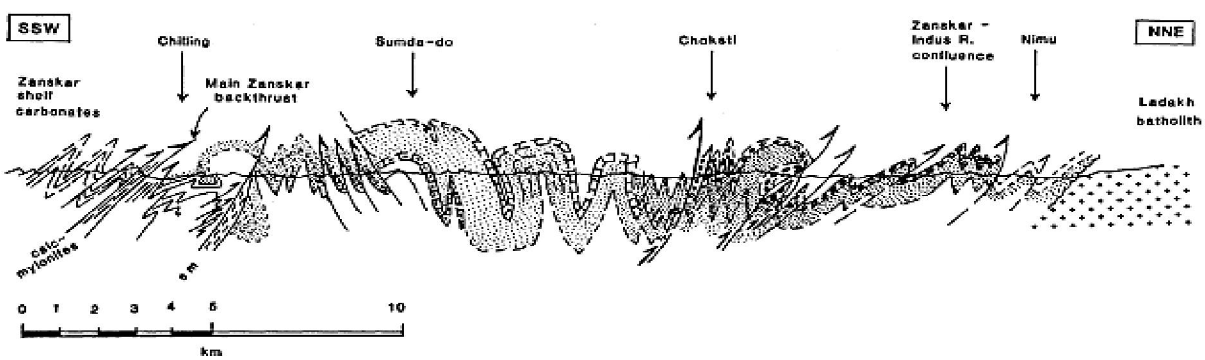


Figure 11: Structural section along the Zanskar River between Chilling and Nimu about 40 km west of Leh.

Tectonic Origin of the Himalayas: The magnificent heights to which the Himalayas have been uplifted is as a result of several orogenic movements. The tectonic history of the Himalayas is a much debated subject. Some workers have recognized five phases of deformation on the basis of small scale shortening structures. Others have deciphered four major tectonic movements, the earliest dating back to the Precambrian or Lower Paleozoic, while the other three postdating the Permian. A few workers however, recognise only three episodes of orogenic activity, post-dating the Cretaceous.

The first phase of Himalayan orogeny-the Daling event (Precambrian or Lower Paleozoic) is marked by medium grade metamorphism but intense deformation accompanied by both acid and basic igneous intrusives. The second phase of orogeny known as the Ladakh phase involved the beginning of earth movements which were responsible for the major uplift of the Himalayas. It is during this phase that the Indian plate is believed to have collided with the Asian plate. This caused a shallowing of seas, emplacement of ophiolites along the Indus Suture zone, granitic intrusions, palingenesis, and granitization. Patches of Eocene rocks over the Tal (Jurassic), Krols (Permo-Trias), Simla Slates (Paleozoic), and Deoban rocks (Paleozoic) indicate folding and erosion of these sedimentary basins before transgression of the sea in Eocene period, and subsequent deposition of Eocene sediments. This phase of the Himalayan orogeny was active from Late Cretaceous to early Eocene times.

The third and most vigorous of all orogenic movements is termed the Dharamsala phase which culminated in the Middle Miocene. The consequent compression due to under-thrusting of the Indian plate beneath the Tibetan (=Asian) plate caused large scale isoclinal and recumbent folding of the Precambrian crystalline rocks. This resulted in the thrusting of huge blocks of these rocks that moved southwards, and came to rest upon the younger sedimentaries. Most of the thrust sheets of the Lesser Himalayas and widespread regional metamorphism and acid igneous activity are associated with this phase. Due to the great uplifting, a foredeep was created in front of the rising Himalayas into which the Siwalik molasse sediments were deposited.

The fourth phase of Himalayasn orogeny is the Siwalik phase. This phase was very active from the Late Pliocene to Middle Pliestocene period. Most of the present structures of the Himalayas developed during this phase. The Siwalik sediments were also uplifted. Tectonic creep along some of the thrust faults of the Himalayas, translation of upper Siwalik rocks over the subrecent gravel beds, and seismicity in the region strongly suggest that this phase has not yet ceased.

Increase in the level of Indo-Tibetian Highland lakes assosciated with Climatic changes: The earlier visits to Tibetan high altitude lakes (Figure 12) by Godwin Austen in 1866 recorded and evidenced the Ice Age, which out shed the attention of the important processes like erosive and bathymetric evidences of recent climatic oscillatory changes. In 1905 Huntington E observed Pangong Tso showing a set of benches and beach lines which lie lower than any of the older terraces surrounding the lake. During summer 1932 Terra and Hutchinson visited several lakes like Pangong, Pongur, Mirpa, Morari and Kar in eastern ladakh along Kashmir-Tibetian Boundary. The investigations have provided new informations regarding changes of depth, of shore features, and related phenomena attributed to regional climatic oscillations. The reasons for the recent changes of the high altitude lake-levels were attributed to topographic, physiographic and hydrographic alterations.

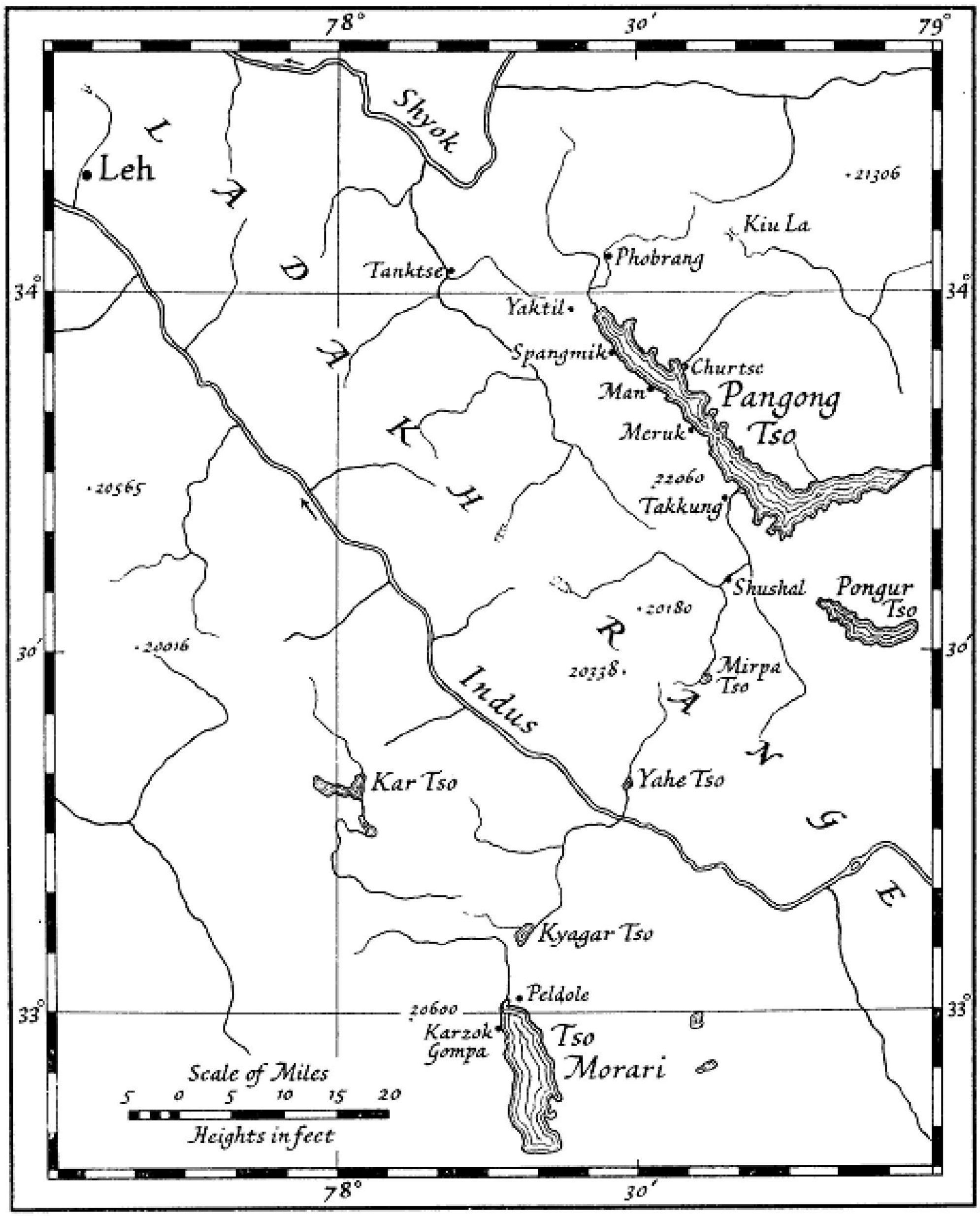


Figure 12: The topto map showing the Pangong Tso lake and other high altitude Indo-Tibetian lakes

The Pangong Tso, being the largest mountain lake north of the Himalaya (13, 915 feet above sea-level), gave the first evidence of recent topographic changes. Terra and Hutchinson (1932) noticed the base of the cliffs near northern shore between Churtse and Lukung were flooded and observed the earlier path for traveling could be seen to lead into the lake, where the path

continued 5 feet below the water and around the cliff. Two drowned beaches at 3 and 5 feet which may also be recognized on Figure 13.1).
According to Hutchinson the landmark a rocky islet (1/4 th of a mile from the shore at Yaktil) had been marked as lying 5 feet above the lake-level on the old survey sheet does not exist during the visit. As the shallowest water was 13.1 feet at the spot where the islets had been in 1861. Thus the lake had risen since then at-least 18 feet.

Along the Southern part of Pangong Lake from Lukung to Man and Takkung further strengthened the rising levels of the lake by strong physiographic evidences. The fan formation making the lake front is seen to be superimposed on the pleistocene deposits and is therefore of post-glacial origin. At the slope of a cliff between Yaktil and Spangmik two distinct beach lines were recorded at 3 and 5 feet above the water, and a third could be seen in the clear water 2 to 3 feet below the level of the lake. Shortly before reaching this spot the path makes a detour around the advancing water of a shallow bay. In some of the shallower flood channels a more recent heavy accumulation of gravel had taken place.

Twelve miles south-east of Takkung the underwater beaches were seen to follow the contours of an old shore-line (Fig. 13.3). A small delta had here been built into the lake, and as the underwater beaches broke abruptly off along the drowned shallow flood-channel of the rivulet it is evident that the beach preceded the delta. Larger bushes could still be seen clinging to the upper beaches while others had already become uprooted and were tossed about by the waves. The rising lake water had then flooded these shore features until the lake is now cutting into the front of the older fan.

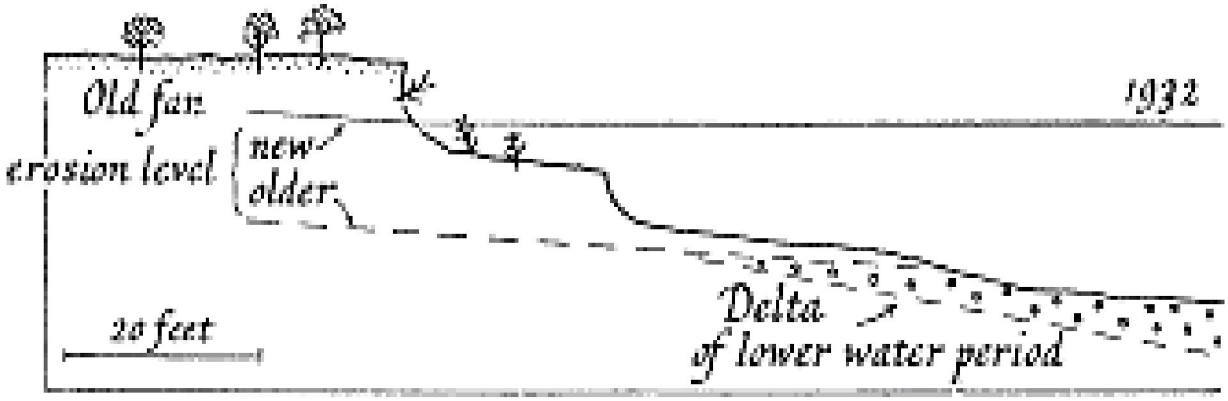


Figure 13.1). Under water beaches of an old-shore line near Pangong Tso- South

Another interesting and important physiographic change connected with the rise of the Pangong is the formation of small lagoons. They appear in parallel rows along the shore and in one place two could be seen at distances of 3 and 10 feet from the shore. Fig. 13.2) illustrates how their peculiar arrangement can be explained by a progressive rise of the lake-level. Their formation is greatly assisted by preceding shore-ice action. The accumulation of gravel and sand in the form of ridges is a common feature along Tibetan lakes (Figure 13.4.). Owing to the severity of the frost, which keeps the lakes solidly icebound during four or five months of the year, shore-ice is a much greater factor of accumulation than around lowland lakes in middle latitudes. Most lagoons on Pangong can be traced back to the same process; particularly where low terraced fans have become inundated, this indicates a recent rise of the lake-level.

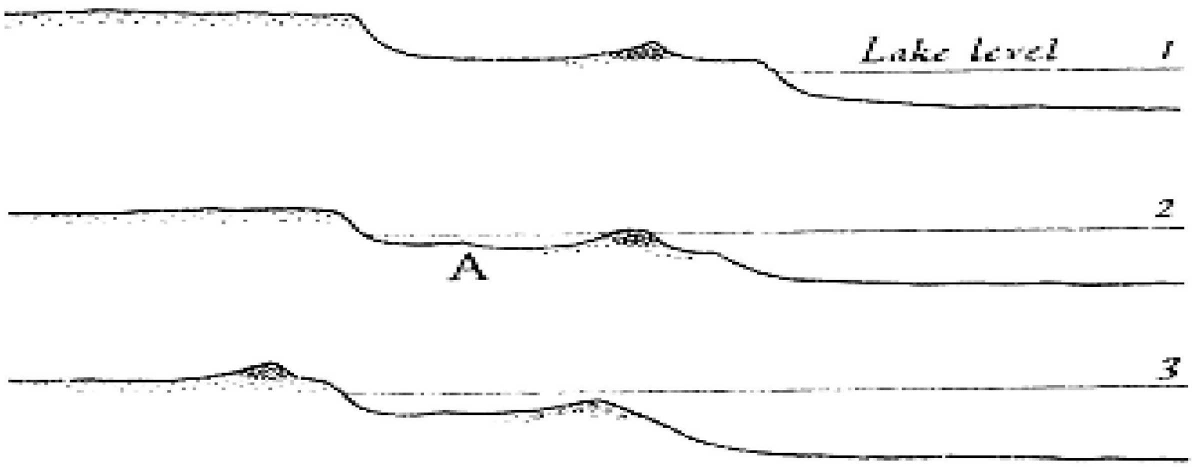


Figure 13.2).The lagoon formations as a result of water level rise

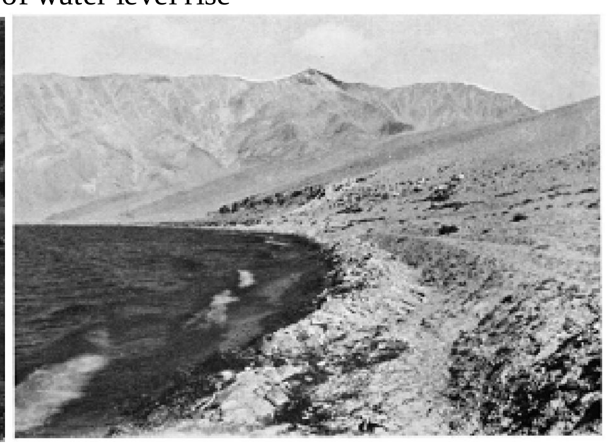


Figure 13.3). Pangong Tso drowned beaches 13.4). Pangong Tso accumulated Gravel and sand.

Historic records indicative of the sequence in changes of Pangong lake water level:

Figure 13.5 documents the changes in water level in Pangong lake.

1. W. Moorcroft and G. Trebeck in 1831 gave the first account of Pangong Tso and mention the lack of a road along the northern shore in 1821.

2. H. Strachey who visited the lake in 1848, remarks on the outflow of the eastern Pangong at Ot. They said that the lake had perceptibly receded in the last twenty-seven years.

3. H. von Schlagintweit relates native information according to which higher lake-levels in connection with good harvests were frequent before 1841. In 1856 soundings were made but no rock islet is mentioned.

4. H. H. Godwin Austen surveyed the rock islet in 1863 which appeared in 1859 above the lake-level. Shore roads were passable. He observed five to six beach-lines, 1 foot distant from each other, and also a submerged lake terrace, 10 feet below the 1863 level. From these phenomena they inferred climatic oscillations.

5. In 1869 F. Drew observed pictures of the islet and mentions a total seasonal rise and fall of the lake by 3 feet.

6. M. S. Wellby in 1898, had the choice to use either the shore route or the longer but safer one across the Poranda La.

7. Sven Hedin gives soundings of 1900 and comments on the condition of the northern shore route which was inundated, but the river at Ot was fordable. The existence of an older road, 10 m.above the path which he followed, makes him believe that his road of 1900 was once flooded.

8. E. Huntington observed in 1905 three to four small drowned beaches 10 to 12 feet below the level, and gives native information according to which the lake was 10 to 12 feet lower during I875-85. Although he recognized that oscillations were recent he attempted to couple them with the formation of clay and gravel deposits near Man which Godwin Austen in 1866 had rightly interpreted to be of glacial and interglacial origin.

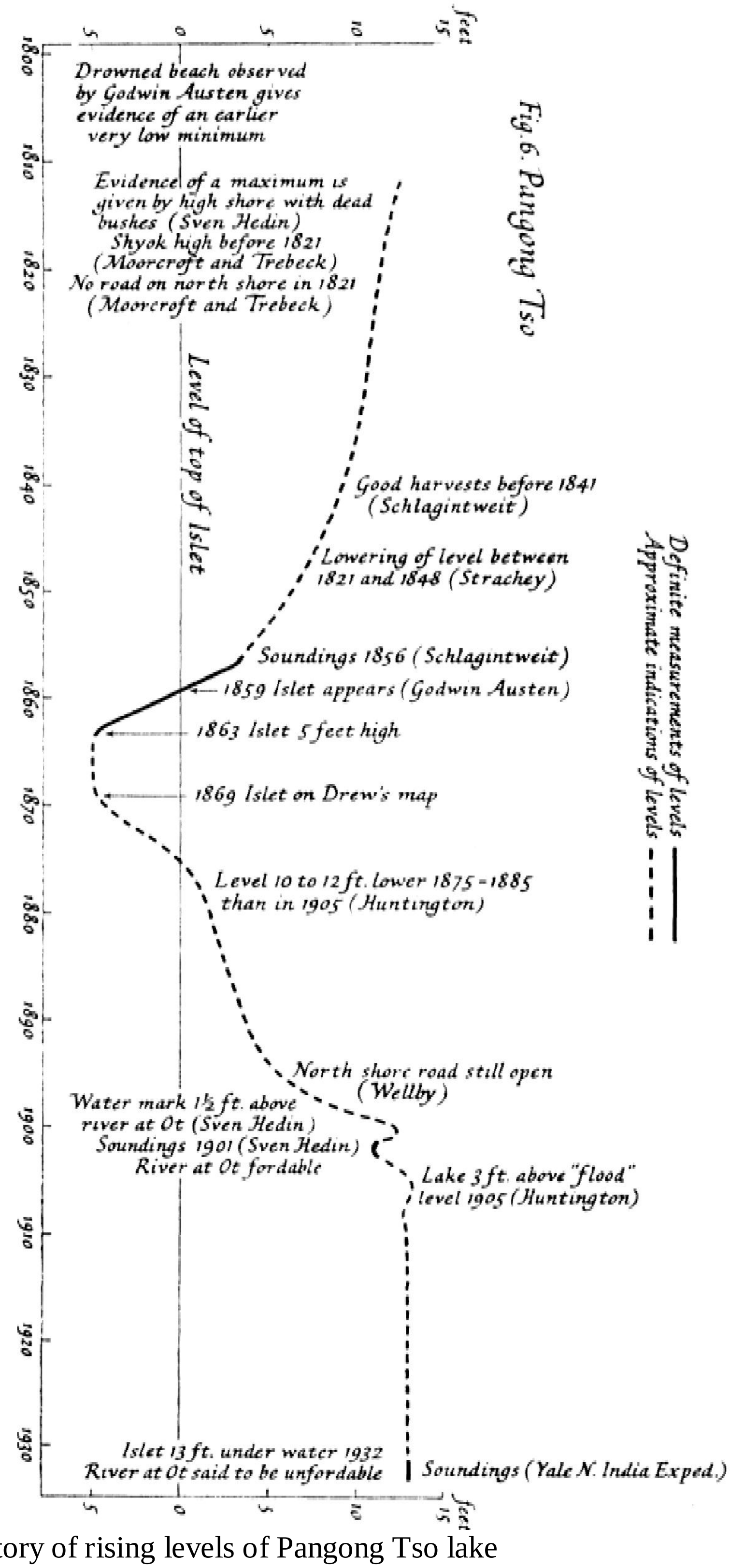
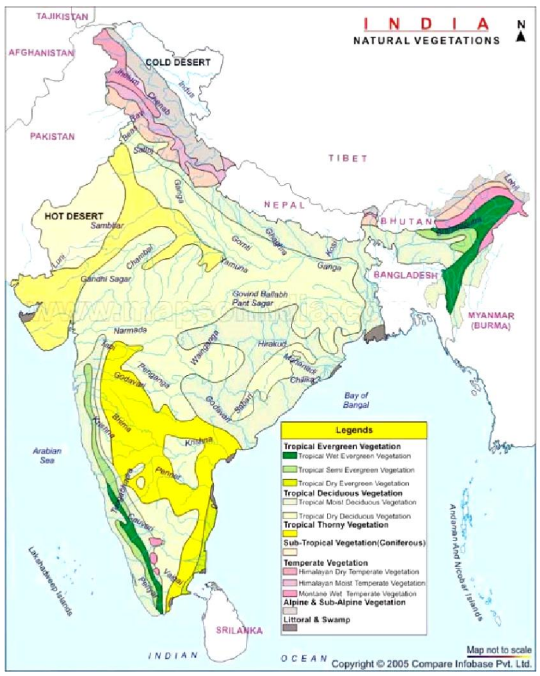


Figure 13.5). History of rising levels of Pangong Tso lake

Ladakh Region: Ladakh is situated between 30° to 36° E latitude and 76° to 79° N longitude. It is part of the state of Jammu and Kashmir, has an area of 96,701 sq. km and comprising a population of 200,000 habitants. Ladakh is bounded on the north by the eastern range of the Karakoram Mountains and the Tibetan Plateau. Across the Kashmir Valley and over the famous Zoji La pass (Zozi La pass) lies Ladakh – “the Land of High Passes”. It is a magical land, so completely different from the green landscape of some other parts of the Himalayas. It is nature at its extreme. A land of freezing winds and burning hot sunlight, Ladakh is a cold desert lying in the rain shadow of the Great Himalayas and other smaller ranges. Little rain and snow reaches this dry area, where the natural forces have created a fantastic landscape. Parts of Ladakh are under the illegal occupation of Pakistan and China, respectively. The border of Ladakh touches those of Afghanistan, Pakistan, China, the Kashmir Valley (India) and Himachal Pradesh (India).



Sources: http://www.mapsofindia.com/maps/india/natural-vegetation-india.jpg

Figure 14: Indian vegetation with biogeographic regions

Ladakh has an average elevation of 2,700 m to 4,200 m. The aridity of this region is due to its location in the rain shadow area of the Great Himalayas, elevation and radiation of heat from the bare soil. The great Himalaya mountain, lying to the south, forms a barrier to monsoon in this area. The most striking physical feature of Ladakh, however, is the parallelism of its mountain ranges. The region is extremely dry, with rainfall as low as 10 cm each year. . It has many lakes and springs, the famous springs are the sulphar springs of Panamic (Nobra), Chumathang and Puga of Changthang, which are famous for early curing of joints/ rheumatic diseases. Many mineral springs are also found in some remote parts of Ladakh. People of region use the spring water as medicine to prevent and cure themselves from many diseases. In Ladakh, large rivers and their tributaries have carved deep gorges far below their steep banks. However, their water is not of much use as the terraced fields (Figure 15.1) lie high above the gorges.

Figure 15.1. The terrace type of cultivation in the cold arid deserts of Leh, Ladakh.

Earlier Ladakh could only be reached over high passes (Figure 15.2). The Zoji La pass connecting Ladakh to Kashmir is at 14,000 ft and is the lowest approach from the west. The south east approach has to cross the 18,200 ft high Tanglang La. And to the north lie the Saser La and Karakoram passes, gateways to Central Asia from where trading caravans used to come for many centuries. The altitude ranges from 3000 m (lower Indus and Nubra valleys) to 7600 m (Zanskar and Karakoram ranges) (Gujja et al., 2003). The region of Ladakh normally remains land locked between November to June every year as Srinagar-Ladakh and Ladakh - Manali highways, which connect Ladakh with the other parts of the country, remain closed during this period because of snow and rigorous winter. Due to this region Ladakh is an isolated cold desert region. Figure 15.3 gives the glimpse the dry vegetation mostly Poplar and Willow at Leh, Ladakh.

Figure 15.2. The Changla pass on the way to Pangong Tso.

Figure 15.3: The dry vegetation mostly Poplar and Willow at Leh, Ladakh.

There are two districts in the Ladakh region, Leh and Kargil, with Leh as the administrative capital. The 21,000 sq.km Changthang sub-division is part of Leh district, with high mountains, wide-open valleys, natural grasslands, and snow-fed streams (jammukashmir.nic.in).

The State Government intends to declare an area of 4000 sq.km in eastern Ladakh at Changthang as a sanctuary (Fig. 16). This area is a barren cold desert sparsely wooded and experiences the severe cold in the region. Thus named as High altitude cold desert Changthang Wildlife Sanctuary. It is located in the North-east of Leh and constitutes the eastern parts of the Ladakh region, at a distance of about 130 km from Leh. The area falls at 34 – 79 degree north longitude and 33 – 79 degree east latitude. This sanctuary includes the water catchment of the Indus River, Hanlay, and Pangong Tso enrooting south-eastern catchment up to China border.The boundaries of Changthang Wildlife Sanctuary are as follows: (i) North – Chilam and Lukoong (ii) South – Kaigar – Tso and Hanlay (iii) East – International boundary of China. And (iv) West – Spanger – Tso and Spangong – Tso.

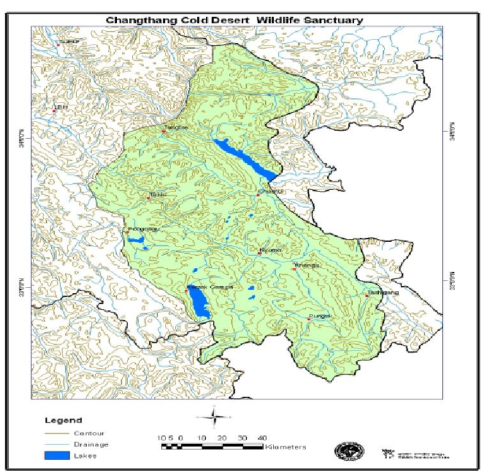


Figure 16:. Changthang Wildlife Sanctuary.

Study Area: Pangong tso

Pangong Tso is a part of the protected area (Figure 17). It has been proposed for Ramsar site due to its biological cultural and geological values (Chatterjee et al., 2002). The Ministry of Environment and Forest, Government of India has identified Pangong Tso under the Wetland conservation Programme (Islam & Rahmani, 2008). The Salim Ali Centre for Ornithology and Natural History, Coimbatore has recommended it to be declared as a Ramsar Site (Prasad et al., 2004).

Pangong Tso represents unique brackish ecosystem example of the highest (4300 m) and largest (50 x 6 km) in India side and remain 75 x 6 km in Tibetan (Chinese) side wetland of the Trans-Himalayan biogeographic Zone of the Indian sub-continent. The adjoining areas of the wet-side abodes high diversity of endemic, rare, and vulnerable species. Pangong Tso is an important breeding area for Ruddy Shelduck and Bar-headed Goose. This lake acts as a stagging and foraging ground for birds, especially on the marshes on the fringe of this Lake (Pfister, 2005; Chandan et al., 2005). Local people graze their livestock in the marshes and meadows, and harvest the grasses for fodder very close to the nesting birds is a conservation issues (Islam & Rahmani, 2008).

The tourists have been seen in Pangong Tso during summer months, from the year 1993, with the opening of the Changthang Wilderness area to the outsiders. The adjacent areas of the Pangong Tso- Wetland having steppe cold desert ecosystem is bestowed with many types of floral species. These provide ample grounds to the “Changpa” pastoral-nomads who take advantage of these grounds on seasonal basis. Since, all the adjacent village-folk are dependent on the raring of the “Pashmina goat”. The wetland invariably helping the economy of the local people.

Pangong Tso- is one of the Wet-site of Changthang Cold desert Wild life sanctuary. The area remained notified as Wildlife Protected area under SRO no. 155 dt. 19-03-1987 issued under the purview- of the J&K Wildlife protection Act (1978) section 17. The ownership of the wet-site remains with the Department of Wildlife Protection J&K State Leh Division” However, some of the surrounding areas of Spangmik, Man, Merak, Chushul are belonging of the local Pangong Tso, at Man-Merak is owned by Indian Astronomical Observation to understand the fundamental processes taking place on the Sun. The current proposal is to construct a 2 m state-of-the-art telescope class telescope (National Large Solar Telescope (NLST)) at this site (Fig. 17 and 18). The proposed site is very close to the Pangong Tso Lake and inside the Changthang Wildlife Sanctuary, which has endemic, endangered species.

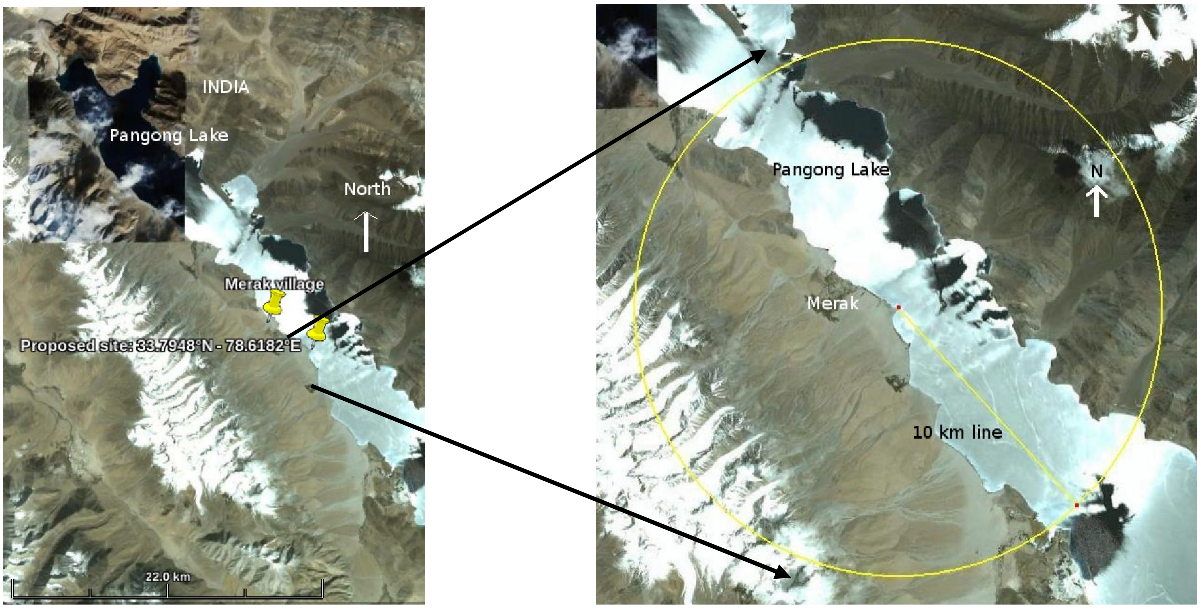


Figure 17. Pangong lake; proposed site and 10 km radius (regional investigations)

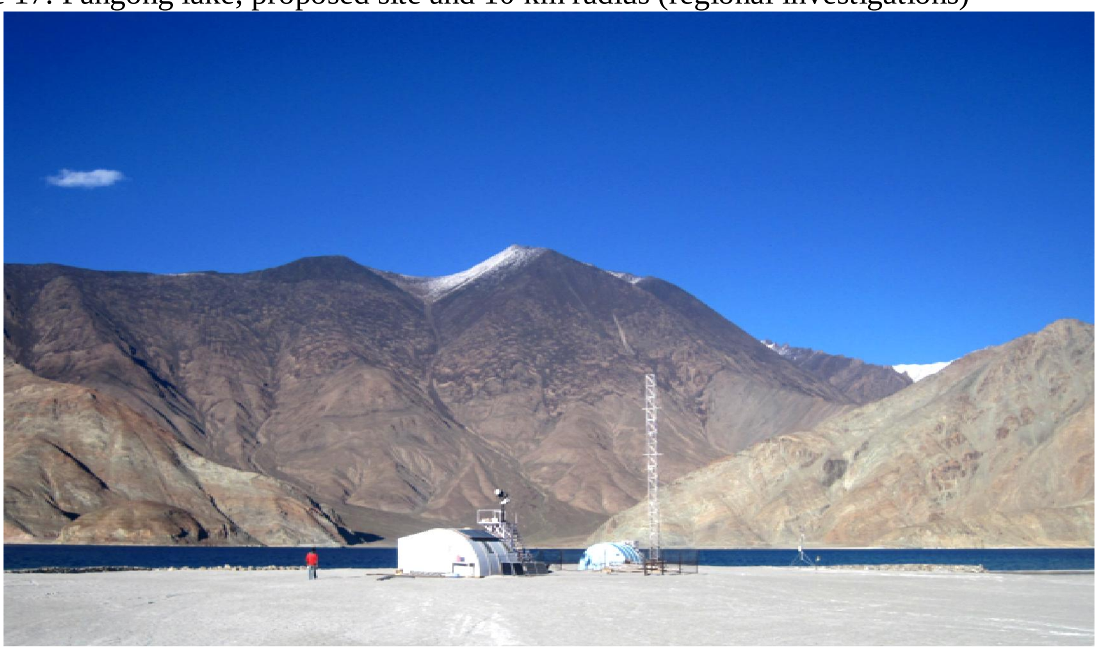


Figure 18. Merak Observatory

The area is of adequate ecological, faunal, floral, geomorphological or natural significance, for the purpose of protecting, propagating or developing wildlife or its environment, including areas adjacent to national parks and those which link one protected area with another. One of the most spectacular lakes in Ladakh is the Pangong Tso, which lies across the Changla Pass from Leh. At an altitude of almost 4,500 metres, the Pangong Tso is only 8 km wide at its broadest point, but is an amazing 134km long. The Pangong is considered to be the longest lake in Ladakh. It is a saltwater lake formed in much the same way as the Tso Morari lake during the Ice Age.

It is a lake situated far away in barren land in Ladakh. This lake is known for its calm, clear and unending expanse. It is the one of biggest lake in Asia. Its area falls under both India and China. One third of it is in India and remaining in China. It is 130 km long and 7 km wide. It is located on the Changtang plateau in eastern Ladakh, around 140 km South-east of Leh, at an altitude of over 14000 feet. Pangong Tso is also known as hollow lake. It is clear symbol of natures craftsmanship. Its brackish water plays with sun light to produce different colour effect. This area falls under army control and requires pass from deputy commissioner of Leh. To reach this lake one has to travel 30 km down the Manali-leh highway to reach karu. From where the road splits, one goes to Manali and one 113 km long to Pangong tso. After the verification of paper at karu, one moves ahead through a green lush valley. This is very uncommon to see a green valley at this height. There are total five army check posts are on the road to Pangong Tso. The second check post is at Zingral (15,500 ft). Here army keeps a copy of the permit. This is rocky area and porn for land slide.

This rocky terrain leads to Chang La (at 17,350 ft), the third-highest motor able pass in the world. Traces of snow along the road welcome us. One crosses the valley on the sinking road. The mountains appeared to be painted in hue of green, violet and brown. A school of mountaineering is situated here, which imparts training in various degree of rock climbing Soon we found our self in pasture which is filled with yaks, mountain cows. The rocky mountain changes into sandy area. The road is full of causeway due water on the road.

Pangong appears suddenly while passing through this area. Just two km short of lake one passes through the gravelly terrain, which is open on the left side. After crossing Lukung, the lake emerges out of its veil in right. This land lock lake stretches through the whole length of Ruthog region towards neighboring Chushul. Stretched towards indo-china border, it enters into china. Most of the fresh water inlets that feed the lake are in Tibet. It is 100 metres deep at certain places.

The sun plays a unique role in displaying the different colours in lake. Its crystal clear water plays with sun light to display the bands of blue, green, purple, violet, orange and red on the surface, like a rainbow. This presents a very beautiful seeing. The lake looks like canvas painted in the different colours of nature. With no outlet, Lake Basin has deposited wealth of mineral, by the melting of snow. The lake is home to a wide range of fauna ranging from migratory birds to mammals of various species. The black-necked Siberian crane, bar-headed geese and waterfowl can be spotted at the lake.

Pangong Tso Wetland Reserve: Pangong Tso – Tsogul Tso wetland situated on the “North East” of Leh city, is 150 kms away from it. The Leh district administrative district. The population of the Leh town as per 1991 census was 11000. The Tangtse town falling on the North – west of the wet-site is 110 kms from it and the nearest Centre/ village of the wetland is

Spangmik on its Southern side just near the shore of lake. The jurisdiction of the wetland rests with the Govt of Jammu and Kashmir State (India) and the functional Jurisdiction of the wetland lies with the Deptt . Of Wildlife Protection, J&K State and its Divisional Wing, Wildlife Division, Leh Ladakh.

The population of the Centre/ village Spangmik, Man, Merak and Chushul with its cattle-head 1993-1994 was: 111 families and 219 persons. Livestock details are given in Table 2.

Table 2: Livestock

Cow	Sheep	Goat	Horse	Yalk/Demo	Donkey	Dzo/zomo	Total
290	3396	9126	337	816	15	7	13987

Hydrologicl values: Due to high velocity and frost actions around the wet-site on regular basis, plays a major role in rock denudation and its transportation. Huge quantities of sand segments are deposited in the Wetland.

Ecological features: The lake shows monomictic and oligotrophic to ultra -oligiotrophic status. The deeper parts of the lake are devoid off of any vegetation. However, the vegetation appear near the margins of the wetland, on the steppe mounts, wet meadows and the bogs have abundant plant life. The steppe vegetation includes, Herbs/Legumes, like,

1. *Pedicularis longifolia*.
2. *Polygonium* spp.
3. *Parmassia cabuilica*.
4. *Gentiana leucomeleana*.
5. *Oxytropis microphylla*.
6. *Potentila aniserina*.
7. *Leontopodium* spp.
8. *Astragalus confertus*.
9. *Juncus* spp.

Towards the northern and eastern side of the wetland, some sedge and grass species dominate the area. They are:

- *Carex steaophylla*.
- *Heontopodium* spp. Or *Trigolochin pulustoel*.
- *Caragana brivifolia*.
- *Dracocepholium* spp.

Besides, this *Caragana* spp. dominate the northern end had played major role in sand trapping. Among macrophytes, *Potamageton pectinatius* is the dominating species, whereas zooplanktons are more varied than the *Phytoplanktons*, they are:

- Keratella spp.
- Alona spp.

- Daphnia spp.
- Gammarus spp.
- Cyclops spp.

Besides this algal species oocystis species can be seen in this area. The people of the Spangmech, Man, Merak developed some crops vegetation of Barley (*Hordeum* spp.); Goosbery (*Ribes*); towards southern area of the wetland.

Noteworthy flora: The flora including sonme wild legumes, macrophytes, grasses, sedges and some other above mentioned plants are all representatives of the steppe vegetation of the Trans-Himalayas ecosystem and thus all play their vital role in the system.

Social and cultural values: With the opening of the Changthang Wilderness area to the outsiders from the year 1993 tremendous influx of the tourist have been seen in Pangong Tso. Tourist approach the area in thousands during summer months. The nmber is mainly of foreigners who approach the area from Leh. All the tourists are being accompanied by the local tour operator and travel agents leading in-direct ecological benefits to the Spangmik, Mulbek villages.

The adjacent areas of the Pangong Tso Wetland having steppe cold desert ecosystem bestowed with many types of floral species. These provide ample grounds to the “Changpa” pastoral-nomads who take advantage of these grounds on seasonal basis. Since, all the adjacent village-folk are dependent on the raring of the Pashmina goat. The wetland invariably helps the economy of the local people.

Cultural land use: The human activities inside the proposed Ramsar site ie. Pangong Tso wetlands are nil. However the adjacent areas of the wetland are mainly used by the local people. All the village-folk around or outside the wet-site area are dependent on the rearing of the Pashmina Goat and are mostly living Pastoral-nomadic life. They are solely dependent upon the availability of the floral species existing around the steppe-mounts of the wetland. Since 1994. Tourism trade helped a little to the people of the village falling around wetland Agricultural practices are being exercised by the local people of Spangmik, Man, Merak on the southern steppe side of the lake. They grow Millets, Barley and local pea species.

Factors past present or potential adversely affecting the sites ecological character including changes in land use and development projects: The regular speedy winds transport large amount of sand into the wetland. Besides it huge soil erosion took place during summer. Months due to glaciations from the surrounding mounts. The ice melting water straight way merge into the wetland through five perennial and three small streams. All these natural calamities bring large amount of sand and soil reducing the wetland size helping in its shrinkage.

Overgrazing of the area by the Live-Stock Changpa Pastrol and nomads who are dependent on rearing of "Pashmina" goats have posed adverse impact on the biodiversity on the wetland. As overgrazing results in pasture degradation increased soil erosion it also leads to the less availability of grasses for wild herbivore and indirectly the Carnivores are invading the Cattle-pens rendering heavy loss to the nomads.

The area of Pangong Tso Wetland is one of the Wet-site of the Changthang Wildlife Sanctuary. The area of 4000 Sq.Kms stands notified as Wildlife Sanetnary since 19-03-1987. The same wet-site is protected under the overview of J&K Wildlife Protection Act 1978. Since the people living around Pangollg Tso are fond of Wildlife, cases of hunting/poaching are almost zero. Any kind of developmental activities would not be carried out without the cognizance of the Wildlife Protection Department, as all the powers about the wetland vests with the Department. With the opening of the Pangong Tso Wetland to tourist in 1994 the influx of the tourist especially from Western Countries like France, Belgium, Sweden, Germany, and asian country like Israel, has increased exponentially. The tourist who made their way through Leh (J&K) and Delhi are being attracted by the wetlands remoteness it is variegated and unique flora fauna pristine high desert landscapes, culture tradition of Buddhist and age old Monastery of "Tangtse". These tourists are being allowed to enter in the wetland only after obtaining a “Inner Line Permission" from the Deputy Commissioner Leh.

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

Land cover Analysis: Land cover refers to the physical status of the Earth' surface and relates to the type of features present on the surface of the Earth like forest, water body, soil, etc. Land use refers to the way in which land is being employed by humans for various purposes. It relates the functional utility of land to the economic activities. Land use/land cover pattern of a region is an outcome of the natural and socio-economic factors and their utilization by man in time and space. Demographic pressure has led to continuous exploitation of natural resources. There are only a few landforms left on the Earth that are in their natural state. Due to anthropogenic activities Earth surface is continuously being modified and the way land has been used has significant effect upon the natural environment thus resulting into an observable land use/land cover pattern over the time. Thus land use land cover change analysis has become a central component is current strategies for managing natural resources. Temporal data aids in a process of identifying differences in the state of an object or phenomenon by observing it at different times. It forms an important parameter in monitoring and managing natural resources as it provides quantitative assessment of the features of interest.

The spatial extent is about 31468 hectares, extended from north: 3751574.007 till south: 3731302.585 and east: 288642.589 till west: 268639.999 (Figure 19).

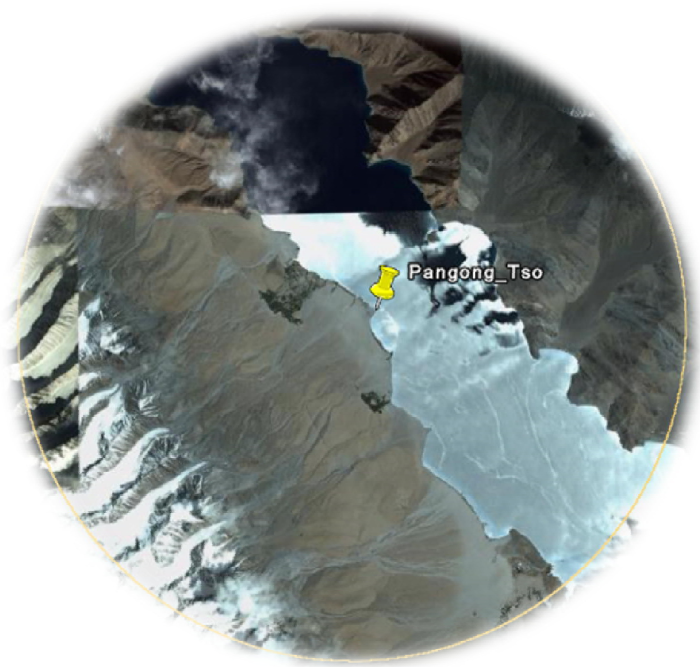


Figure 19: Study area - Pangong Tso

Data: Landsat TM of 1989, 2006, 2010 [downloaded from http://glcf.umiacs.umd.edu/data/] Google Earth image (http://earth.google.com) served in pre and post classification process and validation of the results. Spatial and spectral details of the data used for land cover analysis is given in Table 3.

Table 3: Spatial and spectral details of the remote sensing data used for analysis

Satellite	Bands	Spectral Range	Spatial Res.	Year
Landsat TM	1	0.45 – 0.52	30	1989
	2	0.52 – 0.60	30	2006
	3	0.63 – 0.69	30	2010
	4	0.76 – 0.90	30	
	5	1.55 – 1.75	30	
	7	2.08 – 2.35	30	

Methodology: Maximum Likelihood classifier (MLC), Which is based on the Gaussian algorithm was used to classify temporal RS data into 5 LC classes – Vegetation, Water, Snow, Open Sand area and Rocks. This is done using the signatures generated with the training data. MLC is a parametric classifier that can be used to train a huge number of datasets. This algorithm is Popular and widespread in RS because of its robustness (Hester et al., 2008). Due to absence of historical data, training pixels were collected from the false color composite of the respective bands (for the year 1989, 2006 and 2010). The data were processed using open source software for analyzing geographical resources called GRASS. The accuracy of the classified images on an average was 85 %. The Entire Procedure has been depicted in Figure 20.

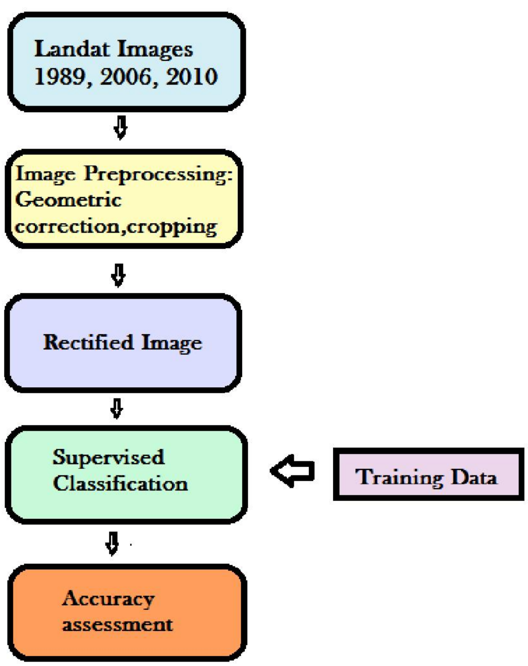


Figure 20: Remote sensing data analysis schematic diagram

Figure 21 shows the classified image of 1989, 2006, 2010 obtained with five land use categories (Vegetation, Water, Snow, Open Sand area and Rocks). Table 4 gives the details of the classified images. The analysis shows that only 0.08% is under vegetation, 23% under water and the balance

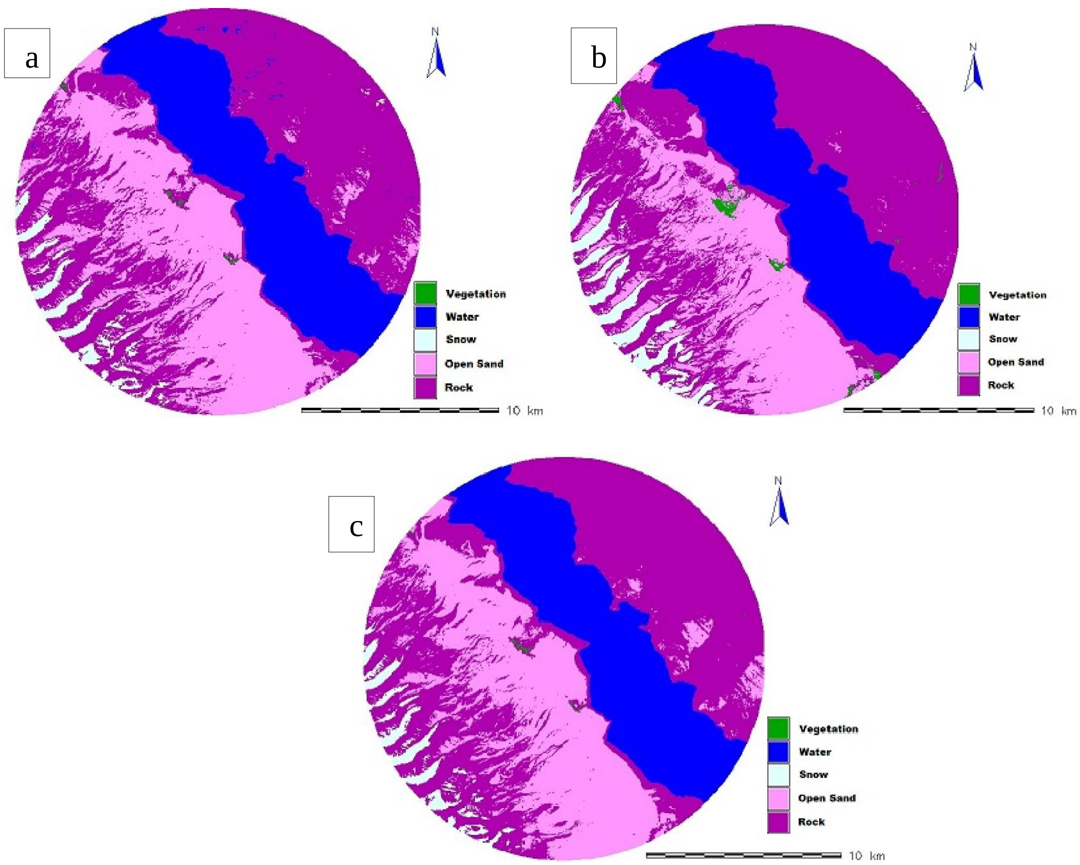


Figure 21 . Classified images of 1989(a), 2006(b), 2010(c).

Table 4: Land use statistics of study area – Pangong Tso.

Year↓	Class →	Vegetation	Water	Snow	Open Sand area	Rocks
1989	Ha	27.788	7420.190	877.883	9207.611	13,935.069
	%	0.09	23.58	2.79	29.26	44.28
2006	Ha	170.235	7446.269	1427.077	7962.190	14,462.770
	%	0.54	23.66	4.53	25.30	45.96
2010	Ha	26.619	7403.284	894.430	8735.216	14,408.993
	%	0.08	23.53	2.84	27.76	45.79

FLORA

The high floral diversity of Ladakh could also be attributed to its location at the junction of three of the six bibliographical zones of the world. The climate is influenced to a large extent by the Greater Himalaya to the south. There is minimal precipitation in the region due to the rain shadow effect of the Himalayan crest. Thus, the plant production is low, and vegetation of the region is characterized by alpine steppe, where the cover hardly crosses 20%. Despite such poor primary productivity, there is a diverse assemblage of fauna that thrived for millenia. Situated in the valley of Changthang, the lake Pangong tso and its surroundings provide a unique habitat for life. It is largely an exposed barren landscape, the cold desert with sparse vegetation exhibiting characteristic adaptations to withstand the adverse ecoclimatic conditions. Nevertheless many wetlands that exist in the valley support extensive pastures. The vegetation in the pastures is largely cold hardy grasses and sedge species. The vegetation in the other places is largely of scattered shrub. Tree cover is almost completely absent. Diversity here is to the minimum, the same species being repeated throughout. These species are not different from those inhabiting rest of the areas in Changthang.

The soil in the valley, particularly that in the vicinity of the lakes is sandy and gravelly, lacks organic matter and understandably a poor substratum to support plant growth. The water of Pangong tso is brackish. The vegetation along the lake is particularly scanty, one species of grass being predominant. The habitat does not appear to be a hotspot area for plant species. The Pangong lake however seems to be teamed with an array of algal species.

The region lack vegetation in the deeper parts of the lake, but at the margins and marshy areas, sedges and grasses are found towards the northern and eastern sides. The surrounding plateau and hills support low thorn scrub and perennial herbs (Islam and Rahmani, 2008). The two biotopes of the Changthang Wildlife Sanctuary via riverine contains Salix sp. and Myricaria germanica, and Caragana scrub contains Caragana pyomea.

Seabuckthorn (Ladakhi:Tsermang): This shrub which is found in large parts of Ladakh is known for its delicious berries. These fruits have a high content of Vitamin C and are known for the anti-aging properties they are said to possess. Some of the varieties of Seabuckthorn are high in Vitamin A and other oils. Over 200 products can be commercially made from this plant, which is very important for the local people too as fuel wood and construction material.

The following flowering plant species (Figure 24-35) are noticed within the 50 sq.km of the proposed site for solar telescope by the side of Pangong tso:

1) Nepeta longibracteata (Lamiaceae)
2) Arnebia guttata (Boraginaceae)
3) Taraxacum officinale (Asteraceae)
4) Echinops cornigerus (Asteraceae)

5) Tanacetum tibeticum (Asteraceae)
6) Aconitum sp. (Ranunculaceae)
7) Silene nigrescens (Caryophyllaceae) - Near Changla pass
8) Potentilla sp. (Rosaceae)
9) Crepis flexuosa (Asteraceae)
10) Nepeta podostachys (Lamiaceae)
11) Cirsium sp. (Asteraceae)
12) Anaphalis triplinervis (Asteraceae)
13) Christolea crassifolia (Brassicaceae)
14) Saxifraga sp. (Saxifragaceae) – An alpine grassland species
15) Rhodiola imbricata (Crassulaceae)
16) Sibbaldia sp. (Rosaceae)
17) Scorzonera virgata (Asteraceae)
18) Sassurea bracteata (Asteraceae)

Figure 22: Seabuckthorn shrub

Ephedra gerardiana, a gymnosperm that is found towards Henle could not be sited in Changthang valley, particularly around Pangong tso. Also, natural populations of Hippophae rhamnoides (Elaeagnaceae) which are almost everywhere in Ladakh and predominant towards Leh are strikingly absent here.

The dominant and widespread among the above listed flowering species are:

1) Tanacetum tibeticum
2) Echinops cornigerus (Asteraceae)
3) Crepis flexuosa
4) Cirsium sp.

Other flowering taxa exist here in small numbers which could not be identified as they were not in their flowering/fruiting stage at the time of our visit.


Figure 24. Clematis sp.


Figure 25. *Cristolea crassifolia*

Figure 26. Gentiana sp.

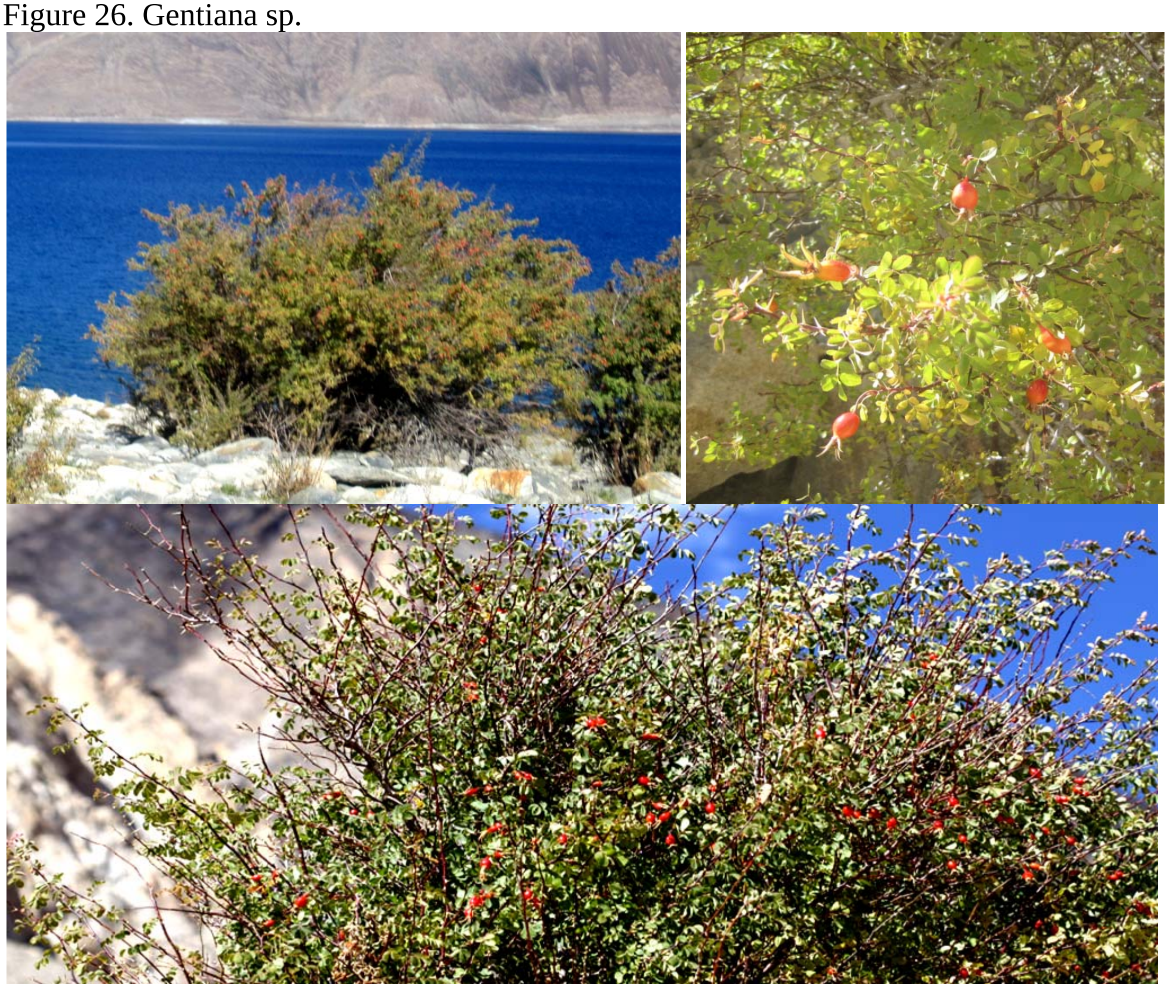


Figure 27. Rosa sp.

Figure 28. Tanacetum gracile

Figure 29. Taraxacum officinale


Figure 30. Urtica hyperborea

Vegetation just adjacent to Study Area:

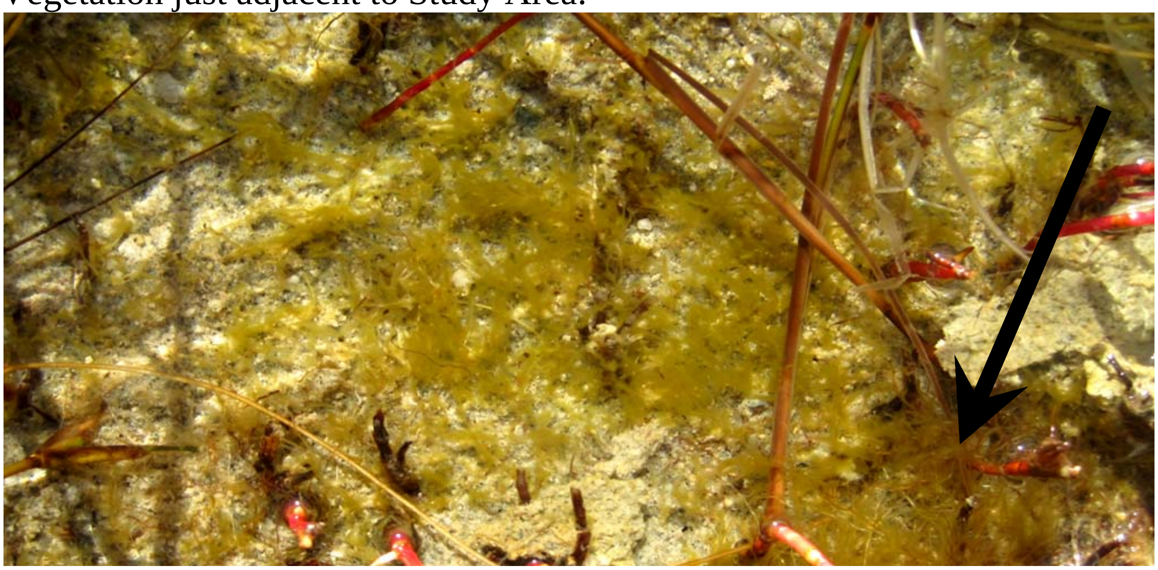


Figure 31. Filamentous alga.


Figure 32. Chara Sp.

Figure 33. Grass sp.

Figure 34. Small angiosperms near the shore lines


Figure 35. Presence of aquatic vegetation

Phytoplankton: During the study period members of Charophytes were present near the shorelines of the lake. (*Chara* sp. and *Nitella* sp.). Among the microalgae the filamentous algae were more predominant as *Oscillatoria* sp. and *Stigeoclonium* sp.

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

FAUNA distribution in the study area

1. Avian distribution in the Pangong wetland Area:

Avifauna of Ladakh was first studied by Ferdinand Stoliczka, an Austrian- Czech palaeontologist, who carried out a massive expedition in the region in the 1870s. Ladakh has a great diversity of birds — a total of 225 species have been recorded. The digital documentation of birds during the field work is given in Figures 37 to 53, which demonstrates the richness. Many species of finches, robins, redstarts (like the Black Redstart that migrates to the south), and the Hoopoe are common in summer. The Brown-headed Gull is seen in summer on the river Indus and on some lakes like the Changthang and Pangong Lake. The Pangong lake acts as an important breeding ground for a variety of birds including a number of migratory birds. During summer, the Bar-headed goose and Brahmini ducks are commonly seen here. Formerly, Pangong Tso had an outlet to Shyok River, a tributary of Indus River, but it was closed off due to natural damming. Two streams feed the lake from the Indian side, forming marshes and wetlands at the edges. Resident water-birds include the Brahminy duck also known as the Ruddy Sheldrake and the Bar-headed Goose. These ducks migrates to South India in winter to escape the extreme cold temperature and return to Ladakh in Mid May. Other birds include the Raven, Red-billed Chough, Tibetan Snowcock, and Chukar. The endangered Black-necked Crane (*Grus nigricollis*), being the state bird of Jammu and Kashmir are found scattered in the Tibetan plateau, is also found in parts of Ladakh. There are about 36 individuals sighted and reported by the wildlife department along with other research institution. The recent team visit for present study could list out 50 species (Table 5) of birds in quite limited time and also spot 26 Black-necked Cranes at various wetland locations between Merak and Hanle. Their distribution is very much restricted to wetlands, marshy areas, even closer to village hamlets. The Lammergeier, Upland Buzzard, Golden Eagle and some other quite interesting raptors are spotted at sereval regions of Ladakh, especially Leh, Merak, Chumatang and Hanle. The Brown-headed Gull breeds at Ladakh region, migrates to Sea coast during winter till summer. Pangong lake, though brakish water quality harboured several Brown headed-gulls at the centre and at the peripheral region brahminy ducks, Bar-headed geese along with other birds. The presence of Brown headed-gull at the upland wetland is quite interesting as they are usually seen only at sea coast. Wagtails like the White wagtail, Citrine wagtail, and Yellow wagtail were observed thriving in great numbers all throughout Ladakh region. These birds breed in Ladakh, migrates to south to warmer parts during winter. The avian diversity of this high altitude wetland proves quite rich, attributing to the landscape, food availability and the climatic condition.

Table 5: List of birds observed during present study at Ladakh.

Sl no.	Common name	Scientific Name	Location	Ind.	M	S
1	Bar-headed Goose	*Anser indicus*	Pangong Lake, Hanle, Chushul	56		LC
2	Black Redstart	*Phoenicurus ochruros*	Leh, She, Changla Pas			LC
3	Black-billed Magpie	*Pica pica*	Leh, Merak, She, Hanle, Chumatang			LC
4	Black-headed Gull	*Larus ridibundus*	Pangong Lake, Chushul, Indus river, Merak, Loma, Chumatang, Hanle	12		LC
5	Black-necked Crane	*Grus nigricollis*	Chushul, Loma, Hanle	26		V
6	Black-winged Stilt	*Himantopus himantopus*	Loma	4		LC
7	Blue Rock Pigeon	*Columba livia*	Leh, Merak, Hanle			LC
8	Brown Wood Owl	*Strix leptogrammica*	Hanle			LC
9	Brown-headed Gull	*Larus brunnicephalus*	Pangong Lake, Chushul, Indus river, Merak, Loma, Chumatang, Hanle	23		LC
10	Chestnut-eared Bunting	*Emberiza fucata*	Chushul, Loma, Merak, Chumatang, Hanle			LC
11	Chukar	*Alectoris chukar*	Changla Pas, Hanle			LC
12	Citrine Wagtail	*Motacilla citreola*	Merak, Hanle	2	*	LC
13	Common Hoopoe	*Upupa epops*	Chushul, Loma, Chumatang		*	LC
14	Common Kestrel	*Falco tinnunculus*	Hanle		*	LC
15	Common Merganser	*Mergus merganser*	Chushul, Loma, ,Indus river	4	*	LC
16	Common Raven	*Corvus corax*	Merak, Chumatang, Loma, She, Hanle			LC
17	Common Redstart	*Phoenicurus phoenicurus*	Merak, Hanle		*	LC
18	Common Sandpiper	*Actitis hypoleucos*	Loma, Tangste	2	*	LC
20	Common Tern	*Sterna hirundo*	Pangong Lake, Merak	1	*	LC
21	Common Wood Pigeon	*Columba palumbus*	Leh, Merak, Hanle, Chumatang		*	LC
22	Cotton Pygmy Goose	*Nettapus coromandelianus*	Chushul, Loma	3	*	LC
23	Daurian Redstart	*Phoenicurus auroreus*	Leh, Changla Pas		*	LC
24	Desert Wheatear	*Oenanthe deserti*	Merak		*	LC

25	Eurasian Tree Sparrow	*Passer montanus*	Leh, Merak, Hanle, She, Chumatang		*	LC
26	Ferruginous Pochard	*Aythya nyroca*	Pangong Lake	4	*	NT
27	Fire-fronted Serin	*Serinus pusillus*	Leh, Changla Pas		*	LC
28	Garganey	*Anas querquedula*	Pangong Lake, Tangste	4		LC
29	Golden Eagle	*Aquila clanga*	Leh, Changla Pas, Tangste			V
30	Great Crested Grebe	*Podiceps cristatus*	Pangong Lake, Merak, Loma, Hanle	12		LC
31	Green Sandpiper	*Tringa ochropus*	Chaumatang, Loma, Pangong Lake	1		LC
32	Himalayan Snowcock	*Tetraogallus himalayensis*	Changla Pas, Hanle			LC
33	Horned Lark	*Eremophila alpestris*	Leh, Merak, Chushul, Changla Pas, Hanle, Chumatang, Loma		*	LC
34	Lammergeier	*Gypaetus barbatus*	Merak			LC
35	Lesser Spotted Eagle	*Aquila pomarina*	Hanle			LC
36	Northern Pintail	*Anas acuta*	Pangong Lake, Tangste, Loma, Hanle	28	*	LC
37	Osprey	*Pandion haliaetus*	Chumatang la			LC
38	Palla's Fish Eagle	*Haliaeetus leucoryphus*	Hanle	1	*	V
39	Palla's Gull	*Larus ichthyaetus*	Pangong Lake	1	*	LC
40	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	Leh, Merak, She, Hanle, Pangong Lake, Loma, Chumatang		*	LC
41	Red-necked Phalarope	*Phalaropus lobatus*	Tangste	1	*	LC
42	Ruddy Shelduck	*Tadorna ferruginea*	Pangong Lake, Chushul, Indus river, Merak, Loma, Chumatang, Hanle	72	*	LC
43	Ruddy Turnstone	*Arenaria interpres*	Chushul	1		LC
44	Tibetan Sandgrouse	*Syrrhaptes tibetanus*	Merak		*	LC
45	Tibetan Snowcock	*Tetraogallus tibetanus*	Changla Pas, Hanle		*	LC
46	Tree Pipit	*Anthus trivialis*	Hanle, Chushul, Merak, Loma		*	LC
47	Upland Buzzard	*Buteo hemilasius*	Hanle			LC
48	White Wagtail	*Motacilla alba*	Leh, Changla Pas, Chushul, She, Loma, Hanle, Pangong Lake, Merak, Tangste	56	*	LC
49	White Wagtail ssp.	*Motacilla alba*	Loma, Chumatang	2	*	LC

	Personata	*personata*				
50	White-winged Redstart	*Phoenicurus erythrogaster*	Leh, Changla Pas, Tangste, Merak, Hanle		*	LC
51	Yellow Wagtail	*Motacilla flava*	Merak	1	*	LC

Note: M – Migratory, S – IUCN status, V – Vulnearable, LC – Least Concern, NT – Near Threatened

The BNHS and BirdLife International have listed Pangong Tso as an Important Bird Areas (IBA) criteria A1 (Islam and Rahmani, 2004).

A1 (Globally threatened species), Criterion: The site is known or thought regularly to hold significant numbers of a globally threatened species, or other species of global conservation concern.The site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable. In general, the regular presence of a Critical or Endangered species, irrespective of population size, at a site may be sufficient for a site to qualify as an IBA. For Vulnerable species, the presence of more than threshold numbers at a site is necessary to trigger selection. Thresholds are set regionally, often on a species by species basis. The site may also qualify if holds more than threshold numbers of other species of global conservation concern in the Near Threatened, Data Deficient and, formerly, in the no-longer recognized Conservation Dependent categories. Again, thresholds are set regionally (www.birdlife.org).

Black-necked Crane: Black-necked Crane (Grus nigricollis) is classified as Vulnerable under the IUCN Red List of threatened Animals (figure 36), because it has a single small population that is declining owing to the loss and degradation of wetlands, and changing agricultural practices in both its breeding and wintering grounds. However, the population has apparently increased in recent years. It breeds on the Qinghai-Tibetan plateau, China, with a small population in adjacent Ladakh, India. Sighting of Black-necked Cranes in the study area is given in Figure 37.Six wintering areas have been identified at lower altitudes on the Qinghai-Tibet and Yunnan-Guizhou plateaus, China, including counts of 3,562 birds in Yunnan and western Guizhou in winter 2003 and, in Tibet, 4,277 in 1999 increasing to 6,940 in 2007. It also winters in Bhutan (500 individuals), and Arunachal Pradesh, India (10 individuals) and small numbers have been recorded in Vietnam. These figures imply a total world population of approximately 11,000 individuals, although it is estimated that the number of mature individuals is perhaps 8,800. Major threats to this species are Intensive grazing, pesticide, planting high yield winter wheat rather than traditional crops, drying-up of marshes and desertification as a result of surrounding development and agriculture, dam, habitat degradation and climate change (BirdLife International, 2009).

Golden Eagle: Golden Eagle (Aquila clanga) has a small population which appears to be declining owing to extensive habitat loss and persistent persecution. It is therefore listed as

Vulnerable under the IUCN Red List of threatened Animals. It breeds in Finland, Latvia, Lithuania, Estonia, Poland, Belarus, Moldova, Russia, Ukraine, Kazakhstan, mainland China and Mongolia. Passage or wintering birds occur in small numbers over a vast area, including central and eastern Europe, north and east Africa, the Middle East, the Arabian peninsula, the Indian subcontinent and south and South-East Asia. Numbers appear to have declined in the western half of its range and in some parts of its Asian range (BirdLife International, 2008).

Palla's Fish Eagle: Palla's Fish Eagle (Haliaeetus leucoryphus) has a small, declining population as a result of widespread loss, degradation and disturbance of wetlands and breeding sites throughout its range. It therefore qualifies as Vulnerable under the IUCN Red List of threatened Animals. It occurs across a huge range from Kazakhstan (may no longer breed), southern Russia (possibly still breeds), Tajikistan, Turkmenistan (probably dispersing non-breeders) and Uzbekistan, east through Mongolia and China, south to northern India, Pakistan, Bhutan, Bangladesh and Myanmar. The main breeding populations are believed to be in China, Mongolia and the Indian subcontinent. The major threats are habitat loss, degradation and disturbance. Across the Indian subcontinent, and probably most of its range, wetlands have been drained or converted for agriculture and human settlements. The felling of large trees near wetlands has reduced the availability of nest and roost sites. The spread of water hyacinth Eichhornia crassipes is a problem in India, as is the siltation of lakes due to catchment deforestation (BirdLife International, 2008).

Ferruginous Pochard: Ferruginous Pochard (Aythya nyroca) has rapid declines in Europe, but evidence of declines in the larger Asian populations is sparse, and sometimes contradictory, so it is currently listed as Near Threatened under the IUCN Red List of threatened Animals. Evidence of rapid declines in Asia would qualify the species for uplisting to Vulnerable. Aythya nyroca breeds in south-western Asia (east to China and south to Pakistan and India), central and eastern Europe, and north Africa (BirdLife International, 2008).

Figure 36. Black-necked Crane (Grus nigricollis)

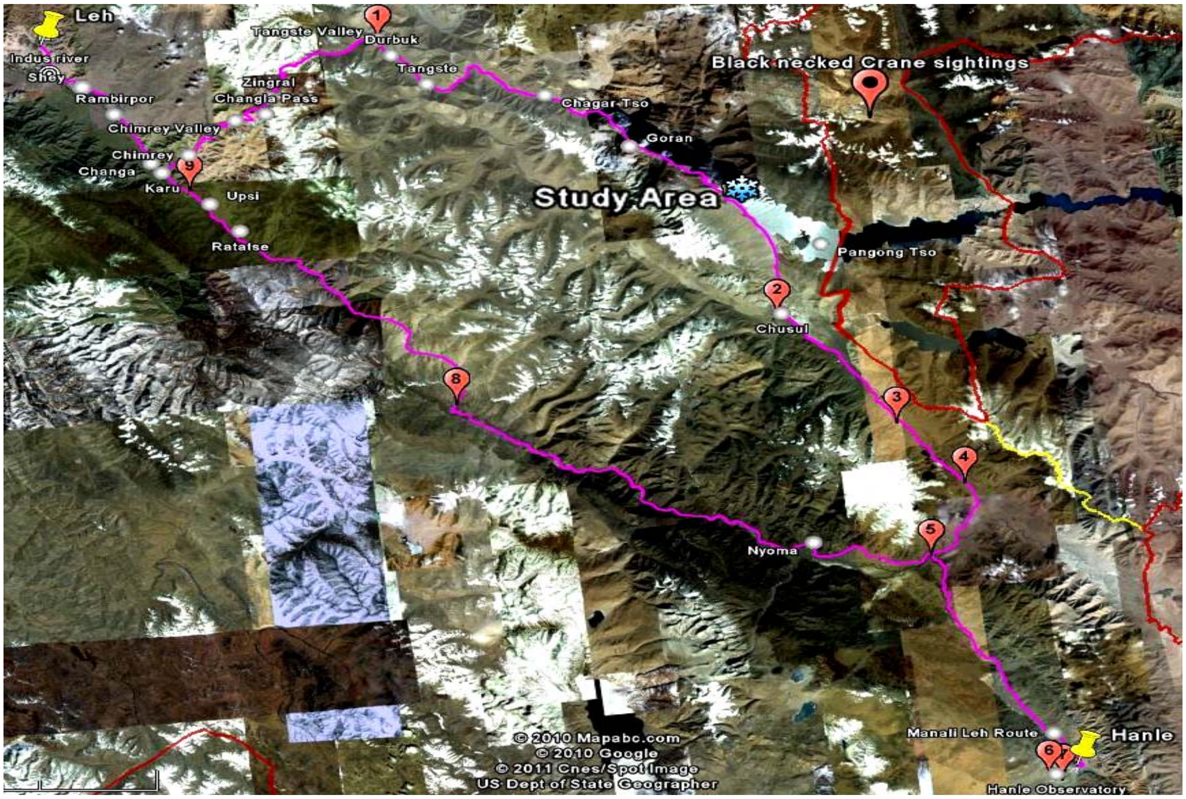


Figure 37: Black necked Crane sightings near Pangong Lake area.


Figure 38:. Brown headed gull


Figure 39: Black headed gull

Figure 40: White wagtail (*Motacilla alba*)


Figure 41: Wood Sandpiper

Figure 42: Ruddy Shelduck

Figure 43: Golden eagle

Source: http://www.birdforum.net/gallery/data/529

Figure 44: Lammergeier

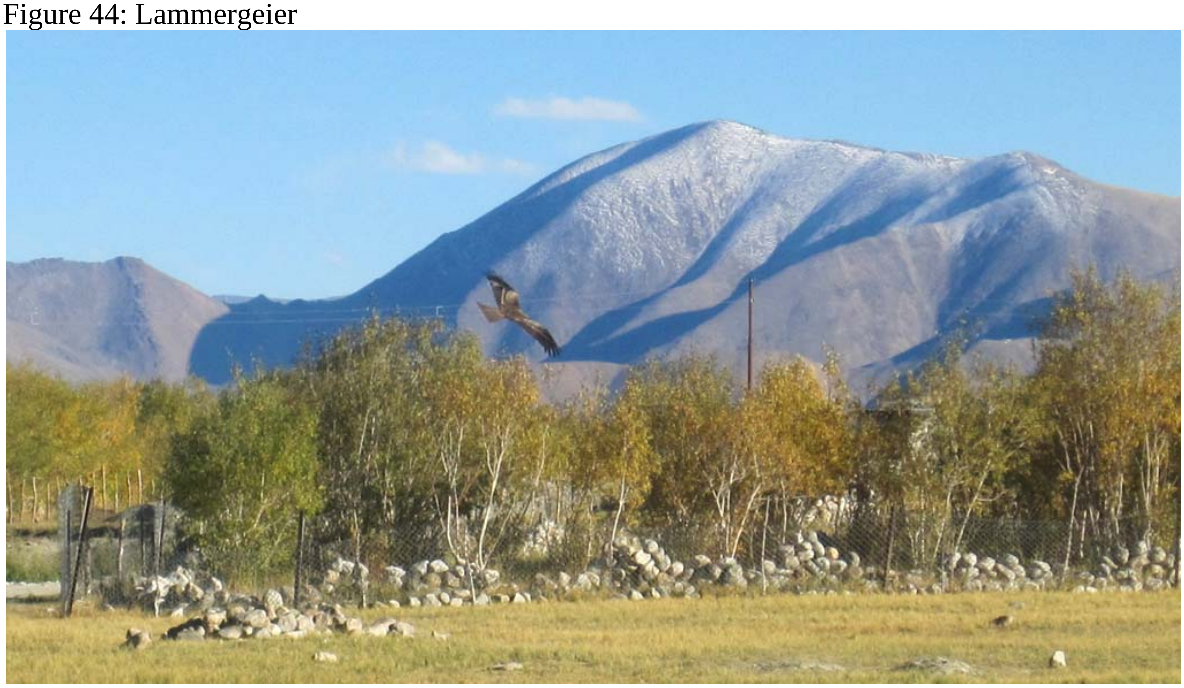


Figure 45: Lesser spotted eagle


Figure 46: Curlew

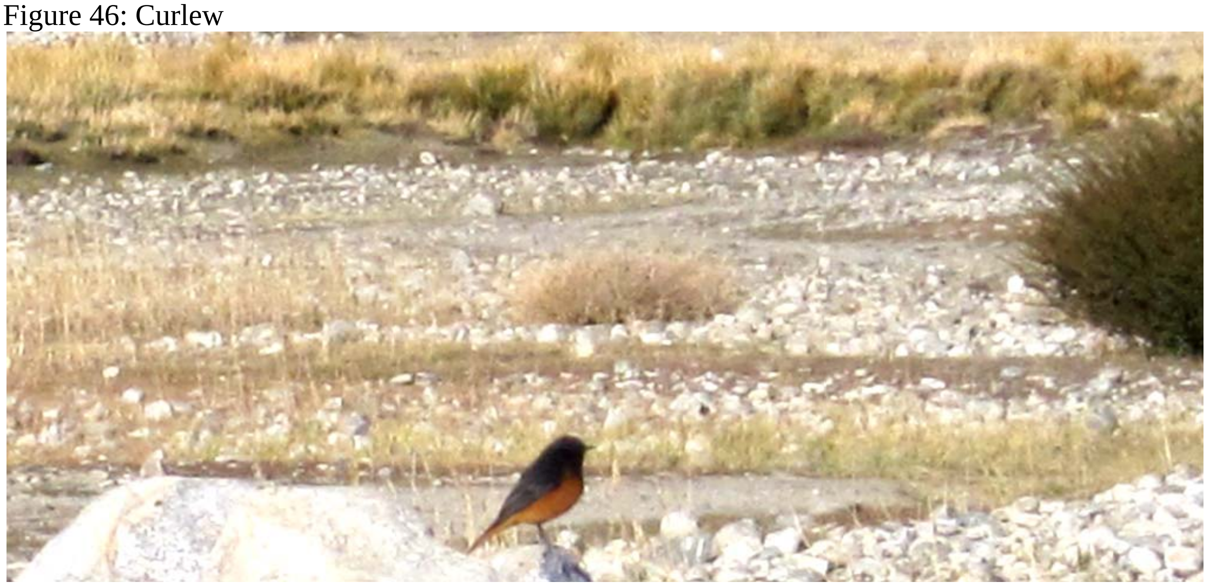



Figure 47: Black redstart


Figure 48: Horned Lark

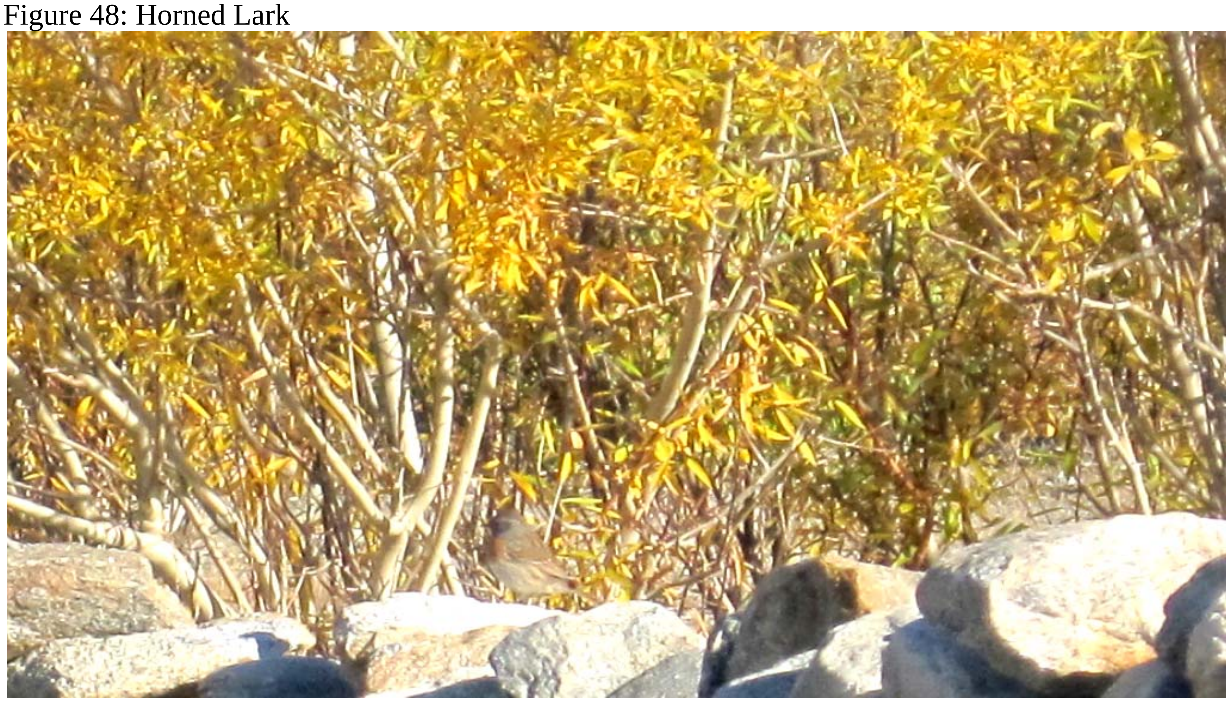



Figure 49. Fire-fronted Serin

Figure 50: Tibetian Woodcock

Figure 51. Red billed Cougch

Figure 52. Chukar

Figure 53. Upland Buzzard.

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

II. Fauna: Mammals, Reptiles...

Wild yak, which is adapted to very low temperatures is quite common in this area. It is the ancestor of the domestic yak (Figure 54), which plays a pivotal role in the life of native people of *Changthang* in eastern Ladakh. *Chiru* or the Tibetan antelope is another animal that is adapted to the harsh Tibetan plateau, which extends into eastern Ladakh. It has large nasal cavities to cope up with the thin air, and soft underwool to fight against the fierce elements of the plateau. This wool also known as Shahtoosh or locally *Rtsoskhul*, is one of the finest animal fibers in the world. The Tibetan argali the largest wild sheep in the world, and the Tibetan gazelle are the other species here. Apart from these, there are animals that use more rugged terrains. For example, the Asiatic ibex and blue sheep are animals adapted to rugged terrain, the former more so than the latter. These ungulate species overlap in their habitat use in some areas, but they have exclusive geographical ranges in Ladakh with the ibex occurring mostly in the western part and blue sheep occurring in the eastern half, which is telltale of competitive interactions between the two. Ladakh urial endemic to the region is distributed only along two major rivers: Indus and the Shayok.

The Tibetan wild ass or *Kiang* (Figure 55) is the largest wild ass in the world with some stallions standing 1.4 m tall and weighing upto 400 kg. The colour is auburn with white belly, chest and legs, and morphologically the sexes are alike.

Apart from large herbivores, there are several small and less celebrated plant eating mammals. The most prominent among them is the marmot (Figure 58), of which there are two species in Ladakh: Himalayan marmot and long-tailed marmot. Two species of hare are Tibetan woolly hare (Figure 57) and Cape hare. Others include six species of pika and two species of vole (small burrowing mammals). Mammals with their IUCN Conservation status are listed in Table 6 given next.

Table 6: Mammals of Pangong Tso Wetland

Common name	Scientific Name	IUCN - Status
Snow Lepord	*Unica unica*	Endangered
Ladakh Urial	*Ovis vignei*	Vulnerable
Tibetan Gazelle	*Procapra picticaudata*	Near Threatened
Royle's Mountain Vole	*Alticola roylei*	Near Threatened
Pallas's Cat	*Otocolobus manul#*	Near Threatened
Great Tibetan Sheep	*Ovis ammon*	Near Threatened
Tibetan Wolf	*Canis lupus chanku*	Least Concern
Tibetan Wild Ass	*Equus kiang kiang**	Least Concern
Red Fox	*Vulpes vulpes*	Least Concern
Large-eared Pika	*Ochotona macrotis*	Least Concern
Himalayan Marmot	*Marmota himalayana*	Least Concern
Blue Sheep	*Pseudois nayaur*	Least Concern
Wild Dog		

* Sightings - Study site. # Recorded at Hanlay.

Figure 54. Yak

Figure 55: *Equus kiang*

Figure 56. Pashmina goat

Figure 57: Wooly himalyan Hare

Figure 58: Marmoot

Snow Leopard (Ladhaki: Shan): The Snow Leopard (Unica unica) is one of the most elusive and endangered big cats, found in the mountainous region of Central Asia and has been recorded from parts of Russia, Mongolia, China, Nepal, Tibet, Bhutan, Pakistan, India, Afghanistan and north-east range over the Pamir, Tienshan and Altai mountains. In India, it is found throughout the alpine zone of the main Himalayan range. It is reported from Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh. It is encountered throughout Ladakh, mostly in the south and central regions between 3000 and 5000m. In Ladakh it can be best sighted within Hemis National Park and Zanskar valley. Its estimated population throughout Ladakh region is around 250-350 animals. Throughout its entire range the estimated population of Snow Leopard is 7000 individuals. Due to the recent conservation efforts, their numbers are probably increasing, but sharp declines in populations have been reported over the past decade from parts of the species range. Globally, high levels of hunting for the animal's skin and for live animals, for zoos, during the last century contributed to the species endangered status, but in India the primary threat relates to decimating wild prey as a result of over grazing in parts of the range ,and locally increasing damage to livestock that may lead to retaliatory killing of the animals and lessening toleration towards conservation. Since the 1970's legal measures were taken for its protection in India. It is listed as Endangered in the IUCN Red List of Threatened Animals, under Appendix 1 in CITES and Under Schedule 1 in the Jammu & Kashmir Wildlife (Protection) Act, 1978 (Shawl et al., 2008).

Ladakh Urial (Ladakhi: Shapo): Ladakh Urial (Ovis vignei) is endemic to Ladakh and has a very restricted distribution. Its distribution is along the major valleys of the rivers Indus and Shyok. As these valleys are heavily populated this brings this species into direct conflict with humans. The total estimated population of this species in Ladakh is about 1500 individuals. Its number is declining drastically due to disturbance and habitat loss. As per reports it has been exterminated from several areas and survives only in small isolated populations. The Urial is best sighted in areas surrounding Fotu La, Nindum and between Lamayuru, Rhizong and Wanla. In Kargil district the animal is reported from Junkar range and between Chiktan and Jukshu. The population is showing a declining trend. The animal is listed as Vulnerable in the IUCN Red List of Threatened Animals and comes under Appendix 1 in the CITES and Schedule 1 of the Jammu & Kashmir Wildlife (Protection) Act, 1978 (Shawl et al., 2008).

Tibetan Gazelle: Tibetan Gazelle (Procapra picticaudata) is distributed in Tibet and Sikkim. Once fairly common in Changthang region of Ladakh, it has since been wiped out completely from most of its range.The estimated population in Ladakh region is between 70-80 animals.The animals were best recorded from Kalak-Tartar plains south of Hanle valley. It is recorded as Near Threatened under the IUCN Red List of threatened Animals, under Schedule 1 of the Jammu & Kashmir Wildlife (Protection) Act, 1978 and under Appendix 1 of CITES (Shawl et al., 2008).

Royle's Mountain Vole: Royle's Mountain Vole (Alticola roylei) is endemic to northern India, where it is distributed in the western Himalayas from Kulu Valley in Himachal Pradesh to Kumaon in Uttarakhand (Molur and Nameer, 2008). In Ladakh it is a common resident of western and southern portion at around 3000 to 3300m and above. This animal is best seen in and around Panikar upto Suru Valley, the Zanskar and Changchu valley (Shawl et al., 2008). This species is listed as Near Threatened under the IUCN Red List of threatened Animals, because this species is probably in significant decline because of widespread habitat loss through much of its range, thus making the species close to qualifying for Vulnerable under criterion A2c (Molur and Nameer, 2008).

Pallas's Cat: In India, Pallas's Cat (Otocolobus manul) is found only in eastern Ladakh at an elevation between 3000 to 4800m. It is represented by three races and is distributed throughout Tibet, France, and Pakistan. The Pallas's Cat in Ladakh is best seen in Rupshu/ Changthang area. The subspecies found in Ladakh is Otocolobus manulnigripectus. This cat was hunted extensively for its fur. This cat has been placed under Schedule I of the Indian Wildlife (Protection Act, 1972 and Appendex II of CITES (Shawl et al., 2008).

Figure 59: Pallas Cat

Great Tibetan Sheep / Argali: Great Tibetan Sheep (Ovis ammon) is found in northeastern Afghanistan, China (Gansu, Inner Mongolia, Qinghai, possibly western Sichuan, Tibet, and Xinjiang), northern India (Ladakh, Sikkim, and Spiti), eastern Kazakhstan, eastern Kyrgyzstan, Mongolia, northern Nepal (near the Chinese border), extreme northern Pakistan, Russia (Tuvan and Altai Republics in the Altai Mountains), eastern Uzbekistan, and eastern Tajikistan. There are no recent records of argali occurrence in Bhutan. Within India, argali are restricted to the eastern plateau of Ladakh, a nearby area in Spiti (Himachal Pradesh), and, separately, in northern Sikkim adjacent to Tibet. Indian biologists consider these animals O. a. hodgsoni.

The main threats are over-hunting and poaching (for meat); competition, displacement and possibly disease transmission by domestic livestock; and habitat loss. In general, argali appear to be extremely intolerant of human disturbance. Argali are listed as a threatened species by the Government of India and are fully protected under Jammu and Kashmir's Wildlife Act of 1978. Poaching appears to have declined in recent years, but has evidently not been accompanied by an increase in argali. Little has been done to address the likely deleterious effects of displacement increasing numbers of livestock on argali in Ladakh. Argali are rare but present in Khangchengzonga National Park in Sikkim. This species is listed as Near Threatened under the IUCN Red List of threatened Animals, because this species is believed to be in significant decline (but probably at a rate of less than 30% over three generations, taken at 24 years) due to poaching and competition with livestock, making the species close to qualifying for Vulnerable under criterion A2de. (Harris and Reading, 2008).

Reptiles: Reptiles of Pangong Tso Wetland.

1. *Phynocephalus theobaldi*
2. *Laudakia himalayana*
3. *Cyrtodactylus monttium salsorum*
4. *Cyrtodactylus lawdernus*
5. *Scineella himalayanum*
6. *Coluber rhodorachis*
7. *Ptyas mucosus*

In this study, reptiles were not sited from the study region. But Toad-headed Agama (*Phrynocephalus theobaldi*) Figure 60, were sited near Hanley. The Toad-headed Agama is a medium sized insectivorous agama of the desert. It found in Himalayas upto 5000 m. The lizard's ear is hidden and the eyelids are strongly projected which acts as a barrier to the entrance of sand when the eyes are closed (Daniel, 2002; Murthy, 1995).

Figure 60. *Phrynocephalus theobaldi*

Mollusc: The Mollusc shells collected from Pangong Lake were identified using Ramakrishna and Dey (2007). Pangong Lake has four species of freshwater molluscs via. Radix brevicauda, Radix lagotis, Valvata piscinalis, and Gyraulus sp (Figure 61a to d). The distribution of Radix brevicauda, Radix lagotis, and Valvata piscinalis are reported only from Jammu and Kashmir in India. Even though, the molluscs shells collected from Pangong Lake are common in Ladakh region, these species were first time recorded from Pangong Lake. This indicates overlook or absence of biodiversity survey in the Pangong Lake, except Sharma (2000) who discovered a fossil molluscs Lymnea auricularia in ancient lacustrine clay deposits above the present level of the lake.

Fig 61a. Radix brevicauda b. Radix lagotis c. Valvata piscinalis d. Gyraulus

INSECTS: Insects are important pointers for species-rich geographical areas. Qualitatively, they are also important, whether, the subject of conservation themselves or as a tool for identifying areas with high endemism. Insects are a dominant and ancient group of animals on the earth. Over one and half million living and about 12,000 species of fossil insects have been identified and described all over the world and they represent about 90 per cent diversity documented for the animal kingdom (Uniyal, 2001).

Table 7: List of insect species of the Changthang Wildlife Sanctuary

Insect Orders	**Family**	**Species**	**Location**	**Habitat**
1.Coleotpera	Carabidae	Bembidion ladas Bembidion sp. Amara sp.	Tso-Moriri Tsokar Nyoma Diskit, Leh	Marsh vegetation Light trap Ground vegetation
Lepidoptera (Butterflies)	Pieridae	Pieris glauconame Pieris brassicae Colias cocandica Colias sp.	Leh Drass Tsokar Kargil	Agriculture field Ground vegetation
Moths	Sphingidae	1 sp.	Nyoma	Light trap
Diptera	i. Ephydridae	Ephydra glauca	Tsokar	Marsh vegetation
	ii. Chironomidae	Micropsectra glacies Micropsectra himachali Agromyza sp.	Tso-Moriri	Marsh vegetation
Orthoptera	Acrididae	2 sp.	Tsokar	Ground vegetation

Zooplankton: Zooplanktons of Panggong Tso wetland are *Keratella* sp., *Alona* sp., *Daphnia* sp. *Gammarus* sp. *Cyclops* sp.

Wildlife Sanctuary: Pangong Tso- is one of the Wet-site of Changthang Cold desert Wild life sanctuary. The area remained notified as Wildlife Protected area under SRO no. 155 dt. 19-03-1987 issued under the purview- of the J&K Wildlife protection Act (1978) section 17. The ownership of the wet-site remains with the Department of Wildlife Protection J&K State Leh Division" However, there are some revenue lands in the surrounding areas of Spangmik, Man, Merak, Chushul. One such land (Figure 5) on the bank of Pangong Tso, at Man, Merak is owned by Indian Astronomical Observation to understand the fundamental processes taking place on the Sun.

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

An attempt was made to understand the migration path of avian population and likely impact in the event the proposed site of NLST is in the avian migration path. This section discusses various paths as per the published literatures.

Bird Migration: Bird migration is the regular seasonal journey undertaken by many species of birds. Birds movement occours as a response to changes in food availability, habitat or weather. Irregular movements only in one direction are not migration but are called nomadism, invasions, dispersal or irruptions. Migration is tracked and recorded by its annual seasonality (Berthold, P., 2001). In contrast, birds that are non-migratory are said to be resident or sedentary. Approximately 1800 of world's 10,000 bird species are long-distance migrants (Sekercioglu, C.H., 2000).

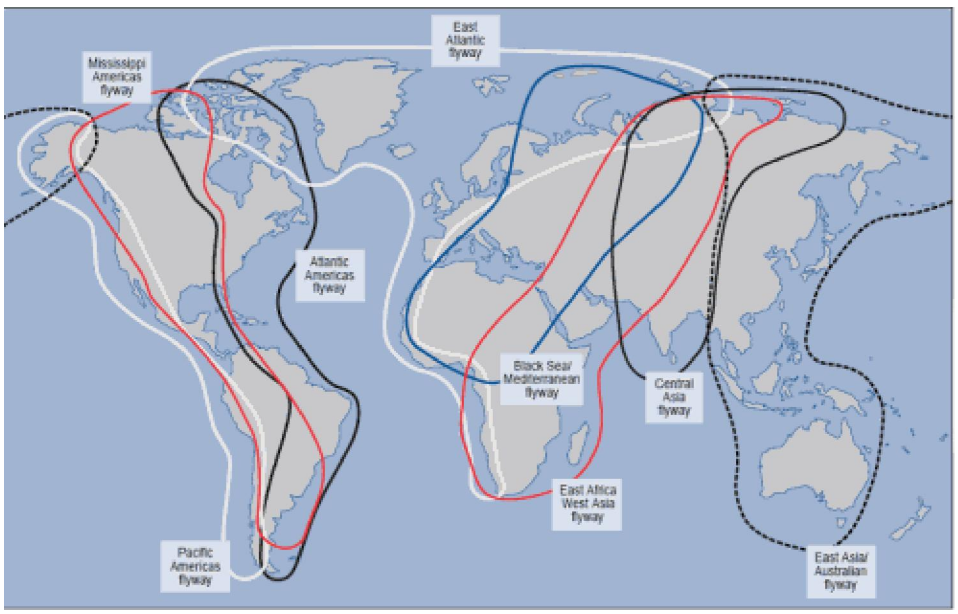
The various geographical features, i.e. mountains, coasts and rivers, leads the migrating birds to travel certain general routes. Migratory routes are not fixed and in some species part of the population follows one route and parts another. In India, the winter migrants from central Asia and Siberia are thought to use two main routes; one in the west along the Indus valley and the other in the north-east along the river Brahmaputra. This is shown in fig. 51. Some migrants fly very long distances the examples being arctic terns which fly 15,000 km each way. Most flights occur at between 600 and 5000 ft above sea level with an average height of 1525 ft. However, mountains may mean greater heights are needed and heights over 10000 ft are not uncommon.

There is a very scant understanding and knowledge about how birds navigate. Most migratory birds have a built-in sense of direction due to which they know innately which direction they need to travel. Experiments conducted on starlings shows that when in first year Starlings in Europe were kept in a covered cage and away from birds which have already migrated once or more, still move to the correct side of the cage when the time comes for them to migrate. Some birds appear to use landmarks and obviously at a height of several thousand feet they can see a considerable distance. A number of elegant experiments involving and/or displacing birds to different geographical regions have shown that many birds use the sun, at least during the day, as a cue to direction when migrating or homing.

Birds of prey, Swallows and Crows migrate by day. Thrushes, Warblers, Cuckoos and Woodpeckers migrate by night. Wildfowl migrate both day and night. Most songbirds migrate at night. Experiments show that there is a hormonal stimulus to migrate, resulting, at least in the spring, in the development of the gonads. Other stimuli appear to involve temperature, daylight/darkness ratios and an internal clock.

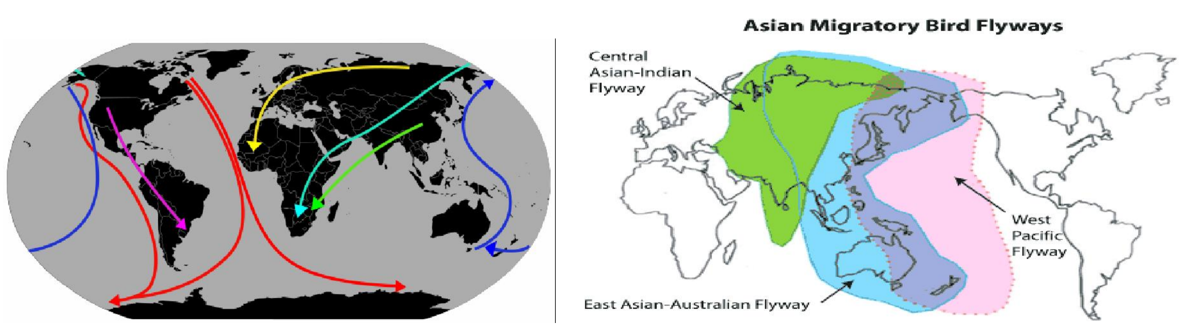
Migrations mostly consist of birds flying south for the winter and north in spring to breed. To a large extent this reflects the distribution of the continents on the planets. There is a lot more temperate and tundra landscape in the north than in the south. Migrations to and from alpine areas are not uncommon, such as the Mountain Quail which breeds at heights up to 3000 m, but winters below 1500 m. Interestingly, the bird is flightless so it walks up and down the mountains in groups single file

General patterns: Many bird populations migrate long distances along a flyway. The most common pattern involves flying north in the spring to breed in the temperate or Arctic summer and returning in the fall to wintering grounds in warmer regions to the south (Figure 62)



http://www.wildlandfire.com/pics/other/bird_flyways.gif

Figure 62: Bird flyaway routes

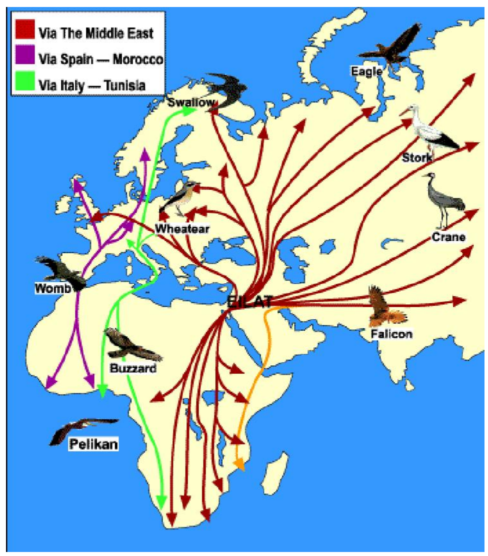


http://upload.wikimedia.org/wikipedia/commons/d/d5/Central_Asian_Flyway_Map.gif

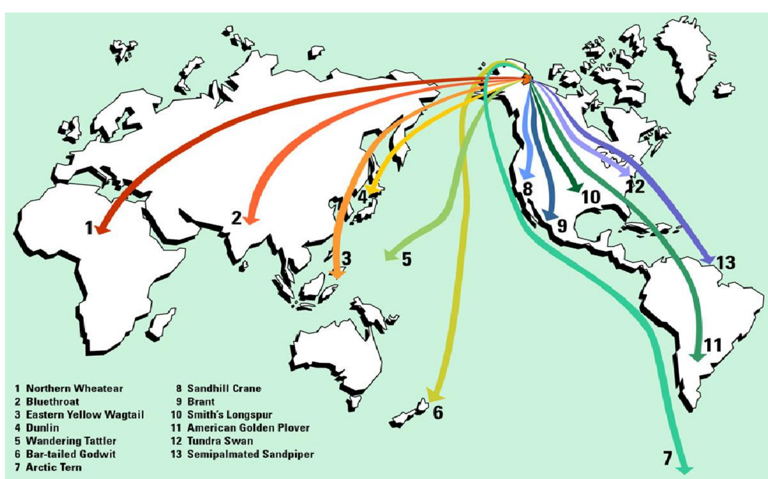
Figure 63.a) Bird migratory routes over the Himalayas

b) Asian migratory bird flyways

Figure 63a and 63b indicate the migratory route of some birds. The blue curve (in Figure 63 a) shows the route for Northern Wheatear (*Oenanthe oenanthe*), Bar headed goose (*Anser indicus*) and the green curve (in Figure 63 a) shows the route for Amur Falcon (*Falco amurensis*). The primary advantage of migration is conservation of energy. The longer days of the northern summer provide greater opportunities for breeding birds to feed their young. The extended daylight hours allow diurnal birds to produce larger clutches than those of related non-migratory species that remain in the tropics year round. As the days shorten in autumn, the birds return to warmer regions where the available food supply varies little with the season. Figure 64 shows the main routes of birds migration in the old world where massive birds migration take place twice a year, before the winter the birds fly from the cold continents Europe and Asia to the hot continent Africa and they do the return trip before the summer.



http://www.holylandtime.us/joomla/images/stories/bird_migration_map.gif
Figure 64: Retreat of birds from Africa to different parts of the world



http://arctic.fws.gov/images/worldbirdmigration.jpg
Figure 65: Bird migratory route from the Arctic's

The birds seen in summer on Arctic Refuge migrate to all corners of the earth. The 6-inch Northern Wheatear travels approximately 13,000 miles one way from its breeding grounds on the Refuge, across Asia and the Middle East, to its wintering areas in Africa. The bird then travels a similar distance back to Alaska in the Spring. The Arctic Tern migrates almost the same distance (approximately 25,000 miles round-trip) but it flies in a different direction, traveling south to Antarctica to escape winter in the northern hemisphere. Tundra Swans that nest on the Refuge fly more than 4,000 miles east in the Fall, crossing North America to winter on the Chesapeake Bay. The Bar-tailed Godwit may have the longest non-stop flight of any bird. These shorebirds fly 7,200 miles across the open waters of the Pacific Ocean in a single, non-stop flight between Alaska and New Zealand during their Fall migration. On their return flight in the Spring, Bar-tailed Godwits rest for a month in Japan before returning to Alaska. The following birds are highlighted in Figure 65: Northern Wheatear to Africa, Bluethroat to southern Asia, Eastern Yellow Wagtail to Indonesia, Dunlin to Japan, Wandering Tattler to Polynesia, Bar-tailed Godwit to New Zealand, Arctic Tern to Antarctica, Sandhill Crane to western United States, Brant to western Mexico, Smith's Longspur to central United States, American Golden Plover to southern South America, Tundra Swan to Chesapeake Bay in eastern North America , Semipalmated Sandpiper to northeastern South America

These advantages offset the high stress, physical exertion costs, and other risks of the migration. Predation can be heightened during migration; the Eleonora's Falcon which breeds on Mediterranean islands has a very late breeding season, coordinated with the autumn passage of southbound passerine migrants, which it feeds to its young. A similar strategy is adopted by the Greater Noctule bat, which preys on nocturnal passerine migrants. The higher concentrations of migrating birds at stopover sites make them prone to parasites and pathogens, which require a heightened immune response. Within a species not all populations may be migratory; this is known as "partial migration". Partial migration is very common in the southern continents; in Australia, 44% of non-passerine birds and 32% of passerine species are partially migratory. In some species, the population at higher latitudes tends to be migratory and will often winter at lower latitude. The migrating birds bypass the latitudes where other populations may be sedentary, where suitable wintering habitats may already be occupied. This is known as leap-frog migration. Within a population, there can also be different patterns of timing and migration based on the age groups and sex. Only the female Chaffinches in Scandinavia migrate, with the males staying resident. This has given rise to the latter's specific name of coelebs, a bachelor.

Most migrations begin with the birds starting off in a broad front. In some cases the migration may involve narrow belts of migration that are established as traditional routes termed as flyways. These routes typically follow mountain ranges or coastlines, and may take advantage of updrafts and other wind patterns or avoid geographical barriers such as large stretches of open water. The specific routes may be genetically programmed or learned to varying degrees. The routes taken on forward and return migration are often different.

Many of the larger birds fly in flocks. Flying in flocks helps in reducing the energy needed. Many large birds fly in a V-formation, which helps individuals save 12–20 % of the energy they would need to fly alone. Red Knots Calidris canutus and Dunlins Calidris alpina were found in radar studies to fly 5 km per hour faster in flocks than when they were flying alone.

The altitude at which birds fly during migration varies. An expedition to Mt. Everest found skeletons of Pintail and Black-tailed Godwit at 5000 m (16,400 ft) on the Khumbu Glacier. Bar-headed Geese have been seen flying over the highest peaks of the Himalayas above 8000 m (29000 ft) even when low passes of 3000 m (10000 ft) were nearby. Seabirds fly low over water but gain altitude when crossing land, and the reverse pattern is seen in landbirds. (Swan, L.W. 1970; Dorst, J. 1963). However most bird migration is in the range of 150 m (500 ft) to 600 m (2000 ft). Bird-hit aviation records from the United States show most collisions occur below 600 m (2000 ft) and almost none above 1800 m (6000 ft).

In contrast, most species of penguin migrate by swimming. These routes can cover over 1000 km. Blue Grouse Dendragapus obscurus perform altitudinal migration mostly by walking. Emus in Australia have been observed to undertake long-distance movements on foot during droughts.

Theories related to Bird Migration: Bird migration is the mechanism behind the seasonal appearance and disappearance of some species of birds, mammals, fish and insects. In India and South Asia, out of over 2000 species and sub-species, about 350 are extralimital migrants. Generally, in birds, migration is seasonal, and in the Indian subcontinent the majority of migratory birds are winter migrants. In India, the physiology and mechanics of migratory bird flight are not very well known. The Bombay Natural History Society (BNHS) has been working since 1926 to rectify this shortcoming.

The first natural historian to write about migration as an observable fact was Aristotle. Aristotle noted that cranes traveled from the steppes of Scythia to marshes at the headwaters of the Nile. Pliny the Elder, in his Historia Naturalis, repeats Aristotle's observations. Aristotle however suggested that swallows and other birds hibernated. Aristotle was an astute observer and as well as recording the times of departure of some species from Greece, and listing Pelicans, Turtle Doves, Swallows, Quail, Swans and Geese correctly as migrants he accurately observed that all migrating birds fatten themselves up before migrating. This belief persisted as late as 1878, when Elliott Coues listed the titles of no less than 182 papers dealing with the hibernation of swallows. It was not until early in the nineteenth century that migration as an explanation for the winter disappearance of birds from northern climes was accepted.(Lincoln, 1979)Though Herodotus described the migration of Cranes from north of the Black Sea to Central Africa 100 years before.

The earliest recorded observations of bird migration were 3000 years ago, as noted by Hesiod, Homer, Herodotus, Aristotle and others. The Bible also notes migrations, as in the Book of Job

(39:26), where the inquiry is made: "Doth the hawk fly by Thy wisdom and stretch her wings toward the south?" The author of Jeremiah (8:7) wrote: "The stork in the heavens knoweth her appointed time; and the turtledove, and the crane, and the swallow, observe the time of their coming."

The discovery in Germany of white storks embedded with African arrows provided early clues on migration. One of the oldest of these Pfeilstorch specimens was found in 1822 near the German village of Klütz, in the state of Mecklenburg-Vorpommern.

Navigation is based on a variety of senses. Many birds have been shown to use a sun compass. Using the sun for direction involves the need for making compensation based on the time. Navigation has also been shown to be based on a combination of other abilities including the ability to detect magnetic fields (magnetoception), use visual landmarks as well as olfactory cues. Long distance migrants are believed to disperse as young birds and form attachments to potential breeding sites and to favourite wintering sites. Once the site attachment is made they show high site-fidelity, visiting the same wintering sites year after year.The ability of birds to navigate during migrations cannot be fully explained by endogenous programming, even with the

In 1251 Matthew Paris writing in Hertfordshire recorded what is the first reference in England of the migration of Crossbills. By the 1600s good evidence had been supplied by the French ornithologist Pierre Belan to refute many claims of hibernation by the simple act of keeping the supposedly hibernating birds in a large aviary supplied with all the facilities it was claimed they needed to hibernate. None ever did.

It is important to remember that until the 19th century optical equipment was extremely rare, bird identification guides non-existent, travel to other countries difficult and expensive and bird ringing of course had not been invented. Moreover, in 1946 the Nuttalls Poorwill (*Phalaenoptilus nuttallii*) was found to be a bird that actually does hibernate; it does so in the Colorado Desert, California where it lives.

Scientific investigation of bird migration began in 1802 when birds were tagged with metal leg bands. It was not until this century when large numbers of bands with printed numbers and letters became available that this method really began to deliver results. The numbering of the rings is controlled by a national body in most countries and the rings have a contact address on them. These national bodies co-operate with each other in exchanging information on banding records (either live caught or found dead) of birds ringed outside the country in which they are caught.

Hundreds of thousands of birds are banded around the world each year, by amateurs and professionals. This work over the last 20 years has generated a lot of useful information. In India, it was only in the 1960s that effective bird ringing projects became possible.

Birds generally begin migration when they have a favorable tailwind. Once started however, only very bad weather will stop them. Many birds fly high when migrating because of prevailing winds at higher altitudes and also because the cold at these altitudes helps them disperse heat being generated by their flight muscles.

Timing of migration is a mix of internal stimulus which results in a feeding binge to put on fat to survive the journey and then the tendency to aggregate into flocks. Once the pre-migration flock is gathered, the feeding continues while the birds wait for suitable weather conditions. Thus while the birds' internal clock probably releases the hormonal triggers at a fairly accurate date each year, the availability of food and the presiding weather conditions decide when the migration starts and hence when we see the first spring migrants arrive and the last autumn ones leave help of responses to environmental cues. The ability to successfully perform long-distance migrations can probably only be fully explained with an accounting for the cognitive ability of the birds to recognize habitats and form mental maps. Satellite tracking of day migrating raptors such as Ospreys and Honey Buzzards has shown that older individuals are better at making corrections for wind drift.

Orientation and navigation: As the circannual patterns indicate, there is a strong genetic component to migration in terms of timing and route, but this may be modified by environmental influences. An interesting example where a change of migration route has occurred because of such a geographical barrier is the trend for some Blackcaps in central Europe to migrate west and winter in Britain rather than cross the Alps.

Migratory birds may use two electromagnetic tools to find their destinations: one that is entirely innate and another that relies on experience. A young bird on its first migration flies in the correct direction according to the Earth's magnetic field, but does not know how far the journey will be. It does this through a radical pair mechanism whereby chemical reactions in special photo pigments sensitive to long wavelengths are affected by the field. Note that although this only works during daylight hours, it does not use the position of the sun in any way. At this stage the bird is similar to a boy scout with a compass but no map, until it grows accustomed to the journey and can put its other facilities to use. With experience they learn various landmarks and this "mapping" is done by magnetite’s in the trigeminal system, which tells the bird how strong the field is. Because birds migrate between northern and southern regions, the magnetic field strengths at different latitudes let it interpret the radical pair mechanism more accurately and let it know when it has reached its destination (Wiltschko. et al., 2006) [20]. More recent research has found a neural connection between the eye and "Cluster N", the part of the forebrain that is active during migrational orientation, suggesting that birds may actually be able to see the magnetic field of the earth. (Deutschlander et al; 1999 Heyers et al. 2007)

The Indian migratory route: There are many earlier studies on world migration of birds, which essentially focuses on the new world birds in the west. However, not much understanding has been gathered on the migratory routes of birds in India so far. The pattern of migration shows movements of the birds from the Siberian region crossing the Trans Himalayas and even the mightiest greater Himalaya. Many cranes sp. as red crowned crane, bar headed goose (Figure 66) and the high souring raptors do cross these high ranges to enter India and finally leave towards Africa during the winters. The Siberian birds do also enter the country through the north eastern Himalayan ranges (Figure 66). This route traverses through the Western Ghats and southern parts of India before leading the birds to Africa (Figure 66).

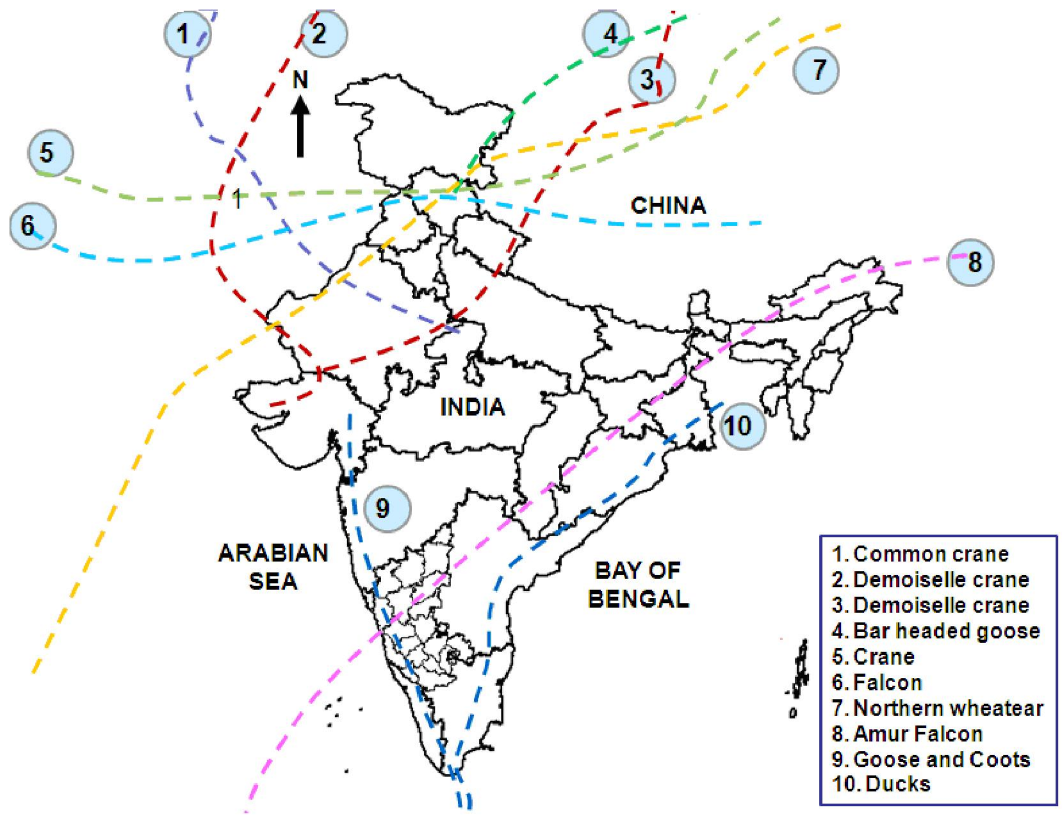
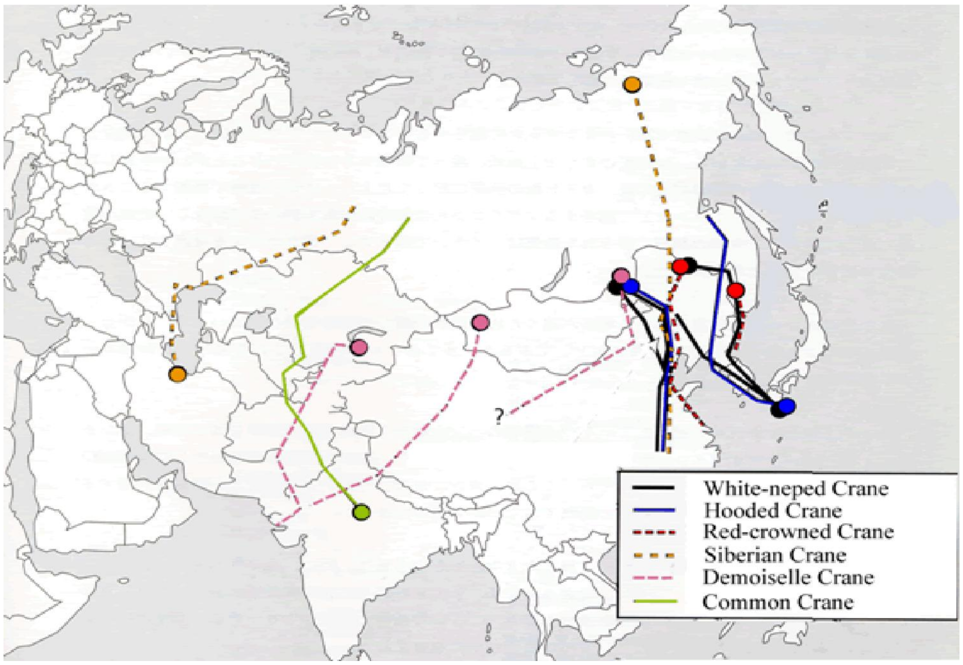


Figure 66. The migratory routes through India (not to scale)

There are also the birds which enter India from the north western side and from the Mexican region (Figure 66). Some birds do migrate along the eastern and the western coasts of the country to Africa and Sri Lanka. According to the geographical location in the Indian Continent, the land of Sri Lanka is situated at the extreme southern point beyond the south of India. The stretch of ocean from here to the south pole contains no other land. Hence, for the migrant birds that travel south from India, Sri Lanka is the final destination.

There are 3 flying routes across India along which immigrant birds come to Sri Lanka. These are – the western route, the eastern route and the Andaman Island route.(Figure 67). From the northern and northwestern parts of the world along the western coastal line of India, then towards the extreme south of India, which is common point the birds fly across this coast and arrive in Sri Lanaka mostly across this coastal line between Mannar and Kaluthara.

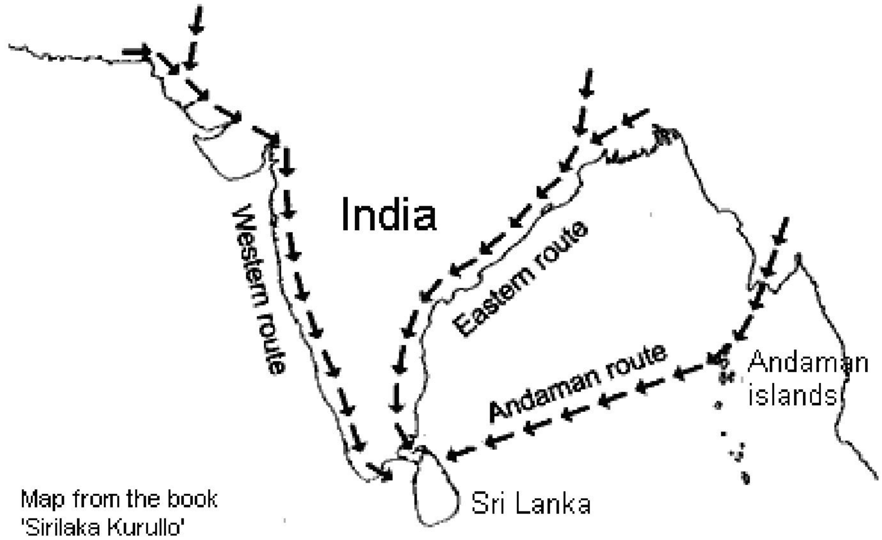


http://www.birdlife-asia.org/crane/ch/migration

Figure 67: The Mexican and asia pacific migratory routes passing through India

The migrant birds take this route initially from Europe, West Asia including Western Siberia, & from the western regions of Himalaya including Kashmir. From the northern and northeastern parts of the world, along the Eastern coast line of India, towards the south. Passing the coastline between Kalmier point and Ramesvaram, which is further south these migratory birds arrive in Sri Lanka from India, from East Asia which includes eastern Siberia and Mongolia, from the Eastern regions of Himalaya including Tibet, these migratory birds fly along this route initially.

Apart from the above-mentioned two routes there is still another route to the North Eastern coast of Sri Lanka, which is the Andaman Islands flying route. This route falls across the Andaman Islands in the Indian Ocean. It is believed that these migratory birds arrive in Sri Lanka along this route from south East Asia and the East each year. Each year the migratory season commences in October and ends in April – May in the following year. Very often, the birds take the same route they arrived. However, some birds return along different routes.



Source: http://www.walkwithjith.com/htm/itineraries_Migration.htm

Figure 68: The migratory routes along the coasts of India

Bar headed Goose: The Bar-headed Goose (*Anser indicus*) is a goose which breeds in Central Asia in colonies of thousands near mountain lakes. It lays three to eight eggs at a time in a ground nest. The summer habitat is high altitude lakes where the bird grazes on short grass. The species has been reported as migrating south from Siberia via the Qinghai lake region in China before its crossing of the Himalaya.(IUCN, 2006). The Bar-headed Goose is one of the world's highest flying birds, having been seen at up to 10,175 m (33,382 feet). It has a slightly larger wing area for its weight than other geese and it is believed this helps the goose to fly high. Studies have found that they breathe more efficiently under low oxygen conditions and are able to reduce heat loss.(William and Scott, 2008). The haemoglobin of their blood has a higher oxygen affinity than that of other geese.(Liu et al., 2001)

The Bar-headed Goose (Figure 69) **migrates over the Himalayas to spend the winter in India, Assam, Northern Burma and the wetlands of Pakistan. It migrates up to Magadi wetlands of Gadag district of Karnataka in the southern part of India**. The winter habitat of the Bar-headed Goose is on cultivation where it feeds on barley, rice and wheat, and may damage crops.

The bird can fly the 1000-mile migration route in just one day as it is able to fly in jet stream (Lee et al. 2008). The bird is pale grey and is easily distinguished from any of the other grey geese of the genus *Anser* by the black bars on its head. It is also much paler than the other geese in this genus. The adult is 71–76 cm (28-30 in) and weighs 1.87-3.2 kg (4-7 lbs). In flight, its call is a typical goose honking. It has sometimes been separated from *Anser* which has no other member indigenous to the Indian region, nor any at all to the Ethiopian, Australian, or Neotropical regions, and placed in the monotypic genus ***Eulabeia*.**

Figure 69: The Bar-headed Goose (*Anser indicus*)

They nest mainly on the Tibetan plateau. Intra-specific brood parasitism is noticed with lower rank females attempting to lay their eggs in the nests of higher ranking females (Weigmann, 1991).

Impact of the proposed activity on migrant avian population and mitigation aspects: Reports reveal that about five million birds, representing about 250 species (most of them are nocturnal migrants), fly through Chicago twice a year get confused with the night time lights of high rise buildings. These birds either crash into high intensity reflection of these buildings or get disoriented causing them to circle around and around, finally setting exhausted in a street tree or bush. These birds tend to fly into glass windows as they fly towards a reflection. Mitigation measures adopted by local residents are to dim or turn off decorative lighting late at night and to minimize the use of bright interior lights during migration season.

In this context, considering the proposed building height of NLST building and implementation of the suggested mitigation measures **(-** Shadow plate covering the primary mirror protects it from the vision of birds; change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections (Figure 3) and use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre) would minimise the impact on birds.

Environmental Impact Assessment of the National Large Solar Telescope Project and its ecological impact in Merak area

Water:

There have been a number of investigations in the Himalayan lakes where various studies had been carried out (Zutshi, 1989; Omkar & Sharma, 1994-95; Jain et al., 1999, Kumar et al. 1999a, Kumar et al. 1999b, Das and Dhiman, 2003; Shewa, 1998, Rai et al 2006, 2007). The physico-chemical characteristics of five lakes as Mansar, Surinsar, Dal, Tso morari, Tsokarand Renuka were investigated by Singh, et al. (2008). There has been many studies based on both physico-chemical and biological characteristics have been carried out by Zutshi (1985, 1989); Chandra Mohan (1992) and Gupta (1992) on Mansar lake.Lakes of Jammu and Kashmir are different in their morphology and thermal behaviour and vary from sub-tropical monomictic to dimictic type. Rai et al. (2001) performed studies on bathymetry, rate of sedimentation and water quality of Mansar lake during 1998-99. Few studies have also been reported for the Renuka lake, which include mainly morphometry, general water quality and catchment related aspects of the Renuka Lake (Singh et. al, 1987). The water quality of the largest high altitude lake Pangong Tso is seldom analyzed and interpreted. Therefore the study was carried out aiming to monitor the status of the lake and analyze the variations in the physico-chemical properties.

Water quality analysis: The earlier studies made by singh et al (2008) on the water quality for the lakes of Ladakh region ((Tsomoriri and Tsokar) were compared with Pangong Tso lake, (present study). The pangong tso and the other lakes were found to show very distinct characteristics due to prevailing cold desert type climate having a very low rainfall in the order of 100 mm. As such, unusually a very high concentration of certain water quality parameters viz. pH, Total Dissolved Solids, Total Hardness, Chloride, calcium, magnesium were obtained in Pangong Tso as also in Tsomoriri and Tsokar lakes of Ladakh region, which may be treated as brackish water. The data of DO indicated that hypolimnion of the Himalayan lakes remain mostly under anoxic conditions condition (Singh et al, 2008). During the present study a positive ORP (50-77 mV) clearly shows aerobic nature of the surface water. The high salt concentration in the lake is attributed to higher evaporation rates as well as links with ancient marine systems (Link to Tethys sea). A very high pH is indicative more of a carbonate rich inorganic C system. The sources of the same again may be attributed to the local hydrogeology of the lake. The lakes also remain stratified during summer and become overturn during winter months. The minimal nutrient content in the lake (Table 8) clearly depicts its oligotrophic state.

Table 8: A comparative account of the water quality of Ladakh lakes.

Parameters	**Tsomorari**	**Tsokar**	**Pangong**	
			Study Site	**adj. merek**
Study	Singh et al., 2008		Present Study, Nov 2010	
District	Leh	Leh	Leh	Leh
Latitude	33.516584	33.310395	33.79464	33.8012
Longitude	78.913344	78.025007	78.61736	78.606
Altitude (m)	4527	4225	4253	4253
Max. Depth (m)	30	--	30.48	100
Area (Sq km)	141.05	0.55	600	600
pH	8.96	8.82	9.39	9.42
Salinity (ppm)	--	--	9702	4967
EC (µS/cm)	3550	63 530	19985	10232
ORP (mV)	--	--	77	50
Turbidity (NTU)	--	--	0.97	0.9
TDS (ppm)	2272	40659	13776	7053
BOD (ppm)	-	-	0.01	0.4
Alkalinity (ppm)	-	-	2250	2450
HCO3 (ppm)	1	4	150	175
CO3 (ppm)	-	-	2400	2650
TH (ppm)	3161	19743	2332	2280
Chlorides (ppm)	24	9028	5916	3029
Phosphates (ppm)	0.03	0.3	0.02	0.014
Nitrates (ppm)	-	-	0.04	0.09
Sodium (ppm)	791	1061	7400	500
Potassium (ppm)	209	1715	1163	75
Calcium (ppm)	35	1300	732	684
Magnesium (ppm)	747	4010	123	139

Environmental Impacts:

The proposed NLST at Merak near Pangong lake would involve the commission and operation of modified reflecting Gregorian-type telescope that would deliver images of small part of the sun (300” ×300”) onto instrument stations mounted on the telescope and on a rotating platform located below the telescope. NLST is expected to create at least 50 jobs for locals at various levels. The schools and colleges in the area will be informed about the goals of NLST and solar astronomy will be introduced to them at an appropriate level for recruitment and collaborations on specific tasks. The facilities would include:

- The observatory facility, which includes the telescope (kept at a height of nearly 26 m), its pier, and the rotating instrument platform,
- The enclosure for telescope,
- The telescope building with a diameter of approximately 15 m.
- An aluminizing chamber at a separate location sufficiently far off from the site.
- The electricity required would be through PV based solar panels (similar to the facility at Hanle).
- The living quarters for the telescope maintenance and observing staff would be located at a convenient place far from the telescope site.

Environmental Impacts associated with the project: The most significant issues which are likely to occur are:

a) During the construction phase local disturbance in the sanctuary region (movement of vehicles and transport of materials).
b) Increase in the human activity adjacent to Pangong lake that might affect the water quality of the region.
c) Increased employment scope of the project would attract human setllements in and around the proposed site, which might affect the ambience and characteristics of the place.
d) Increase in economy in the years to come due to the project would entertain more anthropogenic stress on the wild life as well as the local vegetation.
e) The higher quantum of heat generated at the focus of the 2 m mirror and its dissipation.
f) Heat generated and its diversion to the environment.
g) Disturbance in the bird migration due to the telescope and associated optical properties - The exposure of the illumination/reflectance or the glare to the birds which may affect their migration or attract/distract them from the water body in their due course of migration.

Construction phase: During the construction phase, there are likelihood of local disturbance of the silent and prestine ecosystem. The transfer of raw materials as well as the very movement of vehicles and consequent dust and noise distracts birds. Also, it should be kept in the mind the proposed site has a mixed origin which are parts of sedimentary deposits. This also necessitates pre feasibility investigations of the proposed site from the stability of the structures.

Operation Phase: During the operation of the telescope special care must be taken to restrict the highly focused and concentrated light getting into the immediate environment, which attracts avian population. The very reflection and glare might disturb the birds passing by the region.

The heat generated formed at around the focus needs to be dissipated in the dispersed form. This is to avoid local warming. This may affect the local/ regional ecology.

As the salinity of the water is around 10, 000 mg/l. Special care should be taken for the metals like Fe and Cu, which have ample chances of a very high corrosion. Periodic paints or usage of light wt. alloys would prevent such occurrences frequently.

Earlier reports and findings reveal the levels of water of the Pangong lake has been increasing slowly and there is gradual submersion of the some of the elevated regions along the beaches of the lake. Therefore appropriate steps should be taken to avoid occurrence of possible submersion of the project site and associated equipments. Necessary mitigation measures have to be taken for avoiding any loss due to the increase in the water level.

EMP: Environment Management Plan

Merak near Pangong lake is the most suitable site for commissioning and operation of National Large Solar Telescope. The activities will involve minimal environmental impacts. Setting up of NLST would boost the region as it would provide employment opportunities, and associate benefits (like medical facilities, education, etc.) to the local people. This also gives visibility to the region in the global perspective and might prevent further land encroachments. Bird's death is reported in migratory path sue to Sky scrapers which are constantly lit (high intensity illumination).

The location being the protrusion near Merak at 33° 47' 42" N, 78° 37' 08" E, close to the Pangong Tso Lake (of sedimentary deposits) do not have vegetation. Planting of native species of plants would help the local environment.

- The excavation materials need to be will be relocated within the allotted land (and should not be dumped closer to the lake).
- The building construction should be stored in the enclosures so that the dust does not get into the surrounding environment.

- No solid, liquid or gaseous effluents to the environment due to the operation of NLST. This involves:
    - ü The organic fraction of solid waste will be treated (either through aerobic or anaerobic options)
    - ü Restriction on usage of plastics in the colony
    - ü Sewage from colony households (including the NLST complex and guest house) will be treated before discharging to the lake.

The insolation is captured by an array of mirrors (1, 2, 3 etc). The primary mirror (of 2 m diameter) focusing the entire beam of rays into a 3 cm small receptor, which in turn is used for capture of solar processes through polarization. This process generates enormous heat. The heat stops and the field stops are designed to check and capture maximum heat generated around the first focus.

In the design provision the sun as a whole will be tracked by the movement of the telescope which orients itself perpendicular to the incoming sunrays. Therefore maximum amount of the rays will be focused and a very less amount is reflected. Emphasis will be given on the safety of the spider network of metal trusses through proper orientation of the telescope before any exposure of the primary mirror.

To address the quantity of the light reflected into the environment which might possibly affect the bird path and their migration the reflecting light and heat will be directed towards the ground which would cover a distance of 40 m before touching the ground rather than allowing the heat and light towards the sky. The special design and arrangement made incorporated into NLST would reflect the solar beam side-wards during the morning and evening hrs and downwards during the mid day. This design essentially ensures that the energy density at the ground would be 400 times lesser than the normal sunshine intensity. The highly focused and energy intensive bright spot 3 cm in diameter would only appear with in the cone, which do not affect the birds in proximity and their migration course. In addition to this, ultrasonic sound waves would be used to ward off birds.

Environment Management Plan thus would include:

- ü Suppression of dust during the movement of vehicles –operation phase
- ü Construction work and movement of vehicles only during the day time so that fauna are not affected during the night.

At site:

- ü Shadow plate covering the primary mirror protects it from the vision of birds.
- ü The mitigation measure involves change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections.

- Use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre.
- Planting of native species of flora would aid as heat sinks
- Setting up science centre and primary health centre for the employees and local public (part of the social commitment)

In this context, considering the proposed building height of NLST building and implementation of the suggested mitigation measures (Shadow plate covering the primary mirror protects it from the vision of birds; change in angle to 30 degrees at the heat stop so that the reflection from the heat stop is diffused and directed towards a far off point in the ground and hence flying bird/birds are insulated from any reflections and use of low energy ultrasound transmitters to ward off the birds around the telescope in an area of around half an acre) would minimise the impact on birds.

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