# LANDSCAPE MASTER PLAN FOR MANSAGAR LAKE,

Jaipur, Rajasthan

## MASTER OF ARCHITECTURE (LANDSCAPE)


**DHEERAJ BANDIL**

2016MLA005



**SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL**

**NEELBAD ROAD, BHAURI, BHOPAL – 462030**

An Institution of National Importance,

Ministry of Human Resource and Development, Govt. Of India

**Department of Landscape**

**School of Planning and Architecture, Bhopal**

# DECLARATION

I, *DHEERAJ BANDIL*, Scholar No - *2016MLA005* hereby declare that the thesis entitled *"Landscape Master Plan For Mansagar Lake, Jaipur, Rajasthan"*; submitted by me in partial fulfillment for the award of *Master of Landscape Architecture*, in School of Planning and Architecture Bhopal, India, is a record of bonafied work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Monday, 30th April 2018 **Ar. DHEERAJ BANDIL**

# CERTIFICATE

This is to certify that the declaration of *"Landscape Master Plan For Mansagar Lake, Jaipur, Rajasthan"*; is true to the best of my knowledge and that the student has worked under the guidance of the following panel.

**RECOMMENDED**

Asst. Prof. SHIVANI PALIWAL
**ACCEPTED**

Prof. SANJEEV SINGH
Head of Department
Department of

# LANDSCAPE MASTER PLAN FOR MANSAGAR LAKE,
**JAIPUR, RAJASTHAN**

**A DESIGN THESIS**

***Submitted***
*in partial fulfillment of the requirements for the award of the degree of*

## MASTER OF LANDSCAPE ARCHITECTURE

By

**Dheeraj Bandil**
Sch. No. 2016MLA005

Under the Guidance of
**Asst. Prof. Shivani Paliwal**

**SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL**
**NEELBAD ROAD, BHAURI, BHOPAL – 462030**
An Institution of National Importance,
Ministry of Human Resource and Development, Govt. Of India

# ACKNOWLEDGEMENT

This thesis would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, would like to express my utmost gratitude to my guide Prof. Shivani Paliwal for her guidance, valuable suggestions, during the course of execution of this work. I also thank to Prof. Saurabh Popli, Prof. Sonal Tiwari and Prof. Suninder Suneja for their guidance and suggestions at various stages.

I would like to my family for their continuous support and encouragement in the completion of work.

At last but not the least I would like to thank to my batch mates and friends for their support.

Thanks

Dheeraj Bandil

# ABSRACT

With rapid infrastructure development and modernization, humans seem to be forgetting the importance of natural elements and their ecosystems and the value they hold for the people and the city at large. The Mansagar Lake of Jaipur is one such example of disconnect between man and nature. It is a man-made water body in Jaipur which is surrounded by hills on three sides and forms a mesmerizing picturesque landscape.

The lake falls in the Jaipur – Amer tourist corridor and is the only water body present in Jaipur. Since Mansagar Lake lies on tourist corridor Jaipur Development Authority has proposed various activities and development of open spaces along the lake edge on its south side to attract visitors. Mansagar Lake acts as a natural habitat to various species of local and migratory birds. Water provides sustainable living to countless species of the aquatic ecosystem like fish, birds, insects and it also contribute micro-climatic modifications in the city.

A clean fresh lake is a source of pure pleasure, while on the other hand, polluted and algae infested water body is a major eyesore. But nowadays, the Mansagar Lake and the picturesque landscape of surrounding hills is neglected and is facing major challenges with respect to its ecological balance because of lack of public involvement. This study is focused on devising methods to improve the Landscape Sensitivity, Visual Sensitivity and Landscape aesthetics of the lake area and it's surrounding by establishing an interaction between human and nature, the two main entities integral to the lake, through landscape design as a medium and hence ensure the longevity of the created space.

This study helps to enhance, restore and manage the lake and its surrounding environment and make it closer to nature. From the result of the study, it shows that development of urban open spaces should be incorporated in such a way that it should support its distinct landscape character.

KEY TERMS: Picturesque Landscape, Natural Habitat, Aquatic ecosystem, Ecological Balance,
Visual Sensitivity, Landscape Aesthetics

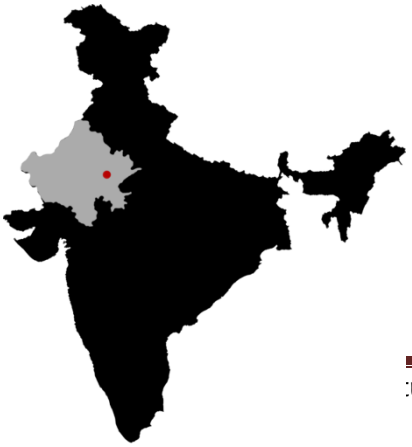
# Contents

## LIST OF FIGURES

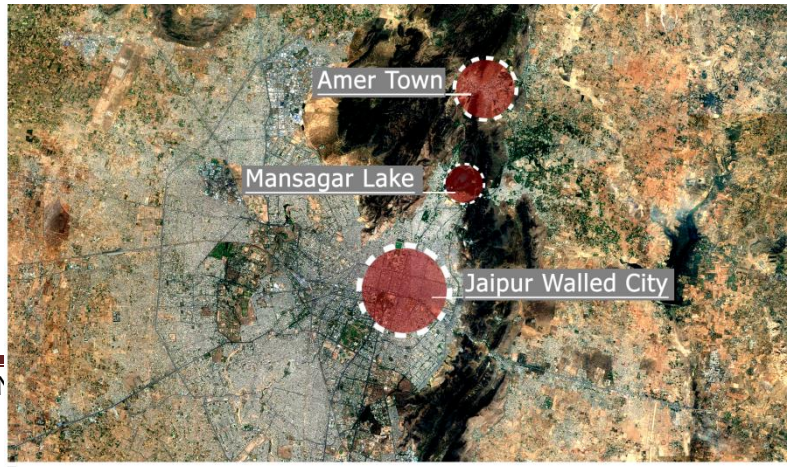
# CHAPTER 1: INTRODUCTION

## 1.1 BACKGROUND

Jaipur the capital of Rajasthan state in India was founded in 1727 by Maharaja Jai Singh II, who ruled Jaipur State from 1699–1744. Initially his capital was Amber, which lies at a distance of 11 km from Jaipur. He felt the need of shifting his capital city with the increase in population and growing scarcity of water. Jaipur is the first planned city of India and the King took great interest while designing this city of victory.



RAJASTHAN, INDIA




JAIPUR

Mansagar Lake is an artificial lake, situated on the outskirts of the Indian city of Jaipur, the capital of the state of Rajasthan in India. It is named after Raja Man Singh, the then ruler of Amer, who constructed it in 1610 by damming the Dharbawati River.

The lake, situated to the north of Jaipur city lies between Amer, the historic city and Jaipur is the only significant water body on the northern fringe of the city of Jaipur. The Lake area includes the dam on the east side, a road leading to Amber on the west side, and a colony Hazrat Ali Nagar on the south, and Kanak Vrindavan valley with temple complex and a reserve forest on the north side.

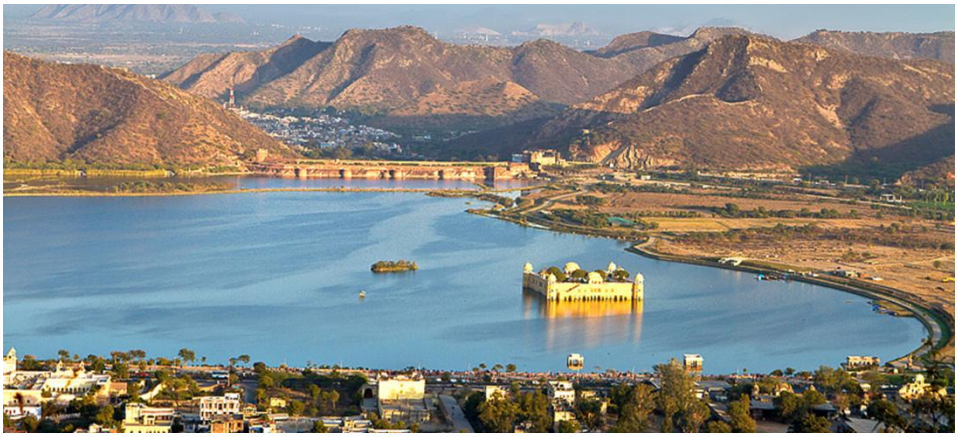


***Figure 1*: Mansagar Lake Bird Eye View** ***Source: Abhay Kumar Photography***

## 1.2 AIM

To enhance the lake ecology through landscape design strategies, to prevents its further deterioration and establish a harmonious relationship between humans and nature.

## 1.3 OBJECTIVE

- To restore lake ecology which has been deteriorated due to anthropogenic activities and make it more aesthetically pleasing and functional.
- To create a functional public open space, fits within its cultural and historical aspects with social amenities.
- To mitigate visual discomfort by introducing substantial vegetation to overcome glare caused by excessive hard landscape.

## 1.4 APPROACH

The idea is to enhance the Lake Ecology and establish a harmonious relationship between humans and nature which can be achieved by two approaches:

**Expert Approach** - The expert approach is particularly powerful in environmental management applications.

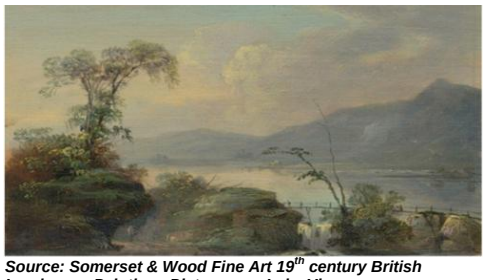
**User Approach** - The user approach is based on user perception.

Both approaches accept that landscape quality originates from the interaction between the landscapes's biological and the observer's perceptual process. The difference between the two approaches is the mutual dominancy of expert and user. It is observed that the first two

approaches should be applied in parallel because it allows analysis and investigation in landscape planning and design. (Erdönmez and Kaptanoğlu, 2007)

## 1.5 NEED OF STUDY

Mansagar Lake is an element of the city which holds significant cultural and historical values. However, post its revival from deterioration, neither its ecosystem could be regained nor the associations which the users earlier had with it. To understand the pertinent threats to its existence, it is important to first establish how the people see it and what are the values associated with it that could make it desirable for the end users and hence ensure its longevity. Moreover, it is equally important to delve into the intricacies of the ecological aspects of the lake and strive towards rejuvenating the lake ecosystem and make it a dynamic part of the urban fabric of the city.



***Source: Somerset & Wood Fine Art 19th century British Landscape Paintings Picturesque Lake View***

***Source: Hudson River School***

# CHAPTER 2: LITERATURE STUDY

## 2.1 LAKE AS A RESOURCE

Since the relic, urban lakes and wetlands have been made to store water and guarantee supply of household utilize and for farming. Indeed generally little and shallow, water bodies essentially made strides the quality of life in urban zones since they have an inborn stylish and recreational esteem and can contribute to moderate the urban climate.

***Source: Scottish painter - lake landscape in front of***

Lakes, which also form the larger aquatic system such as rivers and wetlands, are one form of freshwater supplies. Lakes are highly valued for:-

- Ecology and Bio-diversity,
- Aesthetic and Scenic qualities,
- Recreational,
- Water, one of the most treasured of our natural resources.

***Source: Akagera National Park, Rawada***

Accordingly, humans throughout history have been building artificial lakes (also called reservoirs, impoundments, dams or tanks), in addition to the natural

***Source: Claude Lorrain paintings.***

***Source: Florida artist, Justin Gaffney***

lakes, for various purposes such as water supply, hydropower generation, fishing, irrigation, recreation, etc.

Lakes constitute critical environments and nourishment assets for oceanic life, and natural life, but lake environments are delicate. Lake environments can experience quick natural changes, frequently driving to noteworthy decays in their tasteful, recreational, and oceanic environment capacities. Uncovered to outside impacts from the climate, their watersheds, and ground water, lakes are subject to alter through time. Human exercises can advance quicken this rate.

***Figure 2*: Pictorial representation of lake as a resource**

## 2.2 LAKE AND ITS ECOSYSYTEM

Lakes are inland bodies of water that require any encourage trade with an sea. Lake circumstances are made up of the physical, chemical and characteristic properties contained insides these water bodies. Lakes may contain new or salt water (in bone-dry districts). They may be shallow or profound, lasting or transitory. Lakes of all sorts share numerous environmental and biogeochemical forms and their think about falls inside the discipline of 'limnology'. Lakes are eminent living spaces for the think about of biological system elements: intuitive among natural, chemical and physical forms is habitually either quantitatively or subjectively unmistakable from those on arrive or in discuss. Since the boundaries between water and arrive, and water and discuss are unmistakable, there's tight coupling among numerous environment components.

Although lakes contain 50.01% of all the water on the Earth's surface, they hold 498% of the liquid surface freshwater. Numerous life forms depend on freshwater for survival, and people habitually depend on lakes for an extraordinary numerous 'goods and services' such as drinking water, squander evacuation, fisheries, rural water system, mechanical action, and entertainment. For these reasons lakes are critical biological systems.

A lake environment incorporates biotic (living) plants, creatures and micro-organisms, as well as abiotic (nonliving) physical and chemical intelligent. Lake environments are impacted by their watersheds, the geographical, chemical and organic forms that happen on the arrive and streams that lie tough. The development of chemicals, silt, debris, and of numerous life forms, is ordinarily unidirectional from the watershed to the lake, but angle may move upstream, and sea-going creepy crawlies may rise and scatter on to arrive. A lake and its watershed are frequently considered to be a single biological system (Compares, 1985).

*Source: Georgia Department of Natural Resources*

***Figure 3*: Lake and its Ecosystem**

## 2.3 CLASSIFICATION OF LAKE

Every lake is characterized by
a) Its basin, which is the depression holding the water
b) Its maximum depth of water
c) Its volume of water
d) Its surface area
e) Rate of Inflow and outflow of water
f) Quality of water
g) Total dissolved load of nutrients and sediments
h) Biotic species and their density.
Classification helps us to understand, to communicate and visualize the relationships. The simplest classification is based on the dimension of a lake, whether a lake is small, big or very large.

Lake are classified on the basis of -

- Origin
- Trophic Level
- Mixing of Water

### 2.3.1 ORIGIN

In geological terms lakes are ephemeral. They begin as a product of topographical shapes and conclusion as a result of the mishap of the ponding component, by dissemination caused by changes inside the hydrological alter, or by in filling caused by sedimentation. Types of lake depending on its origin are:

**Glacial Lakes -** Lakes on or in ice, ponded by ice or happening in ice-scraped shake bowls.

**Tectonic Lake -** Lakes formed in rift valleys by earth faulting, folding or tilting.

**Fluvial Lake -** Lakes created by river meanders in flood plains.

**Shoreline Lake -** Lakes cut off from the sea by the creation of spits caused by sediment accretion due to long-shore sediment movement.

**Volcanic Lake -** Lakes occurring in craters and which include dammed lakes resulting from volcanic activity.

**Solution Lake -** Lakes occurring in cavities made by permeating water in water-soluble rocks such as limestone, gypsum or shake salt.

**Meteorite Lake -** These are crater lakes, created by catastrophic extraterrestrial impacts by meteorites or asteroids.

**Anthropogenic Lake -** These are artificially made lakes shaped by human movement like damming of waterways and streams or filling of forsake unearthing by either ground water, precipitation, or a combination of both.

### 2.3.2 TROPHIC LEVELS

This classification is based on the productivity of the lakes or some might say on the relative nutrient richness of the lake. The richness in nutrient level is called as Productivity. It is the basis for the trophic concept of classification. The lake water is also reflected in this parameter as nutrient poor means super clear water in lakes and nutrient rich means very poor water clarity in lakes.

There are four Water Chemistry Parameters used to Determine Trophic State are:
**Chrophyll** - Is the dominant green pigment found in most algae. Chlorophyll empowers green growth to utilize daylight to form nourishment.

**Phosphorus** - Is a nutrient necessary for the growth of algae and aquatic plants.

**Nitrogen** - Is additionally a supplement fundamental for the development of green growth and sea-going plants.

**Water Clarity** - Refers to the clearness or transparency of water.

In this Lakes are classified as:-

**Oligotrophic Lake –**

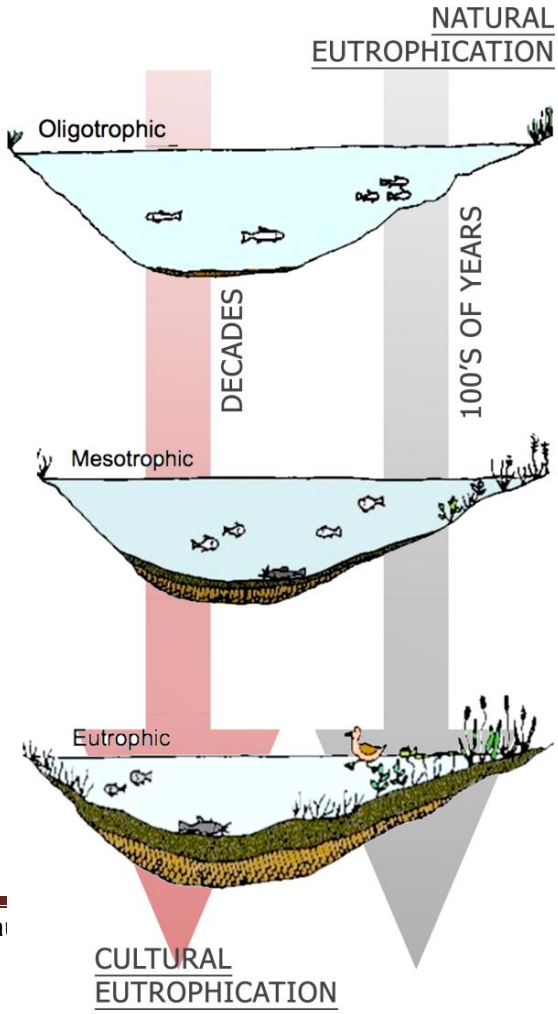
- Steep shoreline and bottom gradient
- Low nutrient enrichment
- Little planktonic growth
- Few aquatic plants
- Sand or rock along most of shoreline
- Coldwater fishery
- High dissolved oxygen content

**Mesotrophic Lake –**

- Moderate nutrient enrichment
- Moderate planktonic growth
- Some sediment accumulation over most of Lake Bottom
- Usually supports warm water fish species.

**Eutrophic Lake –**

- High nutrient enrichment
- Much planktonic growth (high productivity)




*Source: Vermont Lay Monitoring Program Manual*

***Figure 4*: Natural and Cultural Eutrophication**

- Extensive aquatic plant beds
- Much sediment accumulation on bottom
- Low dissolved oxygen on bottom

### 2.3.3 MIXING OF WATER

This classification is based on the extent to which the water is mixed and the number of times during the year. It is also based on water circulation pattern in a year. This is commonly referred to as "Turn-over cycle of the lake".

The circulation or blending is as a rule wind driven and is encouraged when the lake contains a uniform (or close uniform) temperature from best to bottom.

Lakes don't always behave in a consistent pattern. Since mixing could be a work of temperature and wind, we have expansive yearly varieties that direct when and in the event that the water of a lake blends.

**Amixis** - These lakes are usually ice covered throughout the year thus show lack of mixing**.**

**Holomixis** - These show full mixing. In this winds mix the "whole" lake water once or more annually.

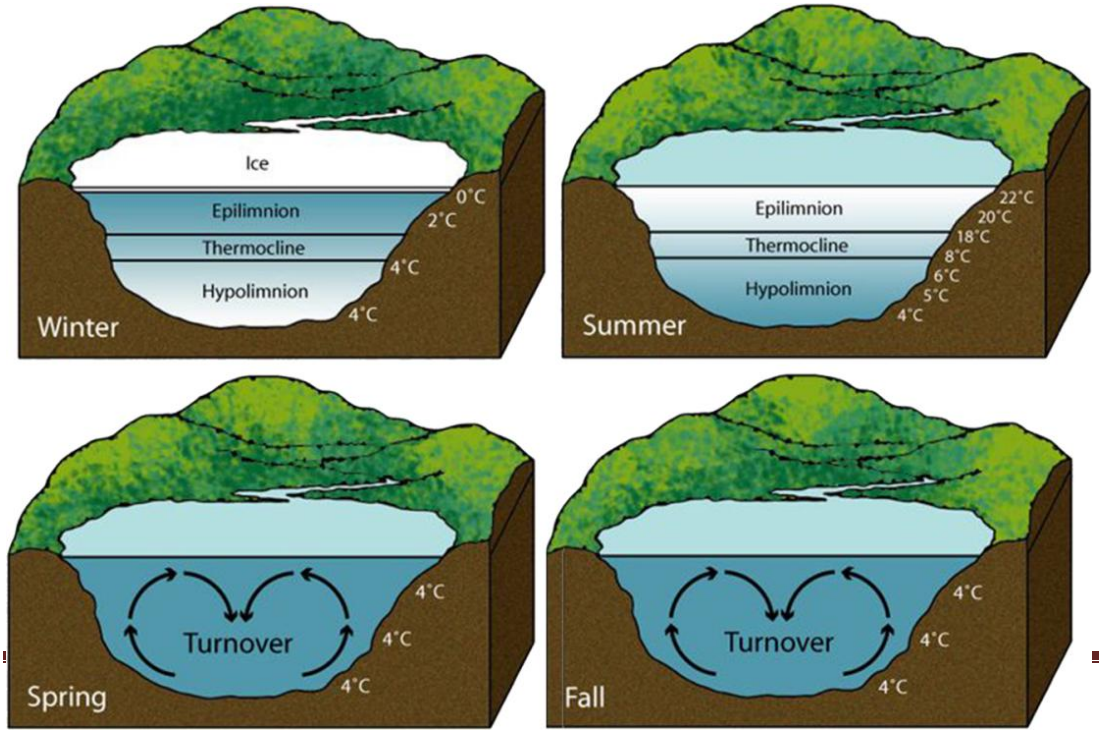
**Oligomictic** - In these lakes mixing is unusual, irregular and of short duration.

**Monomictic** - These lakes have one regular period of mixing during the year.

**Dimictic** - These lakes show mixing twice a year, both in the spring and in the fall.

**Meromixis** - These show partial or incomplete mixing.

**Polymictic** - These lakes have many periods of mixing annually.




*Source: http://cwlview.blogspot.in/2015/10/the-lake-has-turned-over.html*

***Figure 5*: Turn-over cycle of lake**

## 2.2 LAKE ECOSYSTEM COMPONENTS AND CONSTITUENTS

### Lake Catchment/Watershed

The watershed/catchment of lake is the area from where lake gets its water through run off. A healthy lake depends on healthy watershed. Logging, farming, urban development occurring in a watershed affect lake's water quality.

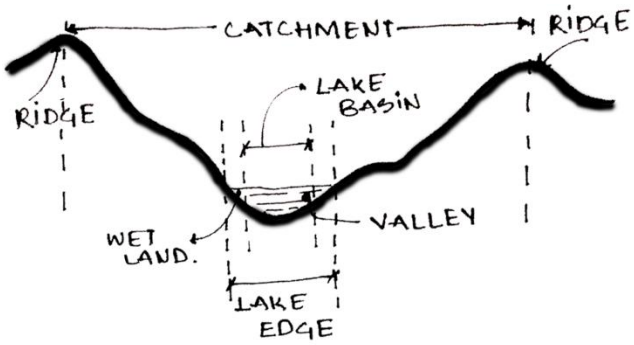



***Figure 6*: Lake and its components**

### Lake Basin

The basin of the lake receives the water from the catchments and temporary store them, as there is further precipitation.

### Lake Edge

The edge of the lake buffers the land and water edges. The edge is naturally characterized by the terraces and also by typical vegetation.

The constituents of Lake Ecosystem are:

**Water** - The amount of water entering a lake is maintained by Precipitation, Percolation, Evaporation, and Inflow & Outflow.

**Sediments** - The main cause for shrinkage of the lake area is due to silt deposited by water coming from the catchment area.

**Nutrients** - The water coming from catchment to lake carries nutrients, along with sediments in the form of ions and salts dissolved in water. The main nutrients are nitrogen & phosphorous.

**Organisms** - Organisms balances food cycle by certain processes such as competition, mutualism or predation.

## 2.3 THREATS TO LAKE ECOLOGY

Urban lakes are very often man-made ecosystems. They have small direct catchment and much of the water feeding these lakes is drained from relatively large metropolitan, paved watersheds through storm water channels and pipelines.

| THREATS/ISSUES | BACKGROUND INFORMATION |
|---|---|
| Algal Boom | Algal blooms create when excess phosphorus compounds and other nutrients enter water frameworks. Not all algal blooms are destructive to the environment; in any case, both Cladophora and blue-green growth debilitate the lake and affect quality of life in neighbourhood communities. |
| Constructed Shoreline | Natural shoreline vegetation encompasses a coordinate influence on the biological astuteness of a lake, because it gives shade, leaf litter, woody flotsam and jetsam, and security from erosion, and littoral territory. Shoreline development by humans, lead to loss of littoral habitats for species such as submerged macrophytes and of littoral reed beds, both vital for the functioning of lakes. |
| Invasive Species | Non-native species enter the Lakes through arrive, discuss and water. Non-native species, a few of which are destructive to neighborhood biological systems. These obtrusive species influence propensities and fisheries, spread illness, and compete with local species for nourishment. |
| Urban Sprawl | The greater our cities ended up, the more space they take up and this impacts the characteristic environment, which influences the quality of water. Urban sprawl moreover leads to expanded territory misfortune, and debilitates natural life. |
| Climate Change | Temperature is changing around the world, caused in portion by nursery gas outflows. These changes can influence water levels and irritate existing environments. Climate alter contributes to other natural issues, such as algal blossom, extraordinary climate conditions. |
| Eutrophication | Eutrophication could be a lake's maturing handle. Silt, disintegration and the development and decay of sea-going plants in the long run fill up the lake foot. Over time, the lake is changed over to a wetland (e.g., a marsh or bog) and afterward, dry arrive. This prepare ordinarily takes tens of thousands of a long time, but human exercises quicken it. |
| Sedimentation/ Turbidity | Increments in collection and suspension of silt can be a disservice to water quality and living space for numerous oceanic species. Such occasions as a rule are caused by overwhelming downpours that deliver disintegration and strongly runoff, carrying overwhelming dregs loads into lakes. |

***Table 1*: Base information and issues faced.**

**Algal bloom and degraded water quality of a lake affected by nutrient enrichment**
***Source: USGS publication Warehouse***

**Invasive aquatic plant species in lake**
***Source: Bob Gibbons Photography***

**Natural Shoreline of a lake**
***Source: Spence Restoration Nursery***

**Eutrophication of Hungabee Lake, Canada**
***Source: Trustedclothes.com***

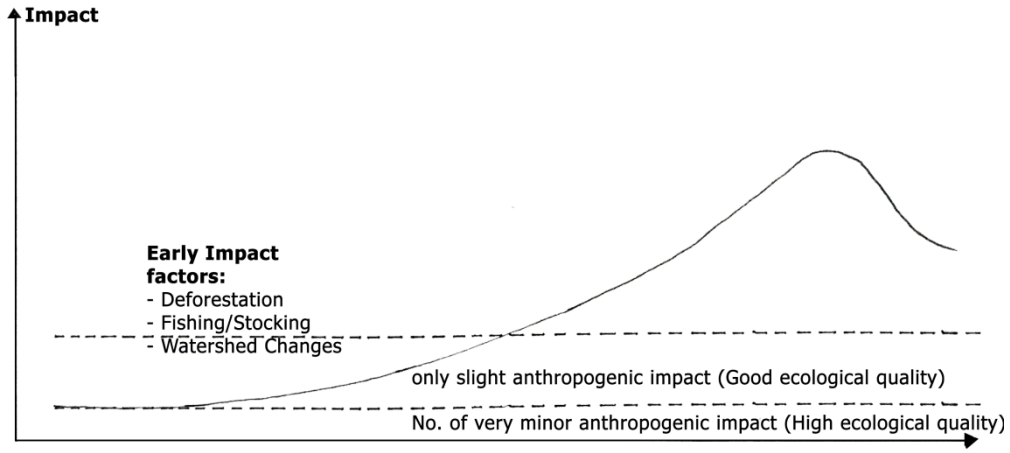



***Figure 7*: Graph of Impact on Lake vs. Anthropogenic activities**

**Generalized scheme showing the historical development of main human impact factors on freshwater ecosystems in industrialized countries and how this has affected the ecological quality.**

# CHAPTER 3: SITE INTRODUCTION

Jaipur the capital of Rajasthan state in India was founded in 1727 by Maharaja Jai Singh II, who ruled Jaipur State from 1699–1744. Initially his capital was Amber, which lies at a distance of 11 km from Jaipur. He felt the need of shifting his capital city with the increase in population and growing scarcity of water. Jaipur is the first planned city of India and the King took great interest while designing this city of victory.

**JAIPUR TIMELINE**

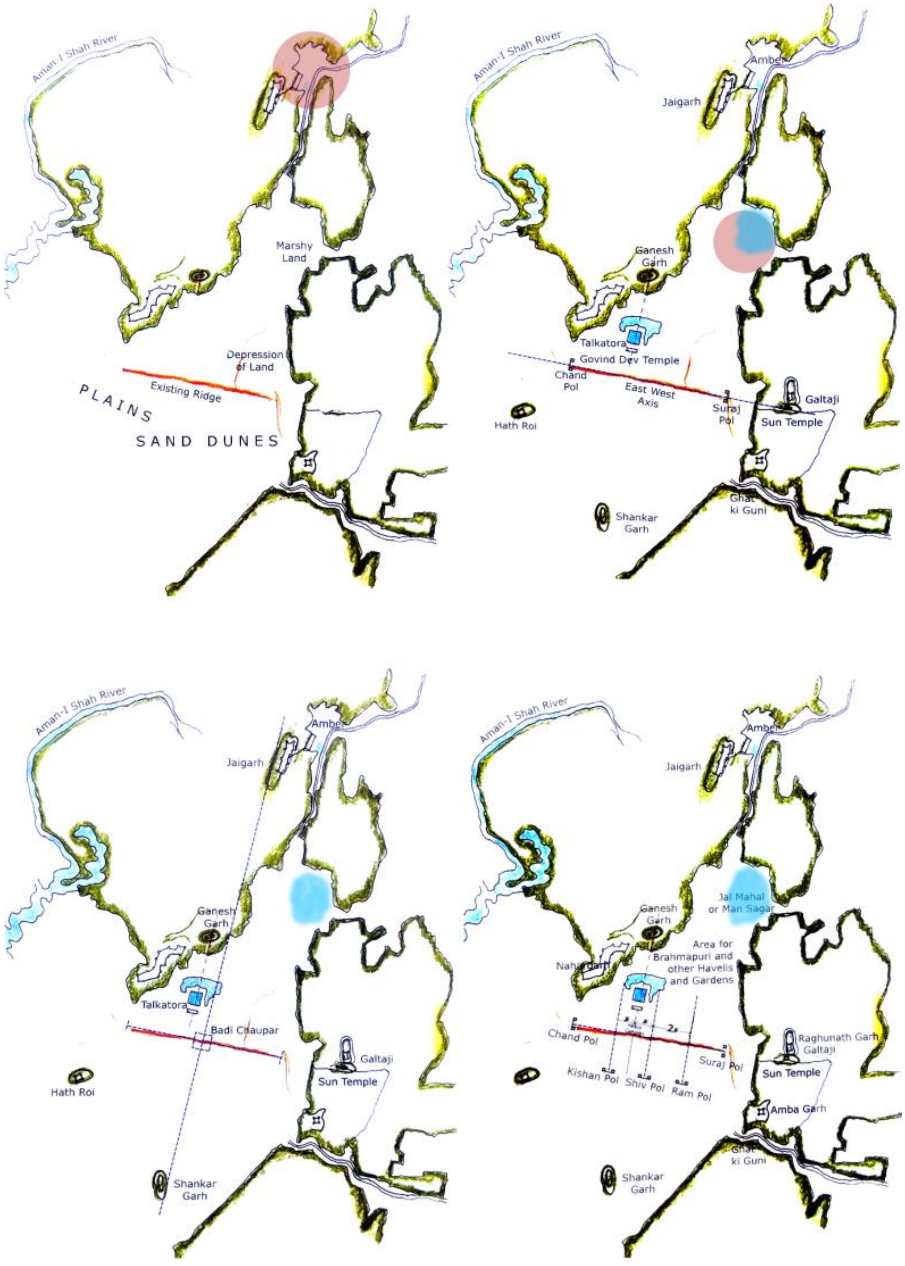



***Figure 8*: Graphical representation of Jaipur city evolution.** ***Source: Princely Terrain Book by Shikha Jain***

## 3.1 MANSAGAR LAKE

During 1596 AD, a severe famine in this region was linked to an acute shortage of water. The then ruler of Amer was, therefore, motivated to build a dam to store water to overcome the severe hardships caused by the famine to the inhabitants. A dam was constructed, initially using earth and quartzite, across the eastern valley between Amer hills and Amargarh hills. The dam was later converted into a stone masonry structure in the 17th century. Stored water is used for irrigation of agricultural land in the downstream area. After this lake all the forts named Jaigarh Fort, Nahargarh Fort, Khilangarh Fort, and Kanak Vrindavan Valley were also built in the vicinity.

The lake, situated to the north of Jaipur city lies between Amer, the historic city and Jaipur is the only significant water body on the northern fringe of the city of Jaipur. The Lake area includes the dam on the east side, a road leading to Amber on the west side, and a colony Hazrat Ali Nagar on the south, and Kanak Vrindavan valley with temple complex and a reserve forest on the north side.


***Figure 9*: Google Earth Image of Mansagar Lake** *Source: Google Earth*

The Lake is flanked by hills on three sides, Nahargarh Hills (western side of the lake), Amer Hills (Northern side of the lake) and Amargarh Hills (Eastern Side of the lake). Hills on three sides set picturesque for Mansagar Lake. Because of this picturesque landscape a palace was built in the middle of the lake, which was also a leisure place of the royal family for fishing, hunting.


***Figure 10*: Panoramic view of Mansagar Lake from Kanak Vrindavan** *Source: Abhay Kumar Photography*

The lake had a water surface area of about 139 ha (in 1970s) and presently lake it has a water spread area of 300 acres (121 ha). The lake is approximately 130 hectares in its full spread with a maximum depth (>7m) at the dam's outflow point. It is at its maximum spread just after the monsoon and then gradually shrinks to its least spread just before the monsoon. The average depth of the lake varies from 1.5 to 4.5 m.

Lake has a catchment of 23.5sq.km., about 60% of which falls inside the dense urban area is presently the major source of water (about 90%) in the lake in the form of storm water runoff during rainy season while sewage in the dry weather. The remaining 40% watershed falls in the forested hills.



***Figure 11*: Lake Catchment Area**


### 3.1.1 TEMPERATURE & RAINFALL

The Indian Meteorological Department (IMD) data for the last 20 years provides the following information.

December to February - Cold Season,
March to June - Hot Season commences with Dry Climate,
July to Mid-September - Monsoon Season

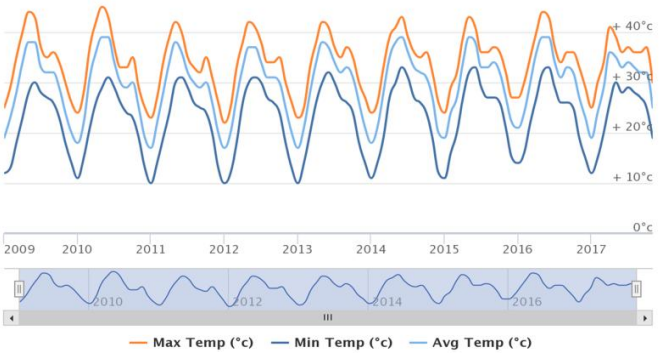



***Figure 12*: Temperature Graph** *Source: Worldweatheronline.com*

Temperature for the period from March to June is continuously on the rise, May and the first half of June being the hottest parts of the year. The mean daily maximum and minimum temperature in June is 40.6 Degree Celsius and 25.8 Degree Celsius respectively.

Average Annual Rainfall in Jaipur is 657.4 mm which is based on rainfall data for the last 30 years available at IMD, Jaipur. The rainfall during June to September constitutes nearly 90% of the annual rainfall. The variation of the annual rainfall from year-to-year is very large.

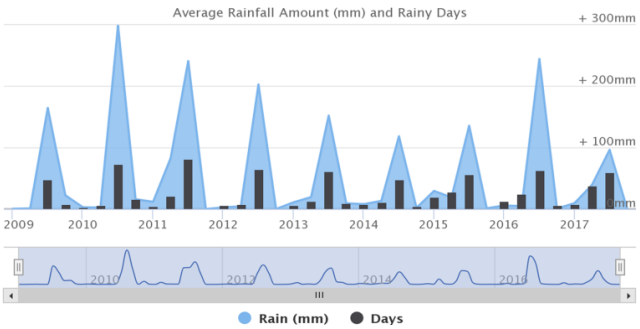



***Figure 13*: Rainfall Graph** *Source: Worldweatheronline.com*

### 3.1.2 GEOLOGY AND SOIL

Geology of the region is a result of folds of sedimentary rocks which forms anticline and synclines in the series where anticline is visible in the form of Aravalli hills. The hills surrounding the lake area, towards the north east of Jaipur, have quartzite rock formations (with a thin layer of soil cover), which is part of Aravalli hills range.

Order of the soil found in the region is Alfisol - Hapulstalf. This type of soil has relatively high native fertility and coarse testure. 'Alf' refers to aluminium (Al) and iron (Fe).because of their productivity and abundance, the Alfisols represents one of the most important soil orders for food and fiber production.

The depth of soil on the hills is less and at steep slope is prone to high erosion, the ground area is made up of a thick mantle of soil, blown sand and alluvium.

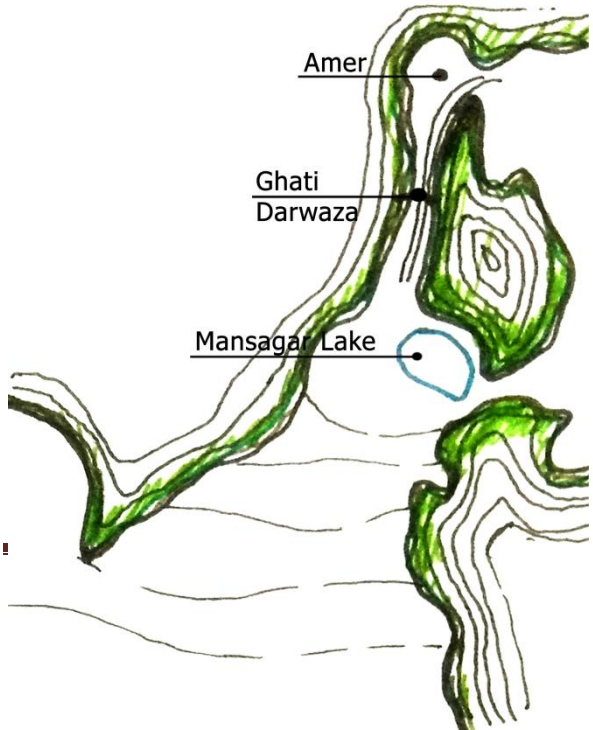
### 3.1.3 HYDROLOGY

The fresh water draining into the lake is seasonal during the rainy months of July to September. This flow originates from 325 small and large streams that drain from the hilly catchment of the lake. The two municipal nalas from Jaipur city contribute a perennial flow to the lake.

| | |
|---|---|
| Max. Vol. of water | 3,130,000 cum (Rainy Season) |
| Min. Vol. of water | 360,000 cum(Dry Season) |

The depth of water at the deepest location in the lake is recorded at a maximum of 4.5 meters (15 ft.) and a minimum of 1.5 meters (4.9 ft.). In addition, the stored water is also used for irrigation at the downstream end of the lake during the summer months resulting in a drying up of the lake during these months. The localized ground water table is high and exploratory bores show that it is merged with the surface water.

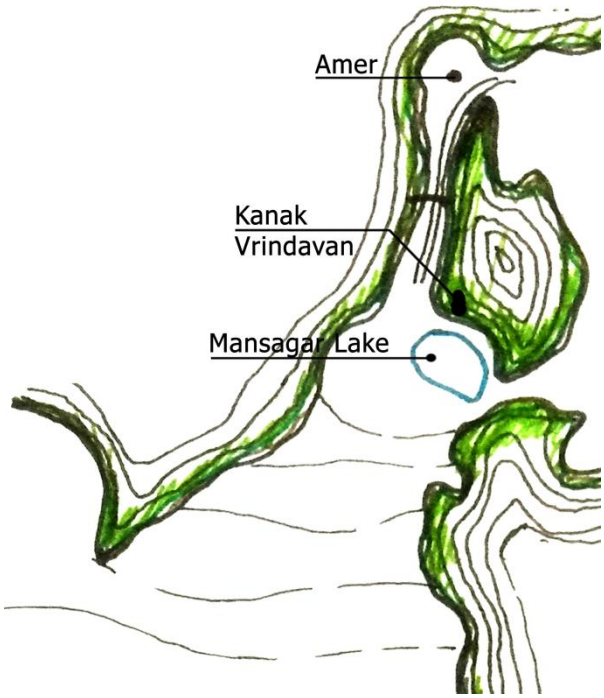
**ORIGIN**




## 3.2 MANSAGAR LAKE TIMELINE

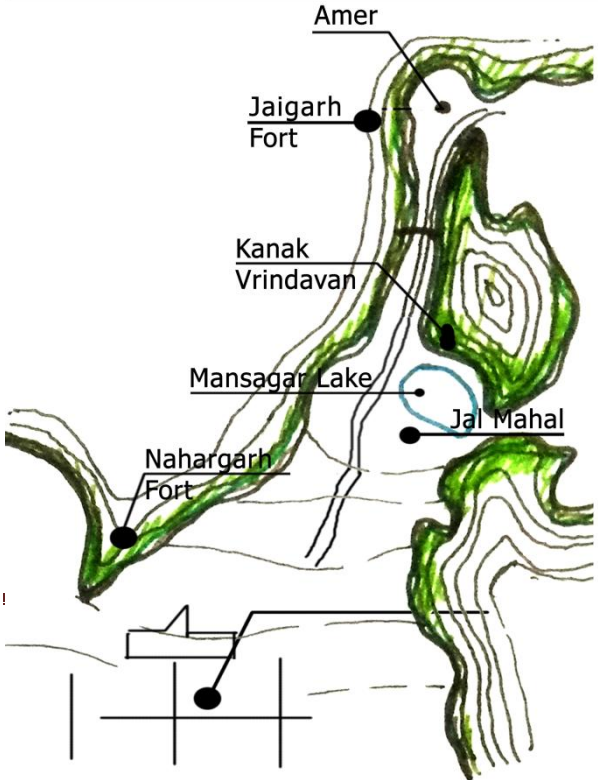
Raja Man Singh, the then ruler of Amer, constructed it in 1610 by damming the Dharbawati river after experiencing the sever famine in the region during 1596. To access this lake, one had to leave Amer city by south gat, called the Ghati Darwaza.

## TILL 1710



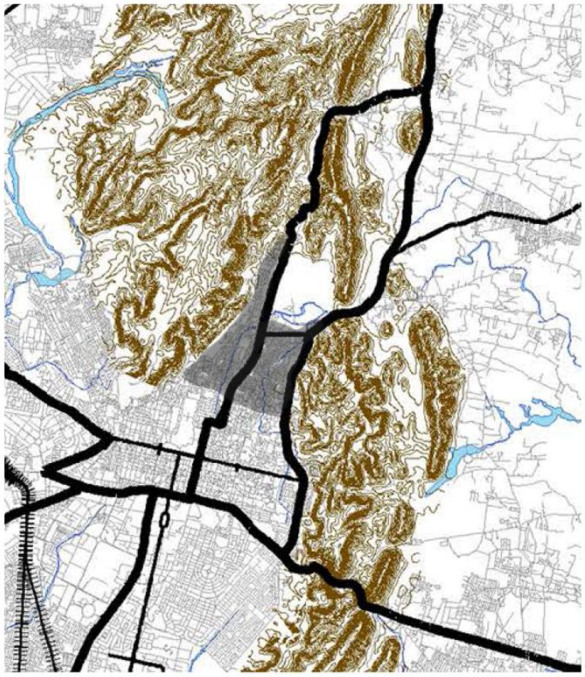

At the foot of the descent, near the marshy region Mughal gardens called Ghati Bagh were created adjacent to the Kanak Vrindavan temple, around 1707-1710. This was an important spot in the low lying area, at 414 meters.

## 1711 - 1750




This is the major era in which major changes were taken places in Lake Precinct. The Jai Singh II, The then ruler of Amer, proposed new capital named Jaipur which is directly linked with Amer. Because city of Amer was built on hilly terrain which was getting congested and physical constraints did not allow for further expansion of the city. He also constructed Talkatora water body in new capital and forts like Jaigarh fort(1726) and Nahargarh(1734) fort for capturing the scenic view of Aravalli dunes. The Jal Mahal was also constructed by Jai Singh II in 1734.

1750 - 2017

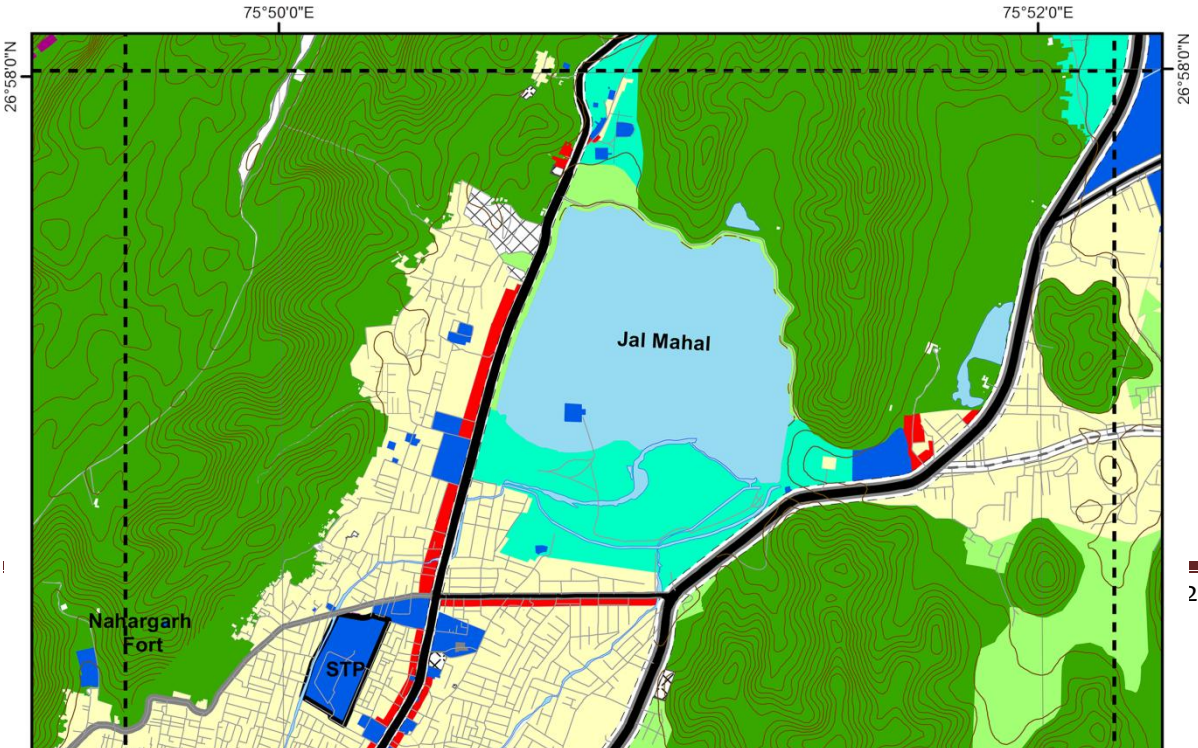


The lake glory as a pristine water body lasted until the former rulers had their control over the city and its surroundings having thick forest cover and a very thin human settlement.

The unpleasant history of the lake began when administration of Jaipur diverted walled city sewage in 1962 through two main wastewater drains namely Brahampuri and Nagtalai. The most notorious aquatic weed water-hyacinth (Eichhornia crassipes) entered in the lake in 1975.

This lake suffered maximum when unprecedented down pour for 2 days in August 1981 deposited enormous amount of sand and silt through two drains.

**LANDUSE PLAN OF MANSAGAR LAKE AREA**



***Source: Jaipur Development Authority***

***Figure 14*: Landuse plan of Mansagar lake area**

## 3.5 PROPOSED PROJECT - JAL MAHAL TOURISM

The Jal Mahal Project Area falls in the Jaipur – Amer tourist corridor and is the only major water body in Jaipur. The project location is in the close vicinity of key tourist attraction viz. Amer, Jaigarh and Nahargarh Forts and walled city of Jaipur. Almost every tourist, visiting Jaipur passes through this area. Private sector developers were invited during 2003 to develop identified tourism components on the land adjoining the lake. The tourism project on 100 acres of reclaimed land on the south of Mansagar Lake includes:-

- Convention Centre and Art Gallery
- Multiplex and Entertainment Centre
- Craft Bazaar
- Arts and Craft Village
- Resort Hotels
- Restaurants and Food Court
- Public Park and gardens

The project will set a benchmark in sustainable development of the urban water bodies with private sector participation.

## 3.4 MANSAGAR LAKE SIGNIFICANCE

### Ecological Value

Lakes ecology helps in maintaining the micro climate balance and bio-diversity of the surrounding area. Mansagar Lake supports rich bio-diversity in terms of flora and fauna and it attracts more than 150 species of migratory birds throughout the year, which enhances the ecological value of Mansagar Lake.

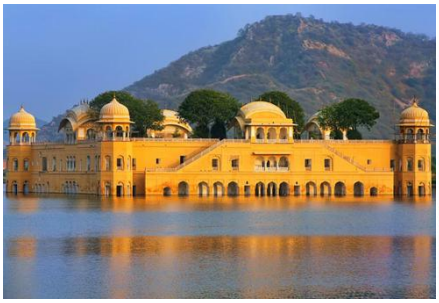


**Lake serves as a habitat to numerous migratory and resident birds along with a variety of native aquatic vegetation.**

***Figure 15*: Mansagar Lake Ecology Images**

### Historical Value

Mansagar Lake constructed even before Jaipur city formation. It played a very important role in origin of the city. The lake act as a bridge between ancient Amer town and Jaipur walled city. Because of lake many historic buildings like temple and places were built in the lake precinct by the late rulers of Amer.



**Presence of Jal Mahal connects lake to history of Jaipur rulers and architecture.**

**View of Jal Mahal form Kanak Vrindavan temple complex**

**Bird eye view of Jal Mahal from Nahargarh Fort.**

***Figure 16*: Historical value of Mansagar Lake**

### Economic Value – Tourism

Jaipur is fall on the famous golden triangle (Delhi-Agra-Jaipur). The Amer road along which Mansagar Lake is situated is the major tourism strip of Jaipur city. Every tourist which comes to Jaipur has to go through this road because it leads to ancient town Amer and Delhi.


***Figure 17*: Tourism at Mansagar lake**
**The Lake is a much desired and frequented spot by Indian as well as foreign tourists, various stalls are arranged along Lake Promenade for tourists.**

## Socio-Cultural Value

Mansagar Lake is the biggest water body in Jaipur region and various socio economic values are dependent on the lake. Employment of local around the lake area due to tourism, like selling traditional goods, eateries and handicrafts which helps locals in generation money. Lake water is also used for irrigation in downstream area of Mansagar Lake.

***Figure 18*: Socio-Cultural Activities at Mansagar Lake**
**Lake Promenade act as interactive public space as well as used for various public gathering for festivals, small fairs and for cultural significance. Promenade place for the native people to associate with their socio-cultural roots.**

## Aesthetic Value

Since the Mansagar lake is covered by hills on three side and by urban fabric on the forth, these hills and lake forms a picturesque landscape scene which is visually appealing. The Jal Mahal palace which is built in the Mansagar Lake for capturing the mesmerizing view of lake and hills in the backdrop by Royal families added visual value to it.

***Figure 19*: View of Jal Mahal and background hills**

## 3.5 LAKE CONDITION TILL 2002

The Lake glory as a pristine water body lasted until the former rulers had their control over the city and its surroundings having thick forest cover and a very thin human settlement of cowmen and farmers.

The unpleasant history of the lake began shortly after independence, when new administration of Jaipur diverted walled city sewage in 1962 through two main wastewater drains namely Brahampuri and Nagtalai.

The most notorious aquatic weed water-hyacinth (Eichhornia crassipes) entered in the lake in 1975. It suppressed algal growth markedly disturbing lake trophic structure and also accelerated siltation by adding dead organic matter that catalysed water quality deterioration leading to mass fish mortality (Sharma et al. 1978, Goel 1980, Trivedy 1980). This lake suffered maximum when unprecedented down pour for 2 days in August 1981 deposited enormous amount of sand and silt through two drains.

***Figure 22*: Dry Mansagar Lake**

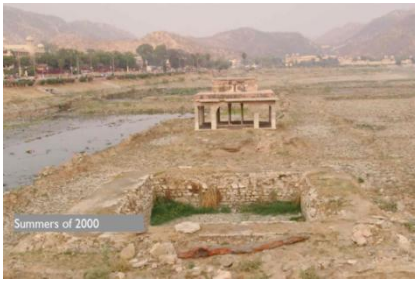



***Figure 21*: Lake Condition in summer**

**Figure 20 : Low water level in lake**


**Google earth image of year 1995 shows lake natural edge with two main drains outlet directly to the lake without any prior treatment.**

The Government of India approved the National Lake Conservation Plan in May, 2001 with the objective to restore and conserve the polluted and degraded urban lakes.

Mansagar Lake popularly known as Jal Mahal is one such important lake which comes under this plan. For this New Delhi supported lake restoration program to Jaipur Development Authority (JDA), Jaipur. Government of India under its National Lake Conservation Plan has undertaken Ecological Restoration of Mansagar Lake in December, 2002. With a view to manage the lake sustainably on a long-term basis, various potential project components have been integrated into a comprehensive development plan. Various activities that have been approved and implemented under it are:

- Realignment of Drains
- Desilting of Lake

- Settling Tank near Amer Road
- STP & Wetland construction
- Insitu Bioremediation
- Analysis of Water Quality and sediment
- Afforestation of the Lake
- Lake Front Promenade
- Nesting Island

**An artificially created island to rejuvenate ecosystem in the lake.**


**Google earth image of year 2017 shows the constructed lake edge, due to which lake loses its littoral edge and outlet of drains is not directly connected to lake.**

## 3.6 MANSAGAR LAKE BIOLOGY

### Plankton

Plankton (singular plankter) are the diverse collection of organisms that live in large bodies of water and are unable to swim against a current. They provide a crucial source of food to many large aquatic organisms, such as fish and whales.

### Phytoplankton

Phytoplanktons were the other primary producers found through out the year in the lake. 16 algal species were observed in the lake belonging to:

Cyanophyceae 4 species (45.1%-79.3%) Feb. - July
Bacillariophyceae 4 species (41.7%-79.3%) Aug. - Jan.
Chlorophyceae 8 species (1.2%-8.9%)
Cyanophyceae - Microcystis(D), Spirulina(D), Merismopedia, Gomphosphaeria
Bacillariophyceae - Cyclotella(D), Navicula(D), Nitzschia
Chlorophyceae - Chlorella(D), Ankistrodesmu(D), Coelastrum, Ankistrodesmus, Chlorococcum

### Zooplankton

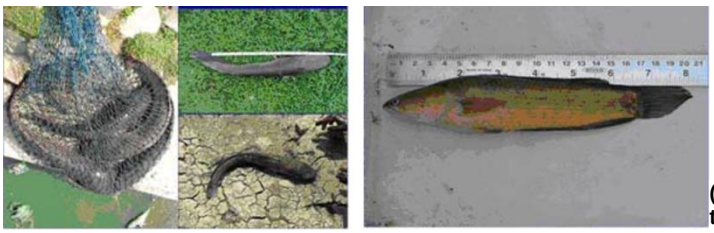
Ten zooplankton species were found in the lake. Moina, Euglena and Paramecium were dominant during warmer period (April-October), more particularly in the rainy season (July-September) whereas Daphnia and Mesocyclops in the winter, both being more abundant in the check dam in 2005. However, diversion of sewage drains in 2006 has led to build up of their higher populations even in the lake. Brachionus, Philodina and Vorticella species were found only in the check dam.

### Arthropods

Nine species of insects were found in lake, water boatman (Corixa species), Backswimmer (Notonecta galuca), creeping water bug (Naucoridae), Dragon fly and Damsel fly were dominant in the rainy and post-rainy season. Chironomus larvae occurring as plankton in the rainy season were however, the most dominant benthos during winter. Tubifex species was found only in check dam sediment.

### Fish

Clarius batrachus, commonly known as African tiger/Mangur is commonly present in Mansagar Lake. It is an African species about 0.5 feet long. It is banned in India this fish devours other small fishes and even birds. In the absence of predator it multiplies immensely thus posing a problem for resident species of birds. Besides Mangur, lake also had Channa gachua surviving in a relatively less polluted habitat.



**(From Left) Mangur fish (African tiger) capture from the lake. Asiatic snake head fish from the lake.**

## FLORA OF THE LAKE REGION

The flora is dictated by the subsidiary Edaphic type of dry tropical forests in the catchment; the total forest area of 9.01 square kilometers (3.48 sq. mi) comprises dense forest cover of 6.45 square kilometers (2.49 sq. mi) area, degraded forest of 0.95 square kilometers (0.37 sq. mi) and encroachment of 1.61 square kilometers (0.62 sq. mi). The dominant floral species found in the area is Dhauk (Anogeissus pendula), which has lean foliage. The low vegetation cover and steep gradient of the hills causes substantial erosion and the eroded material flows into the lake.

List of flora in the region:

| TREES | SHRUBS | SMALL SHRUBS |
|---|---|---|
| Boswellia serrata | Abutilon indicum | Cassia auriculata |
| Crateav nurvala | Acacia farnesiana | Cassia Occidentalis |
| Euphorbia nerifolia | Acacia jacquemontil | Desmodium gengeticum |
| Holoptelea integrifolia | Calotropis procera | Malvastrum |
| Mallotus phillippensis | Capparis sepiaria | Coromandelianum |
| Terminalia bellerica | Capparis zeylanica | Pavonnia zeylancia |
| Anogeissus pendula | Clerodendron phlomidis | Pupalia lappacea |
| Commiphora wightii | Dichrostachys cinerea | Sida cordifoli |
| Lannea coromandelica | Ficus palmate | Sida ovate |
| Wrightia tinctoria | Kirganelia reticulata | Triumfetta pentendra |
| Dichrostachya cinerea | Lantana camara | Triumfetta rotundifolia |

| | | |
|---|---|---|
| Butea monosperma | Mimosa hamata | Urena lobata |
| Tecoma undulata | Opuntia elatior | Xanthium strumarium |
| Colebrookea Oppositifolia | Laptadenia pyrotechnica | |
| Dendrocalamus strictus | Solanum incanum | |
| Mitragyan parviflora | Ziziphus nummularia | |

***Table 2*: Existing Flora of Mansagar Lake**


Commiphora wightii


Anogeissus pendula


Mallotus phillippensis


Tecoma undulata


Prosopis flexuosa


Butea monosperma


Dendrocalamus strictus


Boswellia serrata

| | |
|---|---|
| Indian Fox | Vulpes bengalensis |
| Indian wild boar | Sus scrofa cristatus |
| Hanuman Langur | Semnopithecus entellus |
| Black-naped Hare | Lepus nigricollos |
| Indian Procupines | Hystrix indica |
| Blue bull | Boselaphus tragocamelus |
| Sambar | Cervus unicolor |
| Common Mangoose | Herpestes edwardsii |
| Jackal | Canis aureus |
| Striped Hyaena | Hyaena hyaena |
| Leopard | Panthera pardus |

***Table 3*: Spotted Wildlife species and their scientific name.**


**BIRDS**

The lake used to be a bird watcher's paradise in the past and was a favorite ground for the Rajput kings of Jaipur for royal duck shooting parties during picnics. he lake was natural habitat for more than 150 species of local and migratory birds that included large flamingo, great crested grebe, pintail, Pochards, kestrel, coot, redshank, marsh sandpiper, ruff, herring gull, red-breasted flycatcher, grey wagtail.

In order to attract attention to the lake's condition, a private initiative of holding an annual birding fair was started in 1997. It is reported that the common moorhen, a resident species has started breeding in large numbers at the lake. The other birds seen now are the grey heron, white-browed wagtail and blue-tailed bee-eaters.

## Resident - Non breeding birds at Mansagar Lake Source: 13th Bird Fair, Mansagar Lake


Shikra Juv


Rufous Treeple


Purple Swamp hen


Little Grebe


Grey Heron


Grey Heron Eating Fish


Common Hoopoe


Black Shouldered Kite


Purple Heron

## Resident - Breeding birds at Mansagar Lake Source: 13th Bird Fair, Mansagar Lake


Ashy Prinia


Black Crowned Night Heron


Black Headed Myna


Chestnut Shouldered


Common Moorhen


Cormorant


Great Egret


Greater coucal


Green Bee Eater


Purple Sunbird Male

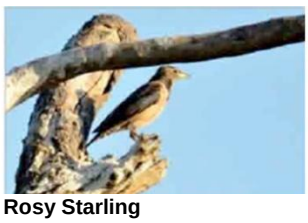

Black Headed Myna


White Throated Kingfisher

**Migratory birds at Mansagar Lake** Source: 13th Bird Fair, Mansagar Lake

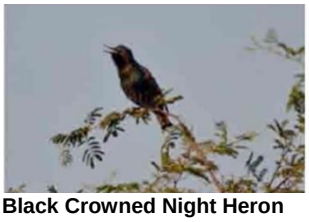

Small Pratincole


Ruff


Rosy Starling


Common Redshank


Ashy Prinia


Black Crowned Night Heron


Temminck's Stint


Chestnut Shouldered Petronia


Common Coot


Comb Duck


Tawny Pipit

## 3.7 PRESENT ECOLOGICAL STATUS OF LAKE

The lake suffers from serious problems of siltation and settled deposits, contamination from inflow of wastewater, decrease in surface area due to artificial land formation as a result of eutrophication and loss of water due to the outflow for downstream irrigation during summer. Topographical survey of edge conditions of the lake and water volume to surface spread relationship.

The lake is approximately 130 ha in its full spread. The lake is at its maximum spread just after the monsoons and shrinks gradually to its least spread just before the monsoon. It may be noted that the full tank level is at 99.0 m contour (with reference level of Amber-Delhi Road as 100.0) (See Table 4).

The lake being on the natural course of drainage of north Jaipur, receives a steadily increasing flow of partly treated and untreated wastewater. During heavy showers, the wastewater and runoff water get mixed and enter the lake through these nalas. The volume of flow from the various sources (currently) is recorded as follows:

- Nagtalai nala: 5000 cu.m /d.
- Brahampuri nala: 24000 cu.m /d.
- Inflows from across Amber road (4 inlets): 500 cu.m /d.

The Brahampuri nala carries the discharge from the city side and from the northern Sewage Treatment Plant (STP-27 million liters /day, extended aeration). The effluent of this plant has become vital to the sustenance of the lake, which would otherwise dry up in summer.

However, the plant is only partly functional due to disrepair; thus, the post-treatment parameters of the effluent are not even of secondary quality. Further, a large part of the sewage is going untreated at present and volume of discharge from the STP will increase in the subsequent years as more and more areas are covered by the sewerage system.

| PARTICULARS | WELL ON EASTERN SIDE OF LAKE | TUBE WELL AT SOUTH EDGE OF THE LAKE |
|---|---|---|
| PH | 7.3 | 7.4 |
| B.O.D. | 10 | 12 |
| C.O.D | 60 | 60 |
| Chloride | 380 | 840 |
| Sulphate | 193 | 365 |
| Phosphate | 05 | TRACE |
| Nitrite | 32 | 34 |
| Nitrate | 60 | 40 |
| Total Dissolved Solids | 1840 | 2660 |
| Coliform Organisms MPN/100 ml. | 3900 | 488800 |
| E.Coli MPN/100 ml. | 23 | 11000 |

***TABLE 4*: Results of the Ground Water Quality Tests**
**Source: PHED, Gandhinagar, Jaipur**

**Primary Surveys**

Towards ascertaining the current status of the lake, the following surveys were carried out.

**Testing Of Water Quality of Mansagar Lake:**

**Groundwater Quality**

Water samples from a tube well located at the southern edge of the project area and a well on the eastern corner of the lake were tested. While ground water in the vicinity is not potable, it is noted to be of high BOD as well as high in nitrate content.

**Lake Water Quality**

Owing to high level of pollutants in the various influent flows, the surface water quality of the lake is found to be very poor and the resultant high level of nutrients has led to the algal bloom (microphytes). This has resulted in eutrophication on southern shores. Land formation as a result of decayed plant settlement is evident near out falls of the major nalas.

The physicochemical and biological examination of water quality tests show high level of nutrients, resulting in the production of macrophytes and macrophytes and rooted weeds on the edge. High levels of BOD and COD lead to low DO level, which combined with high chloride levels leads to absence of aquatic life.

**Conclusion from Water Quality Tests**

- TDS is higher by almost five times for a diverse marine species habitat;
- BOD shows high level of organic matter;
- COD shows very high level of oxidisable chemicals;
- Nitrate content is excessive;
- Phosphate content is excessive;
- Coliform number is in excess by 500 times;
- Chloride content is very high and nearly fatal to plants and fishes; and
- The surface water quality is not uniform, being extremely poor in southeast, south and southwest owing to influent nalas.

**Hydrogeology**

The localized ground water table is high and exploratory bores show that it is merged with the surface water. The topography around the lake is sloping towards it except downstream of the dam. Slopes have marginal topsoil and scanty vegetation due to the elevated and exposed nature of the bedrock. In view of the sandy nature of the sub-soil, the permeability factor is quite high except that in practice this is countered by the saturation of the sub-strata up to impermeable bedrock consisting of hard quartzite. The withdrawal of ground water in the vicinity would have to be regulated to check percolation losses through the lakebed.

**Soil Strata Investigation & Characteristics**

The soil samples were taken from five locations in the lakebed itself for chemical test and analysis. The test results are shown in Table 6. The results of chemical analysis suggest that the nitrate and phosphate contents in the sediments are high. This adversely affects the growth of rooted plants. Further, as the sediments are polluted these interfere with growth and survival of benthic organisms. Lack of dissolved oxygen and pollution near the lakebed results in low survival of bottom feeding fish.

Two distinct layers of silt can be observed. One is about 150-200 mm thick and light coloured that comes by erosion from the surrounding catchment area in the monsoon season, and the other is 25-50 mm thick and dark coloured, which shows that the lake acts as a sedimentation bed throughout the year.

**The Lakebed Characteristics**

The lakebed has increasingly become the depository of eroded silt materials and settled pollutant material from the influent nalas. Boring on the bed of the lake at three locations, gives the information about the strata, shown in Table 7. The deposits in the lakebed consist of alternate layers of eroded silt and settled pollutants. The former is buff coloured like the hill soil whereas the latter is dark coloured. Eroded silt deposition has taken place as a result of rainfall on steep and poorly vegetated slopes and these deposits have accumulated in the northern part of the lake. The substantial level of silting has in fact decreased the water holding capacity of the lake while increasing the spread, which in turn has lead to increased percolation and evaporation losses. This silt also includes pollutants that have settled on the lakebed and water percolating to the underlying aquifer leaches through these deposits. It is estimated that the volume of these eroded deposits would be in the region of 2.5 MCM, whose removal would be a mammoth task having tremendous financial and logistical implications. The nutrient content of the silt will be released into the lake tending to create eutrophic conditions in the lake for years to come.

## 3.8 IDENTIFIED ISSUES PREVALENT AT MANSAGAR LAKE

**Quality of water**

The lake is suffering from serious problems of siltation and settled deposits containing nutrients and other contaminants from the inflow of wastewaters, decrease in surface area due to artificial land formation as a result of eutrophication especially in south – east corner, decline in surface area spread with the onset of summers in part due to the outflow of waters for downstream irrigation. There is a difference in water quality of the lake on its northern and southern side due to the latter receiving the sewage inflows resulting in chemical and organic waste depositions.

***Figure 23*: Sewage water Inflow in Mansagar Lake**

**Rise in Eutrophication due to anthropogenic activities**

Due to water stagnation and limited net outflow from the lake, the quantity of nutrient in the lake builds up constantly. This resulted in rapid eutrophication. The high amounts of nutrients encourage excessive phytoplankton and algal growth that covers the water surface. Due to this, light is unable to penetrate to lower levels affecting the survival of submerged macrophytes.

***Figure 24*: Garbage disposal in Drains**

**Constructed shoreline**

The natural shoreline of the lake on 3 sides has been completely destroyed, while building it to suit the human needs. This is turn has resulted in the stagnation of waste along the built edges and the lake has lost the self-regenerative ability.

***Figure 25*: Constructed shoreline along lake Shoreline**

**Distortion of the natural profile of lake**

Ever since the lake's shoreline has been modified and human intervention has started taking place, there has been a strong polarization between the lake and its surrounding woods and hills, disturbing the bird watching trail.

**Change in the source of the watershed**

Direct rainfall over the lake surface Runoff from the catchment and partially treated wastewater inflow from the north zone STP which is coming mixed with untreated wastewater inflow from the Nagtalai and Brahampuri Nalas catchment.

**Algae bloom**

Owing to a high level of pollutants in various influent flows, the surface water quality of the lake is rated very poor. The resultant high level of nutrient has led to the algal bloom (macrophytes). Land formation as a result of decayed plant deposits is evident especially near the outfalls of the major nalas. The lake thus tends towards hypertrophic to dystrophic condition. The dissolved oxygen is low and thus there is a near absence of fish in the lake.

***Figure 26*: Algae bloom in Lake**

**Soil quality**

Soil Quality and Characteristics impacts the associated life either it is microbial life or the Plant life. And it is impacted by the Quality of water seeps inside it. The soil samples analyzed here are from the soil bed of the Mansagar Lake, which are associated with the water body and thus also reflects the current Physico Chemical status of the soil of the agricultural fields which receives or are irrigated by the untreated water of the Mansagar Lake. Soil is alkaline in nature supporting the plants and to some extent microbial life. PH of the soil is higher in the month of August (8.36±0.057) and lowest in the month of November (7.6±0.346).

***Figure 27*: Degraded soil quality of Lake**

**Siltation**

Due to heavy deforestation of the Aravalli hills in the backdrop, the run-off from the hills erodes the soil and hence the level of the lake is rising due to sedimentation.

**Human intervention**

The uncontrolled human access right till the edge of the lake has been further degrading its already poor condition. There is no check on garbage disposal and other such disturbing human activities.

**Water losses**

Since the lake shoreline is constructed on 3 sides, there is no vegetation at all and there are heavy evaporative losses. Although the percolation losses can't be controlled much, the evaporative losses can be prevented to a great extent by rejuvenating the lake's shoreline into a natural one.

# 4.0 CASE STUDY

## 4.1 SPY POND PARK, ARLINGTON, MASSACHUSETTS

Location - Arlington, Massachusetts
Site Area - 1700 Feet Linear
Restoration by - Carol R. Johnson Associates


***Figure 28*: Google Earth Image of Spy Pond**

Spy Pond, also known as Spy Pond in the 17th & 18th centuries, is a 103-acre (0.42 km2) kettle hole pond located near the heart of Arlington, Massachusetts, adjacent to the Minuteman Bikeway. The Town of Arlington, MA, retained CRJA-IBI Group to restore 1,700 linear feet of the shoreline at Spy Pond Park.
The existing bank had been severely eroded by storm water runoff, resulting in compromised water quality, including high levels of phosphorus in the pond. The architect also revitalized the park by upgrading site furnishings and by providing a pathway system that can accommodate emergency and maintenance vehicles.
They developed a planting plan to deter the Canadian geese that currently overrun the park, further damaging the pond's water quality. This strategy has required a careful selection of plantings, as traditional grasses are a primary food source for Canadian geese. At the same time, the plants that are selected have to provide shelter and nourishment for desirable wildlife, such as nesting birds, turtles, frogs, toads, and mallard ducks.

### Existing vegetation and Habitat conditions of the Pond

With a few exceptions, on site vegetation appears to be healthy and well maintained.

Outliers include the areas where uncontrolled pathways eliminate the plant growth that provides soil stabilization, particularly west of the boat ramp.

Also, along the immediate shoreline, in a few cases where there is a slight escarpment with no stabilizing tree roots, wave action has eliminated the stabilizing vegetation.

***Figure 29*: Foot Paths in Plant Beds with Compacted Soil and Erosion.**

There were also a couple of areas where the exposed tree roots along the bank are being undercut by wave action.
The line between turf and the north beach is poorly defined and requires some material presence to clearly articulate the boundary.

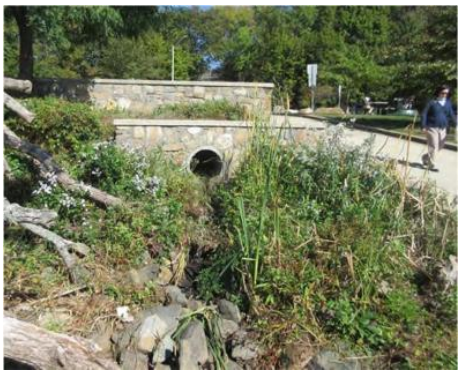


***Figure 32:*** **Storm Water Outflow**

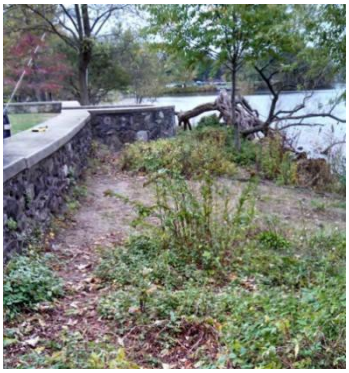


***Figure 33*****: Foot Path**

A well-defined tree and shrub layer on the slope up to the adjacent bikeway provides cover and food for both small mammals and birds.

***Figure 32*****: Eroded Pond Edge**

***Figure 32*****: Exposed Tree Roots Being Undercut**

Shrubs and trees along the shoreline provide additional cover. Spy Pond itself can provide some warm water fish habitat although as a water body classified as hyper eutrophic it has limitations.

The accompanying excessive plant growth, occasional algal blooms, low dissolved oxygen content, low transparency, etc. limit species diversity and, consequently, sport fishing opportunities.

## Restoration strategy for the Pond


***Figure 34*****: Spy Pond Park Plan**

Invasive Plant Management Strategy

1. Woody Trees, Shrubs and Vines:
   - Saplings (up to 1") – mechanical removal with Weed Wrench
   - Mature Plants cut flush to ground and dispose legally offsite (landfill).
   - Suckering Varieties – cut flush and apply approved herbicide.

2. Herbaceous Plants:
   - Pull plants and roots by hand and dispose legally offsite (landfill).
   - Seed and stabilize with native mix appropriate for plant community.

***Figure 35*: Manual removal of Invasive species**

3. Japanese Knotweed Colonies (Manual vs. Chemical Method):
   - Cut stems to ground twice/year and dispose legally offsite (37 years).
   - Cut stem herbicide treatment once/year (repeat second year).

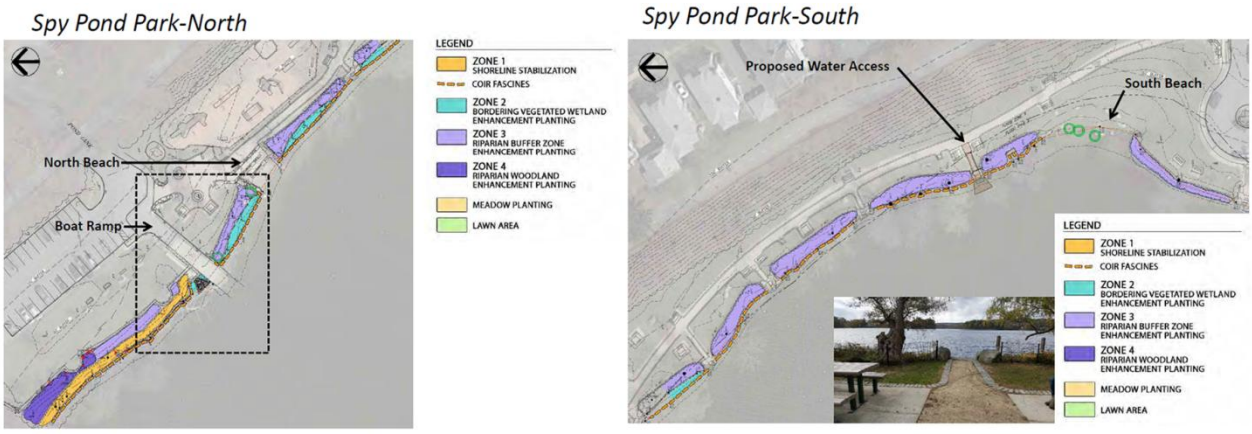



***Figure 36*: Spy Pond Park zones**

***Table 5*: Zone Description**

| Zone 1 : Shoreline Stabilization | Zone 2 : Bordering Vegetated Wetland Enhancement Planting | Zone 3 : Riparian Buffer Zone Enhancement Planting | Zone 4 : Riparian Woodland Enhancement Planting |
|---|---|---|---|
| • Install turbidity curtain<br>• Install coir fascines<br>• Place soil and regarded behind coir fascines<br>• Install planting | • Protect resource and endangered species habitat<br>• Remove targeted invasives<br>• Scarify compacted areas (footpaths)<br>• Top dress with weed free topsoil | • Remove invasives<br>• Scarify compacted areas (footpaths)<br>• Top dress with weed-free topsoil<br>• Install seed and tackifier<br>• Install plugs<br>• Install live stakes | • Remove invasives<br>• Scarify compacted areas (footpaths)<br>• Top dress with weed-free topsoil<br>• Install seed and tackifier |

| | | | |
|---|---|---|---|
| | • Install seed and tackifier<br>• Install plugs and live stakes in hydric soils | in groups to frame views & improve habitat. | • Install native woodland groundcovers<br>• Install live stakes to improve habitat<br>• Install tree tubelings to restore understory & canopy |

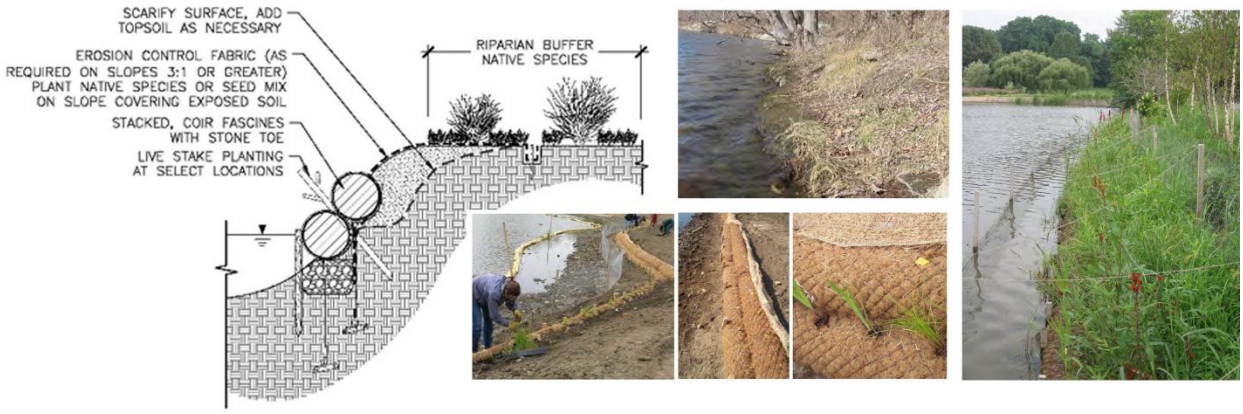



**Figure 37: Zone 1 – Shoreline Stabilization images**

**Figure 38: Zone 2 - Bordering Vegetated Wetland Enhancement Planting**

**Figure 39: Zone 3 – Riparian Buffer Zone Enhancement Planting**

**Figure 42: Zone 4 - Riparian Woodland Enhancement Planting**

**Figure 41: Spaces for access water**

**A space is constructed for visitors to access the water edge.**

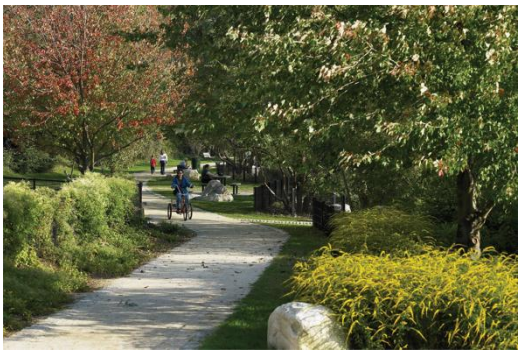


**Figure 40: Pathway along the Shoreline**

**A pathway runs along the shoreline which is surrounded by the dense colourful native vegetation.**

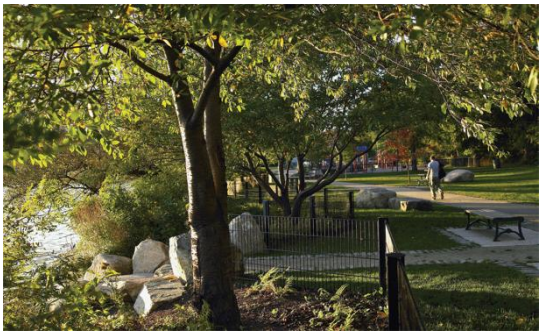


**Figure 43: Created Erosion proof Shoreline**

**Constructed erosion-proof access points with the use of impressive boulders. Planting is done along the shoreline to deter the Canadian geese that currently overrun the park, further damaging the pond's water quality.**

**Figure 44: View Points along Shore line**

**Created several viewpoints along the shoreline with impressive boulders, which capture captivating views for visitors.**

# BIBLIOGRAPHY


**Book**

1. Princely Terrain – Amber, Jaipur, Shekhawati by Shikha Jain

**Published Papers/articles**

1. Anthropogenic impacts on lake and stream ecosystems, and approaches to restoration.
   MARTIN SNDERGAARD* and ERIK JEPPESEN
   *National Environmental Research Institute, University of Aarhus, Department of Freshwater Ecology, Vejlsøvej 25, PO Box 314, Silkeborg, Denmark*
2. Conservation and Management of Mansagar Lake of Jaipur - A Model Study
   Manju Raina
   *Ministry of Environment & Forests, Paryavaran Bhawan, CGO Complex, Lodi Road, New Delhi 110 003*
3. ManSagar Lake - Study of the water and associated Soil Quality, by analyzing their various Physico-Chemical Parameters
   Chetna Pradhan; Dr. Surendra Singh Chauhan
4. Emerging Crisis in Mansagar Lake Governance
   © 2012 Mansee Bal
   *Environment Researcher* at Department of Public Administration, Faculty of Social Sciences and Institute for Housing and Urban Development Studies, Erasmus University, Rotterdam, The Netherlands
   *Development Consultant* at Environmental Design Consultants, Ahmedabad, India
5. Mansagar Lake: Past, Present & Future
   K. P. Sharma, Subhasini Sharma, Shweta Sharma, P. K. Sharma, R. C. Swami, P.K. Singh and G. S. Rathore
   *Department of Botany, University of Rajasthan, Jaipur -302004*
   *Department of Zoology, University of Rajasthan, Jaipur -302004*

**References**

1. en.wikipedia.org
2. ces.iisc.ernet.in
3. ga.water.usgs.gov
4. www.intechopen.com
5. Stud.epsilon.slu.se
6. Scholar.sun.ac.za
7. Rainwaterharvesting.org
8. www.ilfsindia.com
9. www.articlesbase.com

**Thesis**

1. Impact of anthropogenic activities on lake and its environment a case Mansagar Lake, Jaipur, Sristy Agarwal, M.arch Thesis, CEPT University, 2012
2. Envisioning A Cultural Landscape – Mansagar Lake Project, Jaipur, India. Meenakshi Kumar, M.arch thesis, University of Georgia, 2006

# 5.0 PROPOSAL DRAWINGS