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Nal Sarovar dries up during migratory season

SHYAM PAREKH

TIMES NEWS NETWORK[TUESDAY, DECEMBER 31, 2002 12:20:18 AM]

AHMEDABAD: Every December, the air over the picturesque Nal Sarovar is usually pregnant with sounds of birds chirping and cheers of visitors overwhelmed by the sight of the beautiful winged creatures from faraway lands. But, this year has been unusual. To the utter shock of nature lovers, ornithologists and the general tourist, Gujarat's most famous bird sanctuary has dried up, a phenomena being seen after a decade and a half. The migratory birds have gone back, so have the dejected enthusiasts.

Though the lake normally dries up in March-April, this time, it has happened three months earlier, leaving behind a barren landscape across the 120 sq-km lake. Instead of the country boats that were used in the knee-deep water, visitors today drive through what was a lake just few months ago.

Known for some 250 varieties of birds, including 158 species of waterfowls, Nal Sarovar receives over two lakh winged visitors between September and February. Despite being the peak season for these migratory birds, the skyline looks barren as birds find no food, water or any form of activity on the parched land.

A majority of birds that come here are ducks, coots, pelicans, flamingos, which travel all the way from Central Asia and eastern and western Europe. This extraordinary situation has forced the forest department to consider using Narmada water to fill the dried lake. "We have discussed the plan with the Sardar Sarovar Narmada Nigam, which has agreed in principle. But the channel is 20 km short of the Nal Sarovar and we are exploring the possibilities," said chief conservator of forests (wildlife) Pradip Khanna.

Scanty rainfall is being blamed for the lake going dry. "Usually, Nal receives water from the catchment areas of Ahmedabad and Surendranagar districts. But this year, the catchment areas in Ahmedabad remained dry. We received some water only for a day or two from the areas upstream of Ranagadh and Gadhechi in Surendranagar," said a forest official.

The result was that the water level remained very low during the past five months - between 1.5 feet and 2 feet, instead of the usual postmonsoon level of above six feet. The lake, therefore, began drying up soon and a few weeks after Diwali, it went dry.

Tourists flock this sanctuary during this season to watch these birds, which number between 50,000 and one lakh. A dozen villages with over 35,000 population, located on its banks, survive only on tourism. But as there are no tourists this season, locals engaged in boating and running temporary eateries have lost their only source of income. There are ecological considerations bothering the forest department.

"To attract birds, the water level has to remain between two and three feet. Levels more than this will drive them away. Besides, the lake has to remain dry in April and May. It is, therefore, a matter of a couple of months and we are not unduly worried," he said.

Ornithologist Kandarp Katju stressed on the need to develop and maintain satellite water bodies. "We have been talking about developing and preserving other water bodies near Nal Sarovar so that birds have an alternative site. Bhaskarpura, 15-20 km from Nal, has become a haven for birds."

Two years ago, the state government had sanctioned Rs 10 lakh to develop an interpretation centre at Nal Sarovar which has never come up despite the funding.

Uplate 27

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Govt chalks out plans to revive lake sanctuary
The Times of India News Service Tuesday 4 July 2000

AHMEDABAD: The state forest department appears to have woken up to the pressing need of preserving its natural treasure. It has taken some significant decisions to improve tourist facilities as well as the habitat for birds in the Nalsarovar lake sanctuary, 45 km from here.

The department has built a canal -- 6 meters wide and 1 km long -- right from the entry point of the lake, where boats will ferry tourists around. Besides, a 4.5 km long earthen wall has been built, blocking the water outlet from the lake. The wall will raise the level of the lake by about four to five meters, conservator of forest T R M Prasad said.

A decision to facilitate de-congestion of the tourist spot where all the boats used to be concentrated has also been taken, informs Prasad. The wall would help retain water round the year in the shallow lake, spread over 120 sq. km.

The lake is a low-lying area between the plains of central Gujarat and eastern Saurashtra. It was declared as a bird sanctuary in 1969, including its wetlands. Harbouring more than 250 species of birds, Nalsarovar is one of the largest wetland bird sanctuaries in Gujarat. Forest department officials feel it has the potential to match the country's best water bird sanctuaries.

There are 360 odd islets in the lake and most of them lie exposed when the water level is low, like it is at present. The lake gets filled with water that drains from adjoining Surendranagar and Ahmedabad districts in the monsoon. With this fresh water inflow, concentration of brackish content in the lake will be reduced considerably.

Among the migratory birds that home in to the lake are flocks of pelicans, flamingos, ducks, demoiselle cranes, common cranes and several waders.

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PS

ashish kothari

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Hello! Ashish,

I joined CEE in December '96. I look after interpretation for Protected Areas and Wetlands. In '98 I began a wetland Initiative in CEE and thus the Interpretation Programme for the Nalsarovar Bird Sanctuary took root. We have envisaged publications, Nature Trail, Training for the boatman and nature guides. A full-fledged building is also available to put some exhibits in place. Nalsarovar Bird Sanctuary as you know is also one of the recommended Ramsar sites, but problems galore.

When I envisaged the programme, it was with the intention of setting up of this Interpretation/Education Resource Centre, device programmes on a continued basis as the sanctuary is only 65 km from Ahmedabad and a habitual getaway for me and lacs of other Amdavadis. I wanted to look at evolving a model for sustainable resource use for the locals and the birds. All is pending right now, while the locals continue to use the existing resource and the Forest Department acts the policing role. Once in a while at the insistence of some local scribe who screams murder when some birds are poached, some heads would roll in the Forest Department but beyond this, everything is complacent.

The insolence of the Forest Department with whom we have collaborated for this project has put brakes on this initiative.

I have though brought out publications for the visitors to be sold/distributed on site (brochure cum checklist, post cards, school labels, stickers in two languages-English and Gujarati).

It is important that we evolve a mechanism for this wetland to thrive and survive. I would certainly like some inputs from you.

I had written a paper for the Millennium event on wetlands to be held in Canada, this August 2000. My paper was accepted for a poster presentation and I even got a waive on the registration, but travel funds are a rare commodity. I can share this paper with you.

I got two copies of PA update way back in , but I have read up a few in the interim period. I would like to be mailed.

// At CEE A'bad.

Thanks

Lima Rosalind

Environmental Impact Assessment of Sardar Sarovar Project

on

Nalsarovar Bird Sanctuary

By

GUJARAT ECOLOGICAL EDUCATION AND RESEARCH (GEER) FOUNDATION

G-1, 194/3, Sector-30, Gandhinagar-382020.

Sponsored By

NARMADA PLANNING GROUP

SARDAR SAROVAR NARMADA NIGAM LIMITED-GANDHINAGAR

Gujarat Ecological Education and Research (GEER) Foundation,
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ABBREVIATIONS

ACF	- Assistant Conservator of Forests
CF	- Conservator of Forests
Ch.	- Chain
Cm/Cms	- Centimeter
Cumecs	- Cubic meter per seconds
DO	- Dissolved Oxygen
d/s	- Drain section
EC	- Electrical Conductivity
EIA	- Enviromental Impact Assessment
EMG	- Expert Multi-disciplinary Group
FCC	- False Colour Composite
FD	- Forest Department
GEER	- Gujarat Ecological Education & Research
gm	- Gram
GOG	- Government of Gujarat
GOI	- Government of India
Ha/ha	- Hectare
hh	- House-hold
hrs.	- Hours
IRS	- Indian Remote Sensing Satellite
kg	- Kilogram
km	- Kilometer
L/l	- Litre
LISS	- Linear Imaging and Self Scanning Sensor
m/mt	- Meter
mg	- Milligram
mm	- Millimeter
NBS	- Nalsarovar Bird Sanctuary
NPG	- Narmada Planning Group
NRSA	- National Remote Sensing Agency
NWRD	- Narmada and Water Resources Department
OSD	- Officer on Special Duty
PA	- Protected Area
pH	- Potentia hydrogenii
RL	- Reduced Level
SBC	- Saurashtra Branch Canal
SD	- Sub Distributory Canal
SOI	- Survey of India
sq. km.	- Square Kilometer
SSNNL	- Sardar Sarovar Narmada Nigam Limited
SSP	- Sardar Sarovar Project
SSPA	- Sardar Sarovar Punarvasvat Agency
TD	- Tail Distributory
Temp.	- Temperature
TM	- Thematic Mapper
TOR	- Terms of References
WII	- Wildlife Institute of India

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Staff of GEER Foundation and Nalsarovar Bird Sanctury

PREFACE

During last two decades, considerable effort has been devoted to wetlands and their conservation since the setting up of a National Committee on Wetlands in 1983 by the Ministry of Environment and Forests, Government of India. The scheme on conservation and management of wetlands, was started in 1986-87 at national level with the objective of undertaking a comprehensive study and maintenance of naturalness of important wetlands like Nalsarovar.

The Nal, a shallow seasonal fresh water lake, that sprawls at the junction of mainland of Gujarat and Saurashtra, attracts one of the largest concentrations of migratory and resident waterfowl found in India during winter. Although it is yet to be recognised internationally, the lake has been identified as a priority site for intensive conservation and management by the National Wetlands, Mangroves and Coral Reefs Committee of the Ministry of Environment and Forests, Government of India.

Wetlands are highly dynamic systems which continuously interact with other systems and anthropogenic activities in their catchment in various ways. All ecosystems interact with adjoining ecosystems in some manner which are more varied and intense in case of natural wetlands like Nalsarovar. It is also a fact that wetlands are relatively more fragile ecosystems because the wetland biota is adapted to rather narrow hydrological regime. Hydrology in this case refers to all water related features such as precipitation, inflow and outflow, evaporation and the resultant factors like the depth and duration of water, frequency and duration of flooding, and the amplitude of water level changes. Therefore, even small changes in the hydrological characteristics of the lake after completion of Narmada canal would bring about significant changes in the community structure and function. In view of this fact that the management requires a good understanding of wetlands' ecology, their functions and values.

It is fact that every giant multipurpose project like Sardar Sarovar Project (SSP) would not only bring major changes in socio-economic conditions of people but also transform the environment in the command area. Nalsarovar Bird Sanctuary, Velavadar National Park, Wild Ass Sanctuary and Thol Bird Sanctuary are protected wildlife areas falling in the command area of the SSP. Environmental management is a necessity and thus unavoidable for the sustainable development. In Gujarat State, planners are attempting to integrate environmental parameters into decision making process as part of the national efforts towards evolving holistic and sustainable strategies of the development. Sardar Sarovar Narmada Nigam Limited has taken adequate care for conservation of biodiversity in the area of influence by carrying out studies in catchment and command area to assess the impacts, and also to find out strategies for mitigating negative impacts. In view of this fact that the environmental impact assessment (EIA) studies of the canal on Nalsarovar was assigned to the GEER Foundation in March, 1994.

Dr. A.B.Vora, Shri A.A. Ahulwalia and Shri R.Y.Gupte carried out detailed study on water and soil, flora, zooplanktons and zoo-benthos which are important components of the lake. This study has provided relevant information to evaluate the habitat condition.

Mr. U.A.Vora and Mr. Ketan Tatu organised study on avifauna and their habitats in the Nal lake. They also studied various parameters influencing the habitats which have bearing on the assessment of the impacts. Their knowledge and interest on the subject was of immense use in this study.

Mr. Bharat Patel classified the habitats and studied extent of their areas by using remote sensing technology. He also studied the changes in ecosystems within and in different years by studying FCCs procured from NRSA, Hyderabad.

Socio-economic study in and around Nalsarovar was carried out by Dr. Rohit Shukla. Local people including those of 'Padhar' community in the area are dependent on Nal lake where they bring various kinds of the impacts on the sanctuary. Forest Department, Fishery Department and SSNNL provided a lot of data and information which have been used in this study. Study team also consulted historical records as well as previous studies to conclude the findings.

A group of ornithologists, Shri Fateh Sinh Jasol, IAS, Addl. Chief Secretary, Shri Lavkumar Khachar, Shri Lalsingh Raol and scientists from Gujarat University along with members of the study team met at Indroda Park, Gandhinagar to bring accuracy and sharpness on findings and recommendations. The group felt that the Nal is unique, different from other wetlands, and hence attempts should be made to protect and conserve the uniqueness of the lake.

Man can not acquire all knowledge about the nature and it is not possible for human being to predict accurately the response of nature and changes after the implementation of the project. Prediction about the impact in this case is based on the studies for short duration on some of the parameters. In view of this fact, there is a need of continuity of studies even after implementation of project so that necessary modifications would be brought for adapting suitable mitigating measures for minimising the likely negative impacts. It is also hoped that the provisions made in the report would be implemented with all seriousness and sincerity to conserve our nature, of which we are a part.

March, 1998

H.S. Singh,
Director,
GEER Foundation,
Gandhinagar.

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SUMMARY



The "Terms of Reference" as mutually agreed upon by the GEER Foundation with the Narmada Planning Group for assessing various impacts of canal network under Sardar Sarovar Project on Nalsarovar Bird Sanctuary included various baseline studies. Apart from predicting impacts of the project on the area, as per the TOR, studies have been carried out to explore the possibilities of using the canal water for the benift of the sanctuary and to make suggestions for preparing an action plan for the area. The time period of the study, as decided in the TOR was of 15 months including field work of one year. However, the work was delayed due to various reasons, which provided opportunity to collect data for longer period. The study is first of its kind in the State in which various aspects of a natural wetland ecosystem have been studied by a multi-disciplinary team. Various ecological parameters, socio-economic factors and their interrelationships have been taken into consideration by the study team. Major findings and their bearing with the proposed canal network, their impacts and mitigating as well as monitoring measures have been mentioned here in brief.

The area under the study falls in the region-6 of SSP, which is a **natural wetland habitat** with **unique** geophysical and biological features. It is a **natural shallow lake** having catchment of about 10,000 sq.km. The Brahmni and the Bhogavo are two rivers draining into it. The excess water of the lake drains into the Gulf of Khambhat (Cambay).

1. The area supports 216 species of birds including 160 species of **waterfowl** including many **migratory** species. Four species are also listed in Schedule-I of Wildlife (Protection) Act, 1972, which are threatened.

2. Similarly the area supports 13 **mammalian species** including two threatened species listed in Schedule - I of the Wildlife (Protection) Act, 1972. **The Indian Wild Ass** (*Equas heminous khur*) and the **Blackbuck** (*Antilope cervicapra*).

3. 48 species of **algae**, 1 pteridophyte and 71 species of **flowering plants** are found in the area, a majority of which are aquatic and/or mesosoic.

4. In all, 76 species of **zoo-benthos and zooplanktons** are recorded from the area during this study. Reptiles found in the area includes 10 species, showing relatively less diversity.

5. The **fish** fauna of the area is also relatively less diverse as only 20 species have been recorded from the area. Fishing activities, practised in the area adversely affect the bird population.

6. The lake is shallow and it is a **relict sea**. Being a **natural lake**, area under submergence depends upon the quantum and pattern of the **rainfall** in the catchment zone, which also ultimately **decides the level** of depth of water in various parts of the lake.

7. The **chemical constitution of lake water** varies drastically from season to season, which also depends upon quantum and pattern of the rainfall in the catchment zone. The extent of salinity and alkalinity of water exceeds the tolerance limits of most of aquatic flora and fauna during the summer, even during the normal rainfall year. The lake almost dries up during the summer.

8. Water in the lake becomes stagnant after September at RL 9. October to mid-March is the **crucial period** as during this period most of **migratory species** visit the area. The area under submergence in the year of normal rainfall, is hardly about one third of the notified sanctuary area during the preceding winter.

9. In all, 8 types of **habitats** have been identified in the area on the basis of water level and vegetation composition. Of these, two types are outside the sanctuary. **Habitat formation** is found to be a **dynamic process** and **transformation** of one habitat into another occurs even during the same year. Areas under various habitat types vary with the change in the water level.

10. **Habitat preference** of various waterfowl in relation to **food availability** and **feeding habits** have been studied. Shallow open water habitat with water level between 21 cm to 60 cm has been found most favourable to majority of species. Water level from 60 cm to 100 cm or little more is favoured by diving ducks, pelicans, etc..

11. Amongst the **resident birds, only few speices breed** in the sancutary. The lake becomes unsuitable for most resident waterfowl due to dryness and high salinity in breeding season. Otherwise the area offers a great potentiality for the breeding of the species. In better rainfall years, breeding/nestings have been found to increase in the area.

12. People of surrounding eight villages **depend heavily** on the sanctuary for exploiting various resources. Fishing, grazing, irrigation as well as earning through tourism, has been recorded. **Socio-economic** study has revealed that economic conditions of the households in the region is very brittle. **Agriculture** is very poor due to lack of irrigation facility and saline sub-stratum. **Seasonal migration** of people is just affording survival and does not yield much earning. **'Padhars'**, local tribals are sufferers.

13. **Canal** or other structures are not proposed to be constructed in the sanctuary. SBC passes 17 km away from the lake. Project proposes to **release water** from the proposed **escape** located near Bhaskarpura, into the catchment of lake, and ultimately into Nalsarovar.

14. Using Nalsarovar as a **storage tank** has been felt **counter productive**. SSP proposes to provide water to the Nal, if it is required and is beneficial for the sanctuary. The Nal is **unique**, different from many other wetlands of the country, and hence its **uniqueness** should be **conserved** in interest of conservation of avifauna and its habitat.

15. Various **positive and negative impacts** of the SSP proposals have been predicted and mitigating measures have been suggested.

16. Unpredicted, unregulated and irregular **release of water** into the lake can **adversely affect** the ecosystem, however, this situation is not likely to arise because of the latest system planned for canal operation.

17. With a view to **mitigate** the negative impacts and to maximize positive impacts **suggestions** have been made to **fill Bhaskarpura depression** and to **extend Ghoda feeder canal** beyond the sanctuary area for **managing** water released from the **escape**.

18. For **improving the habitat conditions**, **short fall** of water in the lake below RL 9.4 **to be filled** through canal water at the **end of the monsoon** in the manner in which **natural process** of **drying up and rejuvenation** can be maintained for most part of the sanctuary. **No** water is to be **released** in the Nal after **monsoon**.

19. Creation of disturbance-free **sanctum sanctorum** zone, regulation of **fisheries and tourism** and other mitigating measures as well as **monitoring the various parameters** have been suggested.

20. For **overall development** of the area, suggestions including encouragement of bio-pesticides, bio-insecticides and bio-fertilizers, training to boatmen, interpretation programme and regulations for **landuse pattern** have been made.

1. INTRODUCTION



Water resources development projects are indispensable as they are inexorably linked to our economy. The two major criteria, i.e. the project should maximise economic return and it should be technically feasible, are no longer considered adequate to decide the desirability and viability of the project. This is due to growing concern for environmental quality. It is now widely recognized that the development effort frequently produces not only sought for benefits, but other, often unanticipated undesirable consequences. Impact assessment is a concept that is evolved in the search of ways to render development and protection of the environment compatible with the complex and interdependent world of today.

Sardar Sarovar Project (SSP), the largest multipurpose river valley project in the world, being implemented by the Sardar Sarovar Narmada Nigam Limited (SSNNL) is the first of its kind which recognized the need to carry out various impact assessment studies, though 'pari pasu', right from its inception stage. With a view to achieve perfection in this aspect, SSNNL has formed various expert multidisciplinary groups (EMG's) to look into various aspects, besides constituting Narmada Planning Group (NPG) in this regard.

Nalsarovar Bird Sanctuary, the largest protected inland wetland habitat in the State is one of the protected areas which falls into command area of the SSP, for which a separate expert multi-disciplinary group has been formed.

Gujarat Ecological Education and Research (GEER) Foundation, an autonomous body set up by the state government was invited to attend the first meeting of the EMG, as a special invitee. One of the terms in the TOR for EMG, was to consider the feasibility of storage of water from Narmada in Nalsarovar and if such storage is feasible, to what extent and in what manner such storage could be achieved for releasing the same for irrigation.

In the first meeting itself, it was voiced that the use of Nalsarovar as water storage tank could be considered only if pilot scale studies show that such a use will not have negative impacts on the unique wetland habitat. The EMG had identified various studies, for predicting likely impacts and GEER Foundation was asked to prepare detailed proposals for the study, together with Dr. A. B. Vora, the then head of Botany Department, Gujarat University.

GEER Foundation had initially proposed the study for a period of 3 years, which was felt a lengthy period and subsequently at the instance of NPG, proposals for one year's study was made in January 1993. The proposal was accepted almost after one year, i.e. on 1-12-93. The meeting of EMG was held subsequently on 2-12-93 in which it was felt that the use of Nalsarovar for storage may not be considered in immediate future. It was also felt that use of Nal for storage of SSP water would be counter productive and it would be advisable to consider the use of canal water only when the management is certain about its beneficial impacts.

The EMG again met on 13-1-1994 at Nalsarovar during which Shri P. A. Raj, Vice-Chairman, SSNNL, stated that " While storage for lift irrigation was possible at Nalsarovar, this may not be considered now in view of environmental concerns and submergence involved." It was also voiced that now it would be necessary to consider the issue other way round, i.e., how SSP water can be utilised for the benifit of the ecology of Nalsarovar, by providing water only when it is required to improve the habitat conditions.

The study proposals and TOR for the study were ultimately finalized and GEER Foundation was entrusted the study in March 1994

The Foundation had presented two interim reports, first in March, 1995 and second in November, 1996. These interim reports were discussed at length during the workshop held on 30th April, 1995 and various suggestions, comments and remarks were received on both interim reports. A group of ornithologists, Shri Fatesinh Jasol, Additional Chief Secretary, Shri Lavkumar Khachar, Shri Lalsingh Raol, Director of the Foundation and members of the study group met on 16.9.1997 to discuss some of the issues to bring accuracy and sharpness on the findings and recommendations. The draft final report was deliberated in the workshop held on 2nd December, 1997 and the report has been finalised after considering relevant suggestions and comments.

2.1 Location

Nalsarovar is located between latitude 22° 78' N to 22° 96' N and longitude 71° 92' E to 72° 64' E. The area is located amidst the semi-arid lands of Ahmedabad and Surendranagar districts, about 65 km away from Ahmedabad (Fig. 2.1). Biogeographically the area falls in 4B Gujarat-Rajwara biotic province of the semi arid biogeographical zone, as per the classification developed by Panwar and Rodgers (WII, Dehradun).

2.2 Area and boundaries

Nalsarovar is a natural, shallow lake having maximum depth of about 1.5-2.0 meters when flooded. Being a natural lake, the area under the submergence varies, depending upon the rainfall. During the years of good rainfall, the total area in and around a sanctuary under the submergence may go beyond 350 sq.km. However, it has been observed that the average area under the submergence in winter is approximately 60 sq. km during the normal rainfall years. Thus, the actual waterbody in normal years is less than the legal area of the sanctuary, as 120 sq. km area is notified as the sanctuary under the Wildlife (Protection) Act, 1972. The legal boundaries of the area are as under : -

North : Shahpur village in Viramgam taluka of Ahmedabad district.

South : Village boundaries of Shiyal in Dholka taluka of Ahmedabad district.

East : Village boundaries of Kayla and Vekaria of Viramgam taluka and Meni and Durgi villages of Dholka taluka of Ahmedabad district.

West : Village boundaries of Digvijaygadh, Panali, Mulbavla, Ranagadh, Bhagvanpur, Galiela, and Nani Kathechi in Limbdi taluka of Surendranagar district.

The lake has more than 300 islets, most of which are located on the western boundary. They get exposed when water level recedes. Out of this, only 36 islets are having sizable plateau like area, while the rest are very small.

The area receives water mainly from two rivers viz. the Brahamni and the Bhogavo. It also receives water from the surrounding catchment in north, west and east which are having gentle slopes. There appears gentle drainage from north-west to south.

2.3 Statement of significance

Nalsarovar is the largest wetland bird sanctuary in the State and is also amongst one of the largest inland wetland areas of the country. The natural shallowness of the lake supports a variety of habitats, which in turn harbours a variety of resident and migratory waterfowl. Thousands of migratory waterfowl flock to the Nal just after the monsoon. The shallow area of the wetland and ponds on the outer fringes of the lake attract the wading birds that feed in the shallow water. The area supports more than 210 species of birds besides a few mammalian species including the endangered wild ass and the threatened blackbuck. Such a wide range

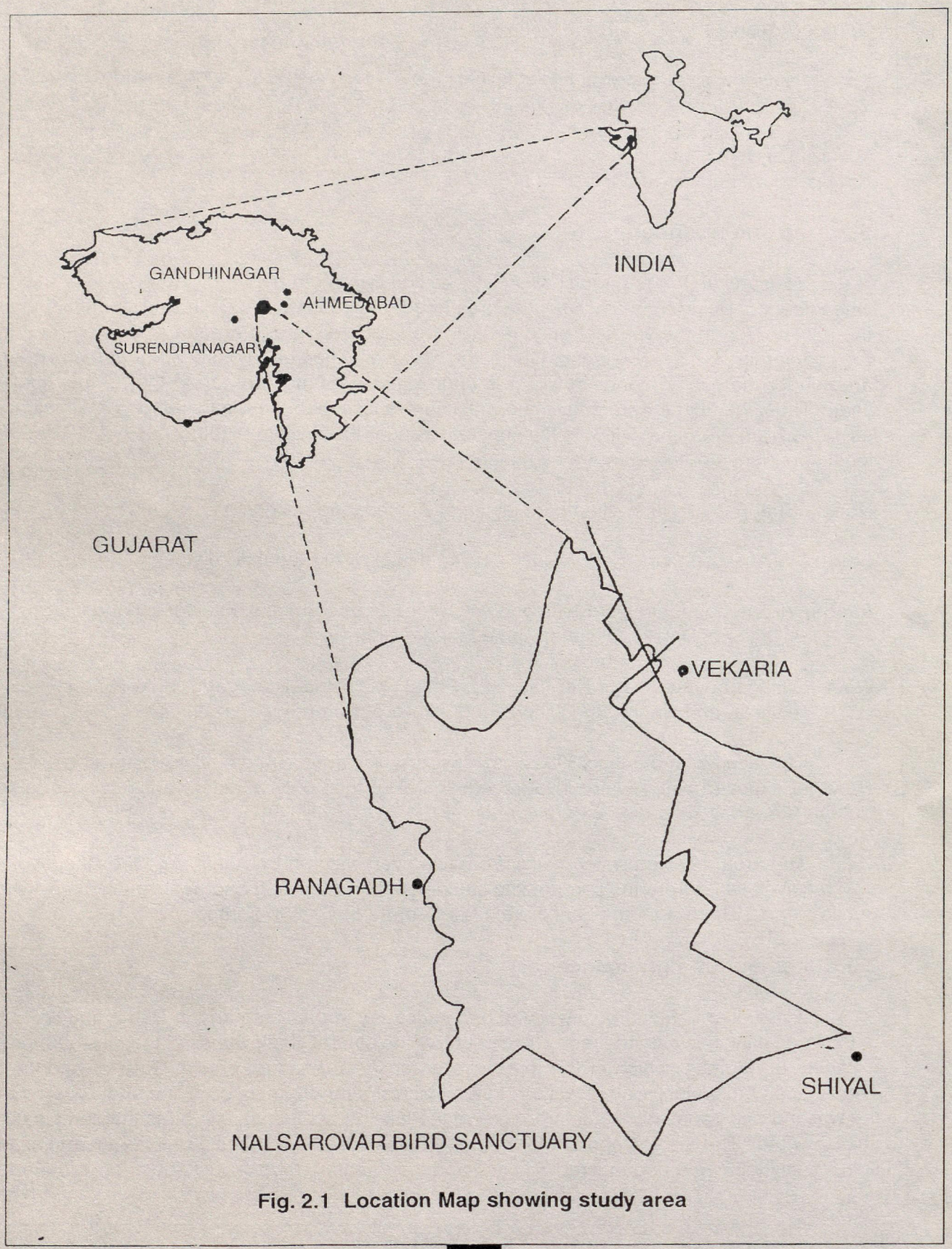


Fig. 2.1 Location Map showing study area

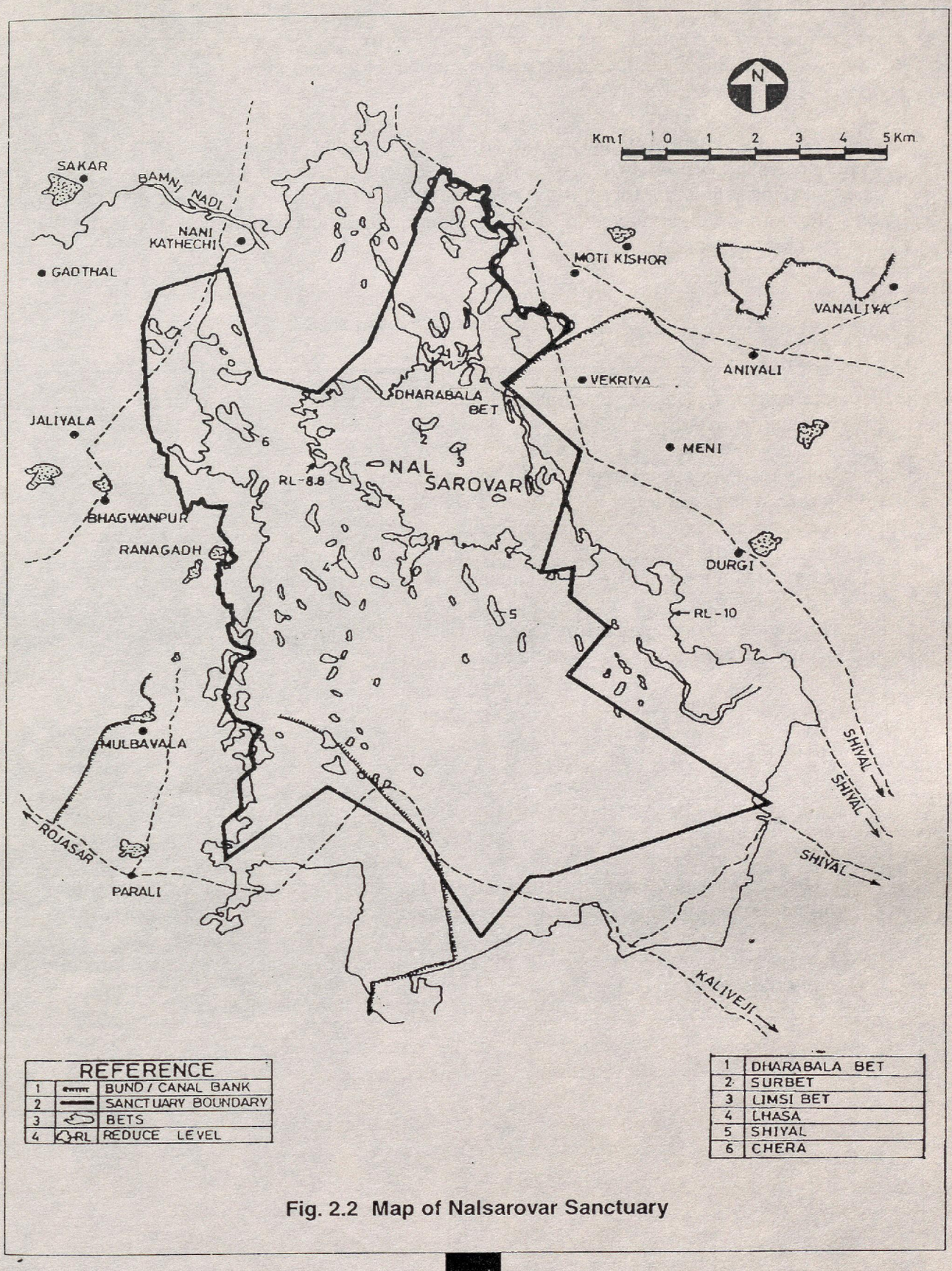


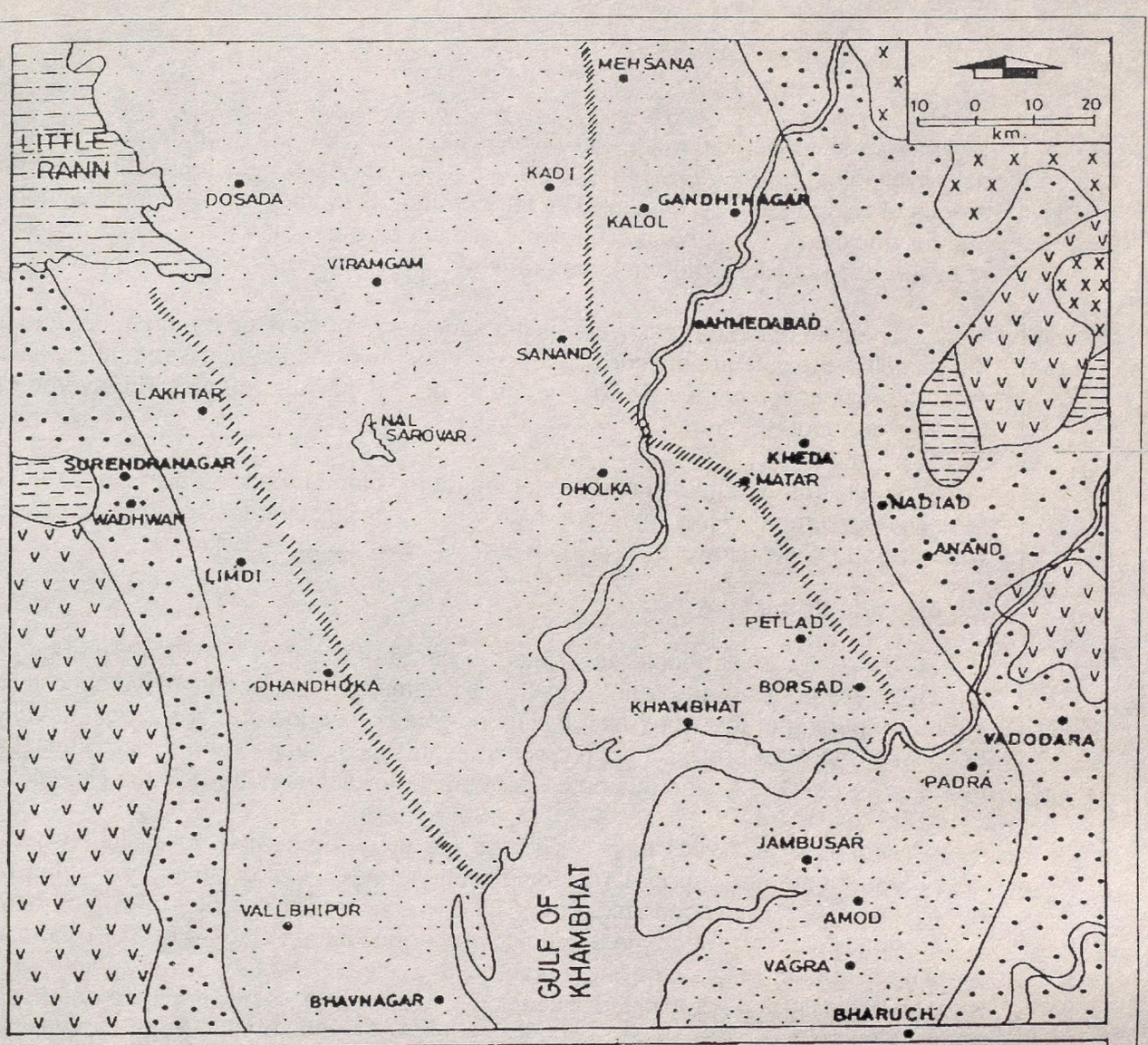
Fig. 2.2 Map of Nalsarovar Sanctuary

of fauna cannot be sustained without the existence of diverse forms of habitats and ecotones formed by them.

The population estimation of waterfowl clearly indicates that the area is internationally important wetland as per the criteria of Ramsar Convention. Accordingly it is one of the proposed Ramsar Sites in the country (Walston *et al*, 1989). Apart from this, the area is also identified as one of the important wetlands for evolving management action plan by the National Wetland Committee (Narayan, 1992).

CONSERVATION VALUES

* Internationally, Nalsarovar qualifies to be an important wetland habitat as per the Ramsar Convention.
* Nal is the largest protected inland wetland habitat in the State, and also one of the largest in the country.
* It is among the 15 wetlands of the country identified by the National Wetland, Mangroves and Coral Reefs Commitee for evolving management action plan.
* The area supports over 210 species of birds, including 4 species of birds listed in schedule-1 of the Wildlife (Protection) Act, 1972.
* Largest population as well as density of waterfowl in the entire state occurs here.
* It is a shallow natural lake having unique genesis.
* Among all protected areas (PAs) of the State, maximum number of tourists visit this sanctuary.
* Because of its proximity to different universitites and research institutions, the area offers an opportunity to conduct various types of research.
* 72 species of flowering plants, 48 species of algae, 76 species of zooplanktons and zoo-benthos, 20 species of fish and 13 species of mammals are recorded in the area.



FORMATION (AGE GROUP)	SYMBOL	LITHOLOGY
UNCONSOLIDATED (COUATERNARY)		RECENT ALLUVIUM
		OLDER ALLUVIUM
SEMI CONSOLIDATED (MESOZOIC)		SEDIMENTRIES
CONSOLIDATED (DECCAN TRAPS)		BESALTIC LAVA
CONSOLIDATED (PRECAMBRIANS)		CRYSTALLINE ROCKS
BOUNDARY OF ARTESIAN FLOW		

Fig. 2.3 Geohydrological setup around Nalsarovar

2.4 Climate

No meteorological station has been established in the sanctuary area. The climatological data available for Sanand, which is the nearest place, clearly indicates that the climate of the area is of arid to semi-arid nature. The temperature rises upto 45° C during the month of May and falls below 7° C in January. The rise in the temperature after peak winter accelerates rate of evaporation of lake water that dries rapidly.

The lake being natural, water in the sanctuary depends on the quantum and pattern of the rainfall in the catchment zone. Rain occurs from mid June to mid September. However, the most of precipitation is recorded during the months of July and August. The average rainfall in the area is about 580 mm.

Apart from the rainfall and the temperature, wind in the area also playes an important role. During summer wind velocity is high which also accelerates the rate of evaporation of water from the lake. However, it seldom exceeds the speed of 60 km/hr.

2.5 Genesis of the lake

Presently, local people associate the name of the lake with "Nal", the king who was known for his honesty and truthfulness. This seems to be a recently developed folklore. The another meaning of the word "Nal" (Naal) indicates presence of a sea creek. Locally, "Nal" is used for a canal like protrusion of a creek or river. This meaning seems more logical as shown by Prasad *et al* (1997) who attempted to study the evolution pattern of the Nal lake.

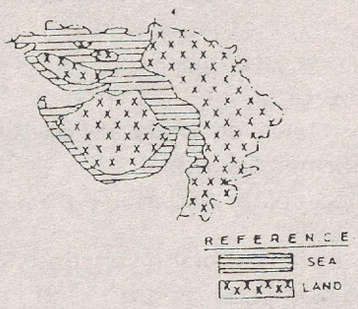
Prasad *et al* (1997) have developed a 3 stage model for the evolution of Nal region during late-Quaternary period. Accordingly, during stage-1 of evolution, spanning the period of 127-73 ka, a shallow sea linked the Gulf of Kachchh with the Gulf of Khambhat. The sea connection broke up around the beginning of marine isotope stage-4 due to regression of the sea. Subsequently only a land link remained. In stage-2 (73-7 ka), fluvial sediments from east were episodically deposited in the Nal region in response to westward migration of depositional front of eastern rivers. In stage-3, due to advance of sedimentation front, tectonism and post glacial sea level rise, the elevation of Nalsarovar came to within few meters of its present elevation at about 7 ka when it became a closed basin. The mudflats, present to south of Nalsarovar, represent recent sea transgression in the area..

2.6 Flora and fauna

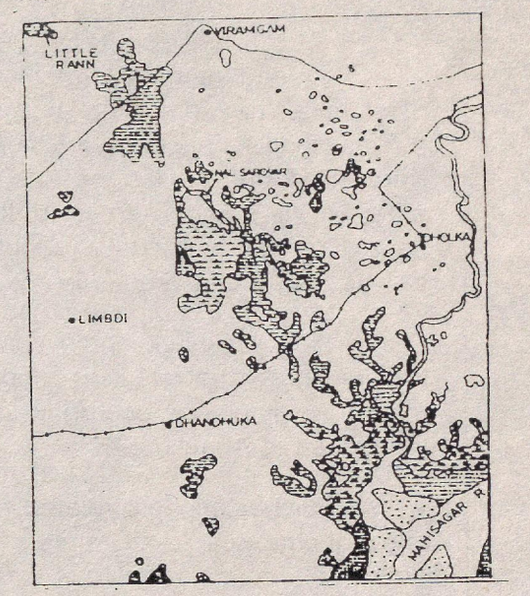
The wetland habitat of Nalsarovar harbours a variety of flora and fauna. Due to varied habitat conditions, one can find an ideal composition of terrestrial as well as aquatic vegetation, which in turn supports various micro as well as macro fauna.

In all, 72 species of flowering plants and 48 species of algae have been recorded from the area, which are presented in Annexures- 1A and 1B respectively.

The area is well known for its avifaunal richness. In all, 216 species of birds have been recorded from the area, which includes various extralimital migrants, local migrants and resident species. A checklist of various species of birds recorded from the area is given in the Annexure -2.

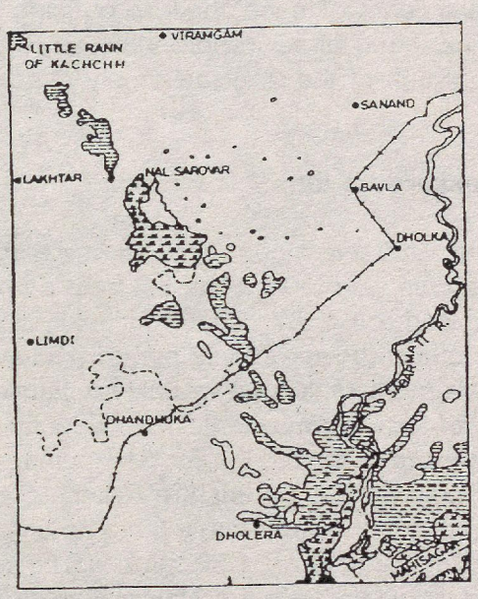


SUB-RECENT (HOLOCENE)
PREHISTORIC PERIOD 20,000
TO 5,000 YEARS BP
DEPOSITION OF NEWER
ALLUVIUM



DATA COMPILATION NOTE
LAND FEATURES ARE DEDUCTED FROM SURVEY OF INDIA QUARTER INCH SHEET NOS 41M 41N 41O 46A 46B 46C 46F AND 46G SURVEY WERE CARRIED OUT DURING 1860-90

LAND FORM AND LAND COVER OF 1875 AROUND GULF OF KHAMBHAT.



DATA COMPILATION NOTE
LAND FEATURES ARE DEDUCTED FROM SURVEY OF INDIA DEGREE SHEET NOS 41K 41N 41O 41A 46B 46C 46F AND 46G SURVEY WERE MOSTLY CARRIED OUT DURING 1950-70.

LAND-FORM AND LAND-COVER OF 1965 AROUND GULF OF KHAMBHAT.

REFERENCE		
NOTATION	LAND-FORM	LAND - COVER
	OFFSHORE BAR	SAND MOSTLY SUBMURGED GENERALLY BARREN
	MOUTH BAR	SAND GENERALLY BARREN
	BEACH SAND	SAND INTERTIDAL GENERALLY BARREN
	INTERTIDAL MUD	SILT & CLAY ALMOST BARREN
	MANGROVE	SILT AND CLAY INTERTIDAL MANGROVE FOREST
	INLAND SWAMP	SILT AND CLAY UNDER MONSOON INUNDATION WITH GRASS & SCRUB
	SALT WASTE	SILT AND CLAY INUNDATION UNDER MONSOON LIGHT SCRUB
	RANN	SILT ENCRUSTED CLAY MOSTLY DRY NO VEGETATION
	INLAND WATER BODIES	PONDS AND LAKE GENERALLY SILTED AQUATIC VEGETATION
	ALLUVIAL PLAIN	AGRICULTURAL AND OTHER LAND AGRI CROPS TREES ETC

Fig. 2.4 Geological changes at Nalsarovar

Among mammals, the blackbuck and the wild ass are notable, among total 13 species of mammals recorded in the area as mentioned in Annexure-3. Wild ass seems to have occurred recently in the area. Individuals probably have dispersed from their natural habitat, i.e. Rann of Kachchh during the last decade or so. A group of about 12 animals is found near Sanknera area, on the southern fringe of the sanctuary. However, since 1993, it is observed that their population has been static, might be due to further dispersal of the population in the area. It can be said that at least this one group has been stabilised in this area.

Few blackbuck, again mainly in the southern part of the sanctuary can be seen. Besides mammals, a variety of fish, zooplanktons and zoo-benthos are found in the area. Micro and macro zooplanktons occurring in the area, together with their distribution status has been mentioned in Annexure-4.

Further aspects related to flora and fauna of the area have been discussed in the relevant chapters.

2.7 SSP vis-a-vis Nalsarovar sanctuary

The sanctuary area as well as the surrounding area falls under the region - 6 of the SSP command. As stated in the first chapter, initially the area was considered to be used as a reservoir, which was felt counter productive in the due course. Hence, the idea of using Nal as a storage tank had been dropped now. This decision has been felt very appropriate, as otherwise it was bound to bring drastic changes in the ecosystem of the lake, adversely affecting its habitat conditions.

2.7.1 Saurashtra branch canal 'escape' and Bhaskarpura tank

The Saurashtra Branch Canal passes through Kadi, Viramgam, Lakhtar and Wadhwan talukas. The different structures from this canal are proposed to facilitate the best running of the canal. The structure called an 'escape' is proposed at Ch. 57.780 km for taking care of mismatching of the flow, sudden failure of pumps, electropower supply etc., on Saurashtra Branch Canal. Canal is passing through the Bhaskarpura tank area in Lakhtar taluka. The locations of the escape is proposed just upstream of Bhaskarpura tank. The capacity of the escape is designed for full capacity of Saurashtra Branch Canal. i.e. for 319 cumecs. (i.e. 11000 cusecs). It is proposed to release the escape water of Saurashtra Branch Canal in Bhaskrpura tank. The tank is shallow with very little depth of water, hardly 50 to 75 cm. It has broad crested spillway of 30 m length having discharging capacity of 31.82 cumecs. The surplus water from the tank is passing through existing spillway towards the Nalsarovar direction, ultimately which ends into the gulf of Cambay. During heavy rains, water does not drain out immediately as the terrain of this region is very flat and hence some times, the water remains for long period in the area.

2.7.2 Drain from Bhaskarpura tank to the Nal

The S.H.No.17 from Surendranagar to Ahmedabad passes d/s (drain section) at distance of approximately 150 m from the spillway of Bhaskarpura tank. The water released through spillway of Bhaskarpura tank passes through this bridge and ultimately meets Nalsarovar through the natural drain.

This drain, most properly may be said as low lying area ranging from 5 to 7 km width in general, with approximately 1:5000 slope towards Nalsarovar. During very good monsoon, this area gets flooded with 2 to 2.5 m deep water, which slowly drains out in Nalsarovar. The total length of drain from Bhaskarpura tank to Nalsarovar is about 17 km. Looking to the topography of the area, the initial 10 km length from Bhaskarpura tank upto Moti Kathechi village, it can easily pass the water released through the proposed escape of Saurashtra Branch Canal and it may not require resectioning of the drain. The remaining length of the drain from Moti Kathechi to Nalsarovar i.e. near Nani Kathechi, is 5 km which has practically less capacity in comparison to discharge of SBC of 319 cumecs. Some modifications are required for this portion of drain. When full capacity escape starts discharging 319 cumecs of water, it may be required approximately 5 hours to fill the Bhaskarpura tank. Thenafter the initial drain portion i.e. from Bhaskarpura to Moti Kathechi has the depression where temporary storage of escape water is possible. Total 17 hours are required to fill this depression. Thus total time requirement to flow the water at Kathechi is (5+17) 22 hours, i.e. about 1 day. Therefore, especially in dry season, this temporary storage very much reduces the severeness of the discharge at the far end.

2.7.3 Spillway arrangement of Nalsarovar

There are two main spillways on Shiyal to Kalivaji road to dispose off the excess water of Nalsarovar when water level of Nalsarovar lake is above the spillway level. At that time, if discharge from escape of SBC may come, the existing spillway capacity is required more, to pass additional 319 cumecs. It is required to provide 1 km long spillway cum causeway deep with 0.9 m spillway depth which is sufficient to pass 319 cumecs discharge.

2.7.4 Nal-SSP linkage and associated issues

The lake and the catchment area falls in the arid to semi-arid tract. Being a natural lake, water level in the lake depends upon the quantum and pattern of the rainfall in the area. The area under the submergence varies every year. SSP authorities have shown possibilities of joining Ghoda feeder channel with the Narsingpura branch canal and supplying water to Nalsarovar as and when required, if the management is certain about its beneficial impacts. (Alagh *et al.*, 1995).

After monsoon the process of drying up begins and water remains in about one third of the lake area in winter, during the normal rainfall year. In the years of less rainfall it dries up completely. While during the years of severe drought the lake area remains dry even during the winter. The population of waterfowl in the lake area depends upon the water level of the lake. Thus, the entire lake ecosystem is rainfall dependent.

On the other hand various biotic pressures affect the sanctuary. People of the surrounding villages use the lake for transportation, fishing, grazing and also for irrigating their fields by draining water from the lake. Their life, particularly the income of those dependent on the lake, is dependent upon the water level of the lake. In the years of drought and scanty rains, due to less population of waterfowl their income through tourism is also adversely affected.

In our country, Keoladeo Ghana National Park, Bharatpur (Rajasthan) is considered as one of the best wetland ecosystems. This ecosystem is maintained by connecting it with the nearby reservoir. This experience had shown that the judicial use of canal water can bring miraculous results.

Presently, Ghoda feeder canal of Fatehwadi irrigation project drains into the lake, through which excess water drains into the area. However, the quantity of water is so limited at present that there is hardly any sizable quantity of water had been poured in the lake so far. This is also because of requirement of water within the command area of Fatehwadi Canal.

Considering these aspects, the impact of SSP on the Nal ecosystem can be viewed mainly on following aspects.

a) Flow of residual fertilizers and pesticides into the lake area from the surrounding zone of the catchment and its likely impact.

b) Whether the Nal can be filled artificially through the canal water without any negative impact on the ecosystem or not.

c) Whether the project will cause any other direct or indirect impact on the ecosystems of the area or not.

For the assessment of above aspects certain baseline information is necessary. Though the sanctuary is established more than two decades ago, very recently it had attracted attention of few researchers. e.g. Tatu (1995), and hence detailed studies pertaining to various components of the ecosystems was felt necessary. That too, particularly with a view to know whether Narmada water can be utilised for the benefit of the sanctuary, or not, and also to know likely impacts of proposed canal network around the sanctuary.

2.8 Objective of the study

As per the TOR, the main objectives of EIA of Nalsarovar are as under :

1. Study on physico-chemical properties of soil and water of the area.
2. Study on avifauna of the area including their habitat preference and feeding habits.
3. Study on fish fauna of the area.
4. Study on zooplanktons, zoo-benthos and other arthropods in the area.
5. Study on algal flora as well as other vegetation of the area.
6. Stud on various land cover/land use pattern of the area as well as seasonal variation in the water spread of the Nal by using remote sensing technology.
7. Socio-economic survey of the surrounding villages and their relationship with the ecosystem.

On the basis of above studies, it is also ained to assess what level of depth of lake can be maintained with canal waters (if found appropriate) for optimum benefits to the sanctuary.

The initial proposal made by the Foundation was for the period of three years. However, as per the requirements of NPG, studies for a period of one year were planned. As the studies were delayed due to various reasons, it has been possible to incorporate data for more than two seasonal cycles.



Nalsarovar is a natural shallow lake, which is an old marine inlet, silted up in recent times. Nalsarovar is a depression between the head of the Gulf of Cambay and the Rann of Kachchh. The lake receives water mainly through two rivers, the Bhogavo and the Brahamni, which drain into the lake. A small quantity is also received through the surrounding catchment area. The lake ecosystem is considered as *lentic ecosystem* as its water remains stagnant for most part of the year, excepting the period when it overflows.

As the area is an old marine inlet and also receives water from its catchment it can greatly influence the physical and the chemical properties of soil and water. Considering the fact that properties of water and soil, influence the biotic component of the lake and the dynamic nature of the ecosystem, it was felt necessary to study various parameters of water and soil. Moreover, in light of likely inflow of fresh water from SSP canal and its impact on the area, it would be necessary to know these aspects.

For the purpose of analysing water and soil, samples were collected from predetermined sampling sites. Sampling sites were selected in the manner that it includes inlet and outlet points of the lake as well as various parts of the lake. Apart from predetermined sampling sites, samples were also collected from other sites as and when felt necessary.

Standard methods as described by APHA, and few others, were followed for analysing various parameters of soil and water, results of which are narrated in the following sections.

3.1 Analysis of water

3.1.1 Temperature

Data collected on temperature shows that distinct thermal stratification does not take place in Nalsarovar. The average variation between the atmospheric temperature and that of water was found to be 3^0 to 4^0 C. The variation in the temperature regimes of water at the surface and below the surface was negligible, which might be due to the shallowness of the lake and the stagnant water.

Vijayan (1991) had also recorded similar observations at the wetland of Keoladeo N.P. (Bharatpur) and observed that temperature of water and air runs closely during the winters.

3.1.2 pH (Hydrogen ion concentration)

pH value measured at various sampling sites are shown in the table 3.1. It can be seen from the table that initially when rain water drains into the area its pH value is between 7.0 and 7.5, indicating almost neutral character. It is likely that the rain water during the run-off might be draining some amount of salts from the surface which are alkaline in nature, due to which the water shows slightly alkaline pH, i.e. 7.5. Moreover, in the beginning of the rainy season, the lake water is more alkaline, which after getting mixed with the fresh water gets diluted and the lake water shows slight alkalinity.

Table - 3.1 Seasonal variation in chemical composition of water in NalSarovar

Sr. No.	Sampling site	Season	pH	Chlorinity	Alkalinity		Hardness		Temp	DO
				ppm.	CO_3 mg/l	HCO_3 mg/l	Ca^+ mg/l	Mg^+ mg/l	°C	mg/l
1	Brahmni River	Post monsoon 1994	7.0	141.80	12.0	170.0	8.80	8.86	22	
		winter 1995	7.5	1915.67	12.0	122.0	19.20	71.24	20	3.6
		Summer 1995	7.5	4882.46	18.0	183.0	20.18	106.02	30	
		Post monsoon 1995	10.0	2204.99	0.0	85.4	163.90	124.70	27	4.8
		Winter 1996.	8.5	1687.42	0.0	280.6	46.20	19.39	-	
2	Lhasa bet	Post monsoon 1994	7.5	694.95	60.0	97.6	10.40	13.17	23	
		Winter 1995	7.5	744.59	60.0	134.2	9.60	36.64	20	1.6
		Summer 1995	7.5	3332.95	12.0	109.8	29.96	34.16	30	
		Post monsoon 1995	10.0	1276.20	36.0	213.5	84.10	84.39	22	
		Winter 1996 .	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-	
3	Damyanti Point	Post monsoon 1994	7.0	191.46	48.0	0.0	3.20	7.80	23	
		Winter 1995	7.5	886.40	0.0	97.6	12.00	23.18	21	2.0
		Summer 1995	7.5	1694.84	1.0	67.0	11.77	123.43	30	
		Post monsoon 1995	10.0	936.62	24.0	36.6	23.12	18.15	23	
		Winter 1996	7.5	2410.60	36.0	219.6	67.20	16.34	-	
4	Surbet	Post monsoon 1994	7.5	290.70	36.0	12.2	3.20	5.36	-	1.0
		Winter 1995	7.5	587.97	0.0	134.2	8.00	19.52	20	
		Summer 1995	7.5	3332.95	12.0	104.8	15.97	8.34	30	
		Post monsoon 1995	7.5	2566.58	N.A.	N.A.	N.A.	N.A.	23	2.8
		Winter 1996	N.A	N.A.	24.0	280.6	113.40	19.88	-	
5	Dharabla	Post monsoon 1994	N.A	N.A	N.A	N.A	N.A	N.A	-	
		Winter 1995	7.5	886.40	12.0	97.6	10.40	24.15	24	6.4
		Summer 1995	7.5	2106.14	19.0	115.4	15.13	37.64	30	
		Post monsoon 1995	10.0	2063.19	30.0	48.4	21.02	19.37	25	
		Winter 1996	7.5	3190.50	60.0	30.5	100.80	39.77	-	
6	Limsi bet	Post monsoon 1994	N.A	N.A	N.A	N.A	N.A	N.A	-	
		Winter 1995	7.5	496.39	0.0	109.8	10.76	29.76	26	
		Summer 1995	9.0	N.A	9.0	115.9	44.10	13.17	32	
		Post monsoon 1995	10.0	957.33	18.0	36.6	26.91	27.59	25	
		Winter 1996	8.5	2226.26	24.0	48.8	25.20	37.10	28	2.4

7	Panvad bet	Post monsoon 1994	N.A	N.A	N.A	N.A	N.A	N.A	24	
		Winter 1995	7.5	921.88	12.0	97.6	6.40	13.17	25	
		Summer 1995	7.5	4963.98	N.A	N.A	N.A	N.A	30	5.8
		Post monsoon 1995	10.0	645.31	42.0	207.4	31.11	37.54	30	
		Winter 1996	8.0	1212.39	75.6	541.0	121.80	37.10	-	

It was observed that during 1994-95, at majority of places pH remained between 7.0 to 7.5 till the beginning of the summer and then shown a rise. However, at some places, e.g. Limsi and Takhuda bet pH value of 9.5 and 8.0 respectively were recorded in the beginning of the summer itself, which might be due to localised effect as these areas are having elevated bed. The rise in pH continued even up to postmonsoon period, and went up to 10. This was mainly because of less rainfall, due to which there was very less inflow of fresh water. The scum was formed much earlier which might have shown impact. However, findings of HCO_3 and CO_3 values have failed to establish any definite correlation with the increase in pH values. This aspect is further discussed in the section 3.1.5 pertaining to alkalinity.

3.1.3 Chlorides

Values obtained for Chlorides (Table-3.1) in the lake water show typical conditions prevailing in the area due to its geological structure. Chloride content has been found increasing from post-monsoon through winter to summer, being lowest in the post-monsoon and highest in summer. The reason for this can be attributed to the soil at the bottom and climatic conditions prevailing in the area. Chlorides being water soluble, leach down on accumulation of rain water in the lake and hence the low values during the monsoon and post-monsoon period. Once the monsoon is over, and inflow of water is ceased, there is a gradual shrinkage of the waterbody due to the evaporation which accelerates with the rise in the temperature. As a result, chloride concentration increases. On the other hand chlorides, mainly $CaCl_2$ and/or $MgCl_2$ come up and ooze out by the capillary action. Resultantly, chloride concentration reaches the peak during the summer.

The trend observed clearly indicates its impact on the vegetation. During winter of 1995, it was highest at Nal-Brahmini river junction which was without any vegetation. Such areas, when dry up fully, show salt encrustations on the upper surface of the soil.

It has also shown inherent salinity of the soil. Sen et al (1982) had also observed similar phenomenon in the areas of western Rajasthan where chlorinity in water is inherent in nature. Vijayan (1991) had also observed rise in chlorinity during the summer at Bharatpur.

3.1.4 Dissolved Oxygen (DO)

DO was found generally within the normal range indicating that oxygen is not a limiting factor. However, at least one sample collected near Dhrabla bet had shown very low DO. As this is a bet area with a large number of algae growing along with sedges and reeds, it is likely that oxygen is consumed by these vegetation as well as gastropods, fishes, etc., to the extent that no sooner oxygen is evolved it is used by the living organisms. Low oxygen value also indicates its chemical use, as there are large number of salts, i.e. carbonates and bicarbonates.

Vijayan (1991) relates this kind of fluctuation in the level of DO with the growth of aquatic microphytes and decomposition of the macrophyte litter.

3.1.5 Alkalinity

Alkalinity is measured by carbonates (CO_3) and bicarbonates (HCO_3) present in the water. The trend observed is quite similar to that in the case of *chlorides* and *hardness*. During monsoon, when there was fresh inflow of water, alkalinity was low, which gradually increased in winter and reached to highest during the summer.

However, when the results are compared with respect to various places, it seems that it varies with places and also varies with the drying process. It is evident from the results observed (Table-3.1) that alkalinity from post-monsoon period onwards, is almost highest at Brahmni river which is the main source of water for the lake. At this site, drying process is also faster due to its higher elevation.

Changes in carbonates and bicarbonates also depend upon release of CO_2 through respiration of living organisms. This is also used by aquatic vegetation for photosynthetic activities, but eventually, when organisms die due to decomposition CO_2 is released, which forms carbonates and bicarbonates. They are also helpful in maintenance of lake water/soil pH, providing a buffering action. When vegetation dies out, acids are also released. These acids may restore pH of the soil and/or water. Such transformations from alkalinity to acidity or vice versa periodically occur, thereby not affecting pH drastically. It is called buffering action.

Bishop (1973) observed that the total alkalinity declined during the monsoon season due to incoming of rain water leading to dilution of ionic content of the waterbody. Poorly drained soils may give basic reactions as a result of which either $CaCO_3$ or Na_2CO_3 or both salts will effervesce with HCl. A pH above 8.4 certainly indicates higher Na_2CO_3 (Daubenmier, 1950).

3.1.6 Hardness

Total hardness (Table-3.1) was also found highest in surface water near Brahmni bank followed by juncture of the Brahmni river to the lake's surface water, but again in the vegetated area it was less. Hardness increases with hot day, as summer season approaches. Low hardness in early February may be because of high volume of water as well as vegetation. Number of plants - macrophytes and algae use CO_3 and hence CO_3 amount reduces. Calcium and Magnesium being used up/absorbed by living organisms, hardness is low when vegetation decomposes, they are released back into the substratum, increasing hardness thereby.

The hardness is either due to Ca or Mg. Both Ca and Mg show variable concentrations from place to place in the sampling sites. Generally, both of these elements are lower in monsoon and winter. This is because of their uptake by all the living organisms when the lake is full of water (Vegetation, gastropods, molluscs, fishes - all these absorb Ca and Mg and are released back into substratum by the process of decomposition). Thus during monsoon in the year 1996 the lake's water volume was low and therefore these elements were higher in February 1996 because of shrinking of water volumes and disappearance of vegetation. Palmer (1967) and Graham *et al.* (1974) have reported higher value of calcium in fertile water. Zafar (1964) considered Ca as an important factor which influenced the distribution of diatoms in waterbodies.

Among these two elements, Mg is in greater proportion than Ca as the lake is a relict sea and sea water has greater Mg as compared to Ca.

3.2 Soil analysis

3.2.1 Geological aspect of the area

Prasad *et al* (1997) of PRL, Ahmedabad studied area which is bound in the west by basaltic trap rocks of the Saurashtra and the north-west by the Jura Cretaceons sandstone. The extreme north-east is constituted by the igneous and metamorphoic rocks of the Aravallis. In the immediate east are the Quartenary alluvial plains, occupying the Cambay basin. All these indicate evidence of tectonism in the form of entrenched streams, cliffy sections and fault controlled river carves (Sridhar, 1995).

On the basis of soil characteristics, they divided the area into three lithounits from the core obtained.

Horizon-3 (18-45m) clay and silty and silty clay with occassional sand lenses and basalt fragment base not reached.

Horizon-2 (18-3m) clayey silt with organic matter and shells of isttium and land snails.

The presence of red beds (10-14m) is indicative of subaering exposure, presence of gypsum at 4m-7m depth also indicate a period of an arid period.

Further discussing and explaining the presence of thick sandy horizon in the basewell section in the entire Nal region, the PRL team observed that during its deposition the bulk no longer existed to the region and high energy fluvial sediments were being deposited in the river bed.

Horizon-1 is dominated by clay-mineral matrix indicating the source of sediments to be from east and north-east. The S13C and C/N rations of organic fraction from this horizon reported by Prasad *et al.* (1997), indicate the lacustrine conditions started slowly setting in and the area consequently and subsequently transformed into a closed basin.

It is thus clear from this sediment core study by PRL team that the soil is silty/clayey overlaid by sand which is also revealed in analysis of various soil samples.

As originally it is a marine formation, salinity of waters and soil is very evident.

Discussing the origin of the saline basins of Rajasthan, Sen *et al.* (1982) explain it as a process of evaporation of collected water leading to drying of the soil surface then gets covered with a white crust of salt in the form of patches; these patches consist of clayey soils with salt deposits. A similar situation also exists with regards to salinity of Nalsarovar where also one observes white salt crusts on soils dried up or drying throughout the Nal Kantha region. *Suaeda* which is a typical halophyte i.e. saline plant was observed in the vicinity of this patch. We observed wheat and 'Dillo' being harvested. The halomorphic soil is typical of Bhal region,

Table 3.2 Analysis of soils of Nalsarovar (physical parameters*)

Sr. No.	Sampling site (zone)	Bulk density (g/cm^3)	Sp. gravity	Soil texture %			Water holding capacity	Soil moisture %	Electrical conductivity (μ mho)
				Sand	Silt	Clay			
1	Brahmni	1.38	1.54	50.36	17.82	6.11	20.58	16.2	715
2	Lhasa	0.97	1.06	47.67	16.64	28.12	26.2	8.92	3912
3	Damyanti	0.96	1.06	55.2	20.42	13	33.21	19.68	5700
4	Dharabla	1.14	1.31	58.47	21.54	19.86	28.41	32.07	3640
5	Panward	1.24	1.36	67.36	21.56	11.02	32	0	8200
6	Limsi	1.1	1.15	52.12	28.77	18.96	32	29	11263
7	Between Limsi-Vekaria	0.96	1.29	39.2	27	34	N.A**	N.A	0
8	Vekaria	0.99	0.8	52.6	19.6	16.2	15.6	26	20600
9	Ranagadh	0.95	1.44	63	23.73	13.12	9	13.76	7570
10	Takhuda no Jharo	0.99	1.11	N.A	N.A	N.A	40	27	2600

Notes : * Average values of samples analysed.
**N.A. Not analysed.

Table - 3.3 Soil analysis (chemical parameters, mg/g)

Zone	Season	Chlorinity	Alkalinity	Ca	Mg	Na^+	K^+	Organic carbon	Organic matter
Brahmni	Winter - 94	0.838	0.927	0.020	-	-	-	-	-
Brahmni	Post monsoon- 95	0.770	1.600	-	-	-	-	-	-
Brahmni	Winter - 95	10.406	0.594	-	-	0.532	0.007	0.936	5.430
Dharabla	Winter - 95	2.647	0.957	0.060	0.039	0.030	0.001	-	-
Dharabla	Summer - 95	2.710	0.966	0.099	0.010	0.023	0.004	-	-
Dharabla	Post monsoon- 95	0.501	1.800	0.020	0.008	0.013	0.003	-	-
Dharabla	Winter - 96 (a)	7.837	3.265	0.050	0.008	0.247	0.002	6.320	36.667
Dharabla	Winter - 96 (b)	5.870	74.930	0.110	0.405	0.435	0.005	-	-
Dharabla	Summer-96	16.130	0.940	0.090	0.080	0.011	0.002	-	-
Lhasa	Post monsoon-94	0.838	0.927	0.020	0.077	0.012	0.020	0.594	10.240
Lhasa	Winter-95	3.176	2.710	0.020	0.004	0.040	0.005	0.590	10.240
Lhasa - 1	Summer-96	11.090	1.360	0.300	0.210	0.046	0.001	0.669	11.540
Lhasa-1B	Summer-96	9.398	0.450	0.090	0.070	0.025	0.003	0.620	10.780
Lhasa - 2	Summer-96	1.710	0.480	0.020	0.120	0.330	0.020	0.570	9.830
Surbet	Winter-95	0.093	0.810	0.050	0.001	0.016	0.001	-	-
Surbet	Winter - 96 (c)	58.383	3.334	-	-	0.465	0.004	-	-
Surbet	Summer-96	13.060	1.410	0.110	0.200	0.080	0.002	-	-
Limsi	Summer - 95	0.886	0.865	0.028	0.030	0.008	0.002	0.660	11.500
Limsi	Post monsoon- 95	0.053	1.440	-	-	0.532	0.007	-	-
Limsi	Winter-96	0.079	0.015	0.110	0.035	0.056	0.004	4.611	26.750
Ranagadh	Post monsoon	0.086	2.450	-	-	-	-	-	-
Ranagadh	Summer-95	1.025	0.930	0.030	0.040	0.330	0.020	-	-

Ranagadh	Summer-96	18.120	1.020	0.840	0.390	0.260	0.110	0.928	12.950
Damyanti	Summer-95	1.994	0.978	0.070	0.040	0.016	0.004	0.660	11.540
Damyanti	Winter-96	10.830	15.200	0.120	0.364	0.503	0.006	0.171	2.953
Damyanti	Post monsoon	0.429	1.627	-	-	0.200	0.001	-	-
Damyanti	Winter-96	0.058	0.011	0.130	0.427	0.115	0.016	-	-
Damyanti	Summer-96	Very high	1.310	0.830	0.440	0.190	0.100	0.700	12.000

indicating soil spread over a 1-1/2 sq.km between Shiyal and Sanknera, southern part of the lake. Elsewhere some isolated individuals of *Suaeda* are seen scattered here and there. *Cressa critica* another halophyte is very common, along with *Aeluropus* sp. and *Sporobolus orientalis*.

3.2.2 Soil texture

Mostly soil samples show a greater proportion of sand than silt and clay (Table- 3.2.) One possible explanation that most of the bets are flooded by water from upstream which bring sand along with water and hence sand fraction is high. However, analysis of soil texture of the bottom sediment, (i.e. when water recedes, lake dries up) has shown that the soil exhibits a typical lacustrine feature, i.e. silty-clayey. This is evident on drying soils, from land showing black patches and charred masses. This claey part or fraction of Nal region makes its soil and land highly waterlogged.

3.2.3 Waterholding capacity

This depends on texture of the soil. In fine-textured soils, there is more aggregate surface to accommodate films, and consequently more colloidal material and more can be held per unit of volume of soil than coarser soils. However, up to certain extent it would also depend on hydrophilic compounds other than colloidal ones. Soils in the upper strata of study area have greater proportion of sand relative to silt and clay. Hence water holding capacity and soil moisture content are lower (Table-3.2).

However, despite of more proportion of sand in the upper strata of the lake bed, there is relatively less percolation or seepage, due to high proportion of clay and slit below it and due to higher water table which makes area capable to retain water within it.

3.2.4 Bulk density and specific gravity

The data on bulk density of soil samples collected from different places and time does not show any variation and is more or less the same as can be seen from Table-3.2.

Normally the bulk density ranges from 1.1. to 1.5 g/cm^3 for medium to fine textured soil and from 1.2 to 1.65 g/cm^3 for the coarse textured soil. Soil samples with more of organic matter have relatively less density. The alkaline soils have a slight higher bulk density. The soils with high bulk density are inhibitive to root penetration, low permeability and infiltration. The bulk density is inversely related to pore space of soil. Most of the soil samples collected in the present study have shown that bulk density falls within the normal values.

The specific gravity also does not show any variations with reference to place and time of soil sampling (Table-3.2).

3.2.5 Electrical conductivity

This is the parameter showing total electrolytes present over soil micelles of colloids. Thus highest EC values are found in clayey soil in general and lowest in sandy soils. Lowest EC values, however in some silty soil especially indicate that electrolytes/ions are not yet

released by the decaying biota. These soils are poor in minerals though values of EC in the silty/clayey soil is due to the faot that the micelles of colloides in these two types of soils have greater tendency to adsorb electrolytes.

When the water volume is high in the lake, soil EC value is less i.e. a dilution factor is seen in the water of lake and hence electrolytes are showing low values. Another possibility of low EC value concomitant with high water volume is because all living organisms - plants, macrophytes, microphytes, gastropods, fishes, insects-require these electrolytes as biogenic salts, and also for osmoregulation in water. But as the summer approaches, EC values also rise because of their (electrolytes) release through decomposing matter.

However, there are site-wise variations, and also seasonal variations were discerned even in winter or post-monsoon period of the year 1995-96. EC values were higher perhaps because during that year, the monsoon was weak, less volume of water in the lake and also shrinkage of lake had started in early winter.

3.2.6 Organic matter

The nature and amount of organic matter greatly influence site quality, soil texture and structure, water holding capacity, availability and abundance of nutrients etc. Organic matter was found higher in soil samples from Lhasa bet. The variations observed in organic matter at various places indicated the time to decompose, total quantity present and available for decomposition, the decomposers themselves and their activity etc. These are not constant or fixed and hence variation were found among various places, as can be seen from Table-3.3.

3.2.7 Organic carbon

The total organic matter includes all organic compounds, whereas organic carbon represents amount of carbon containing compounds, i.e. polysaccharides like starch, sugars, organic acids, citric acids, aspartic and other C4 compounds, ribuloses etc. Its minute quantity indicate a better or greater rate of decomposition when the decomposition yields CO^2 which may be again trapped by plants for photosynthesis or may enter the atmosphere.

3.2.8 Sodium

Sodium content is high in soil sample collected from the Brahmni river as well as near some bets, elsewhere, it is low as mentioned in the case of chloride, alkalinity etc. Sodium content is generally lower when water volume is high. These values correspond with those of chlorides in many (though not all) soil samples.

3.2.9 Potassium

Potassium is generally low; soils in general are deficient in "K", although this amount observed may be adequate for vegetation growing there.

3.2.10 Chlorinity

Increase or decrease in amount of soil chlorides is correlated with seasons. Chlorides show a decreasing trend with increase in water volume. Thus in post-monsoon months, it is quite low being water soluble. But when water-spread area shrinks, i.e. with reduction in volume of water, chlorides increase. The solution becomes more concentrated till saturated, and as being water soluble, all chlorides leach down in the lower soil horizon but come up with capillary rise. Water, therefore, remains sweet and potable when lake has a greater or large volume of water and the soil also reflects the similar trend.

3.2.11 Alkalinity

The similar trend is discerned as with chlorides, generally it is less in monsoon and post-monsoon. However, at certain sampling sites especially in winter of 1996, it was higher because of drying processes. But on the whole, soil alkalinity is quite low. It is known that the soil has a buffering action, a lot of acidic and basic ions are present in the soil which help in maintaing the soil pH (Daubenmire, 1950; Oosting, 1958).

3.3 Chemistry of water and the vegetation

It may be mentioned here that the water chemistry of Nalsarovar is typical of tropical lakes in India found elsewhere; moreover it is a seasonal lake and not a perennial one. Hence the seasons and climate affect and influence its chemistry, showing similar trend every year. The data analyzed for the past three years exhibit the same trend every year, although actual values of a particular year and site may vary, yet rise and fall pattern is observed, i.e. when the monsoon water are filling the lake they dilute all chemicals, gradually rising through evaporation processes when volume of water shrinks or starts shrinking. When the lake is full of water past after monsoon, it is also full of vegetal cover with *Naias* spp., *Vallisnera spiralis, Hydrilla* sp., *Chara* sp. and *Nitella* spp., and a number of benthic and epiphytic algae and other algae. This vegetation helps in maintaining water chemistry e.g. utilising CO_2 in photosynthesis, releasing simultaneously oxygen absoring biorganic salts/ions like Ca, Mg, K and others. Further, the emergent vegetation of sedges, grasses and cattails with their air spaces or aerenchyma tissue help maintaining the gaseous exchange apart from providing roosting etc. for birds.

A large number of gastropods, other molluscs and algae thrive there. The biodiversity in terms of macrophyte plants is sparse. But quite a good number of algae exist there which are primary producers.

Changes in algal composition and dominance of cyanophytes or chlorophytes are in agreement with similar changes elsewhere. Besides the present hydrophytes, species, like *Potamogeton, Ceratophyllum* could also be introduced to enrich diversity.



4.1 Introduction to remote sensing

Remote sensing is the science and art of making inferences about an object or area or phenomenon from measurements made at a distance without coming into physical contact with the object under study (Lillesand and Kiefer,1979).

4.1.1 Principles of remote sensing

Remote sensing is largely concerned with the measurement of electromagnetic energy from the sun which is scattered or emitted by the object on the surface of the earth. Different objects on the surface of the earth reflect different wavelengths of electromagnetic spectrum. In remote sensing technique the most useful regions of EM-spectrum are visible, the reflected infra-red, thermal and microwave region.

The distance sensing of objects through non-contact methods involve the use of electromagnetic radiation (EMR), emitted by the object. These radiations which are reflected and emitted by objects are recorded by the sensors on the earth observation satellites. The reflection or emission patterns (normally referred to as its spectral signatures) by any object is very much dependent on the wavelength of the energy evolved and is also specific to the object depending primarily on the atomic or molecular composition of the object. The whole edifice of remote sensing is based on this unique spectral signature of objects (Lillesand and Kiefer,1979).

4.1.2 Image interpretation

The main objective of image interpretation is to extract information about features displayed in an image. It is defined as the act of examining images for the purpose of identifying object and finding their significance(Manual of Remote Sensing,1960). Interpreter studies remotely sensed data and attempts through logical processes in detecting, identifying, measuring and evaluating the significance of physical and cultural object, their patterns and relationships (Manual of remote sensing, 1960,Vol-I, p.369).

There are certain fundamental photo elements or image characteristics seen on an image which aid in the interpretation of satellite imagery. Although there is a difference of opinion on the number of elements to be included, there is a general consensus on tone or colour, pattern, texture, size, shape, location, association and converging evidence.

4.1.3 Resolution

Resolution plays vital role in remote sensing which is a measure of the ability of an optical system to distinguish between signals that are spatially near or spectrally similar (Swain and Davis,1978).

The resolution of Indian remote sensing satellite IRS-1B data is 36.25 m in case of LISS-II data whereas it is 72.5 m for LISS-I. The resolutions of LANDSAT (American Satellite) TM and MSS data are 30 m and 79 m respectively.

4.2 Methodology

In the present study the visual interpretation method has been adopted for interpreting the remote sensing data. Methodology flow chart is shown in Figure-4.1.

The environs is the area between the sanctuary boundary and the nearest villages located around NBS. This area has been selected after deliberation with other teams engaged in the study and the officials of Forest Department.

4.2.1 Selection of data

The basic remotely sensed data available for interpretation have been the imageries of LANDSAT MSS and TM, IRS, LISS I and LISS II and SPOT satellites. LANDSAT TM and IRS LISS II data are ideally suited for present study. In case of unavailability of LANDSAT-TM data, LANDSAT - MSS data have been used.

4.2.2 Data used

In the project proposal of EIA studies for Nalsarovar Bird Sanctuary, it was proposed to identify various land cover and land use classes of wetland and other than wetland of the study area by using satellite imageries of 1975,1980,1985 & 1992.

The project proposal was prepared in 1992 and its implementation has been taken up recently (November 1994), therefore, the recent data are preferable. Moreover, it is better to consider drought period so that land cover/land use pattern can be known for the drought period and it will be useful in arriving at certain conclusion.

Considering the aforesaid reason and unavailability of data for the period prior to 1984, it has been necessary to deviate from the proposal for the data to be used for assessment in four different years. The detail of satellite data used is given in Table-4.1.

Moreover, the data of January/February, 1985 have not been available with NRSA and other institutions/offices in Gujarat, hence, for 84-85 the data of only two seasons viz. November, 84 & March, 85 could be used.

The following ancillary data have also been used during the course of the study.

i) Survey of India topographical maps on 1:50,000 scale (Map sheet no-46 B/1, B/2, N/13, N/14)
ii) Maps provided by NPG
iii) Map of Forest Department for Nalsarovar Bird Sanctuary
iv) Ground truth data

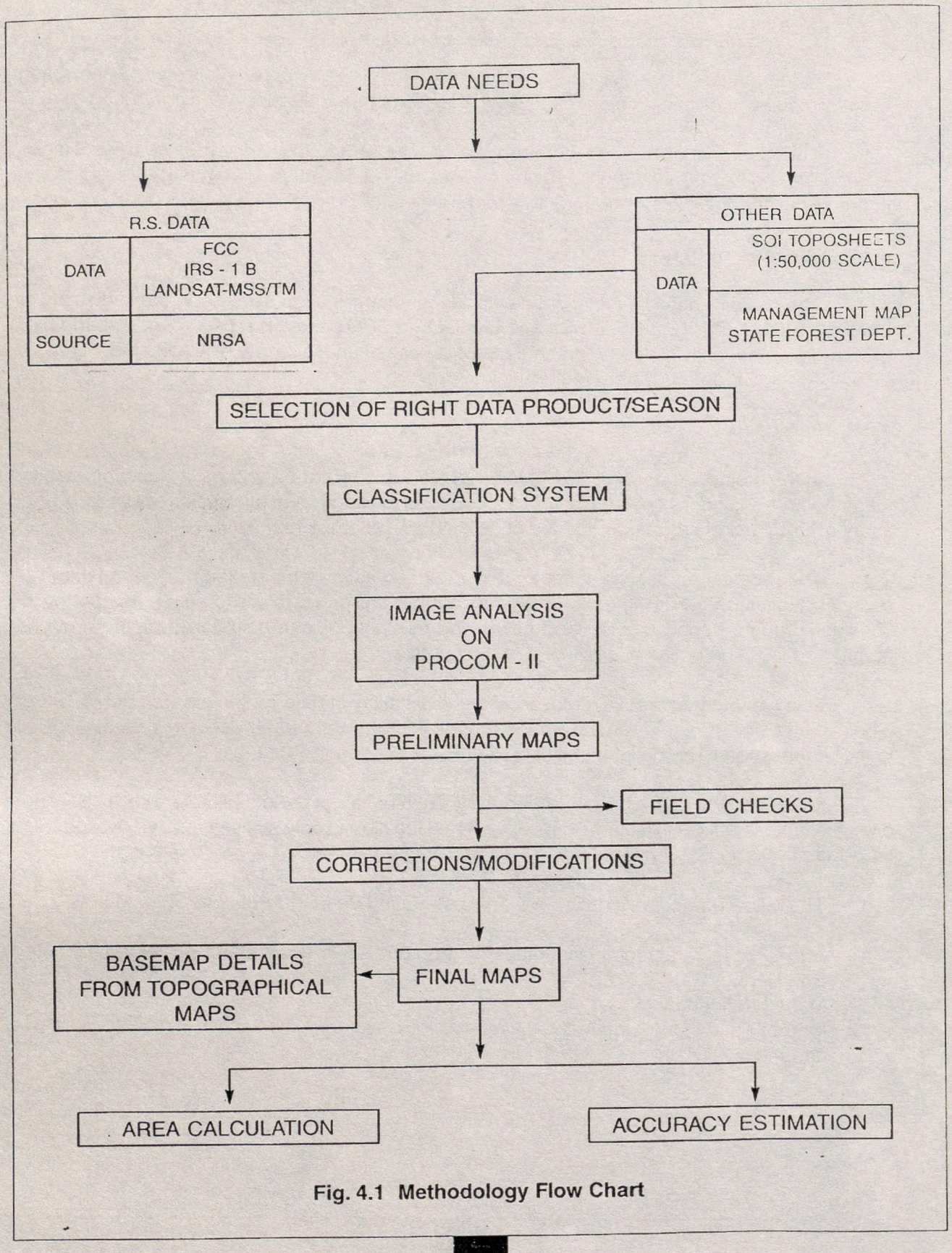


Fig. 4.1 Methodology Flow Chart

Table-4.1 Satellite data used for mapping

Satellite	Path	Row	Sub-scene	Product	Date
Landsat	149	44	-	MSS-FCC	18-11-84
Landsat	149	44	-	MSS-FCC	18-03-85
Landsat	149	44	-	TM-FCC	19-11-87
Landsat	149	44	-	TM-FCC	22-01-88
Landsat	149	44	-	TM-FCC	27-04-88
IRS 1B L2	32	52	A1	FCC	19-10-91
IRS 1B L2	32	52	B1	FCC	19-10-91
IRS 1B L2	32	52	A1	FCC	15-01-92
IRS 1B L2	32	52	B1	FCC	15-01-92
IRS IB L2	32	52	A1	FCC	04-05-92
IRS 1B L2	32	52	B1	FCC	04-05-92
IRS 1B L2	32	52	A1	FCC	14-11-94
IRS 1B L2	32	52	B1	FCC	14-11-94
IRS 1B L2	32	52	A1	FCC	10-02-95
IRS 1B L2	32	52	A1	FCC	26-03-95

Notes : FCC- False Colour Composite
MSS- Multi Spectral Scanner
TM - Thematic Mapper
L2 - LISS II
IRS - Indian Remote Sensing Satellite

4.2.3 Classification system

The classification system which has been evolved for this study is based on

i) Wetland
ii) Nature of vegetation.
iii) Management of Nalsarovar Bird Sanctuary
iv) Land use pattern

The classification of turbidity and different types of vegetation into dense and sparse is purely qualitative and based on visual appreciation of density as seen on the imagery. The classification system is given in Table-4.2

The effort has been made to provide such a classification system which would be useful in implementing various management practices in NBS and in its environs and in planning developmental activities in command area falling in environs of NBS.

4.2.4 Image interpretation key

Image interpretation key has been prepared with the help of ground truth information and Survey of India topographical maps on 1:50,000 scale. Inherent elements within an image that can provide clues towards the detection, identification, measurement of various features include tone, texture, shape, location and associated features.

On the basis of image interpretation key various classes like aquatic vegetation, open water, herbaceous cover, *Prosopis*, salt affected area etc.. have been delineated using false colour composites (FCCs) of satellite.

4.2.5 Data analysis

Various steps followed for interpreting remote sensing data are as under.

(I) The false colour composites (FCCs) of LANDSAT-MSS, IRS-1B, LISSII, have been enlarged by using an optical instrument PROCOM II and visual analysis has been done for delineation of various categories based on image interpretation key.

(II) The categories of very small size have not been made in order to avoid confusion in map reading and error in drawing inferences by the users of the maps.

(III) Interpreted details have been transferred to the base maps prepared from Survey of India topographic sheets. The base maps show details such as village, town, river, road etc.

(IV) All the doubtful areas were identified and listed for ground truthing. The ground truth verification of these area was done, which was considered for modifying subclasses.

Table - 4.2 Classification system for EIA study of Nalsarovar bird sanctuary

Level-I	Level-II	Level-III	Level-IV	Symbol	
				Sanctuary	Environs
Wetland	Open water	High turbidity	-	T_1	
		Moderate turbidity		T_2	
		Low turbidity		T_3	
	Aquatic vegetation	Emergent vegetation	Dense	EVd	
			Sparse	EVs	
	Islets	Non vegetated	-	BI_1	
		vegetated	Sparsely	I_2	
			Densely	I_3	
	Mudflat	Without vegetation	-	MF	M+F
		With vegetation	Dense	MVd	M+Vd
			Sparse	MVs	M+Vs
		Salt encrustation	-	SE	S+E
		Salt affected area	-	SA	S+A
		Salt affected with vegtation	-	SAV	S+AV
	Marshy vegetation	-	-	MSV	M+SV
	Waterbodies			WB	W+B
Other than wetland	Agriculture land	Cropland	-	AC	A+C
		Fallow land	-	AFL	A+FL
		Prosopis	Dense	Pd	P+d
			Sparse	Ps	P+s
		Herbs/Shrubs	Dense	Hd	H+d
			Sparse	Hs	H+s
	Barren area	-	-	B	B+
Other features	Road				
	River				
	Village				
	District boundary				
	Sanctuary boundary				
	Environs boundary				
	Canal				

(V) Final thematic maps have been prepared on 1:50,000 scale using Survey of India topographical maps.

(VI) Area of various classes of the final maps have been calculated using dot grip representing 1 dot=1.56 ha. and digital planimeter.

(VII) The accuracy of interpreted maps is about 85-90 %.

4.3 Result and discussion

As shown in the classification system (Table-4.2), various categories have been interpreted by using the satellite data of 1984-85, 1987-88, 1991-92 and 1994-95. The detail of habitat types (land cover classes) in NBS and land cover/land use classes in environs is given in table-4.3 and 4.4 respectively.

4.3.1 Nalsarovar bird sanctuary

NBS is categorised mainly into two categories viz. wetland and other than wetland. Under the 'wetland' category, 13 classes of land cover pattern have been identified and area of each class is given in Table-4.3. The analysis indicates that the wetland area covers about 105-110 sq.km (about 87-91%) of NBS.

4.3.1.1 Changes in open water habitat

Table-4.3 shows that the area under open water was the highest in 1984 which was the year of good rainfall and the lowest in 1987 which was the culminating year of three consecutive droughts.

In 1991 less than normal rainfall was received and the open water area was about 16 sq. km in good rain year of 1994 the area of open water was 25 sq. km at the end of monsoon season. It is observed that quantum and pattern of rainfall play significant role as far as water spread area is concerned.

The area under open water was 2.6 sq. km in 1987 which was the culminating year of the three consecutive droughts. There might be small pockets where the water might have been accumulated and depth of water might be very less, hence, the delineation of such small pockets was difficult.

As far as seasonal changes are concerned, the open water area has been reduced from post-monsoon to pre-summer season in 1984/85. It is observed that the area had increased slightly in winter as compared to post monsoon season in 1991/92 & 1994/95 mainly due to disappearance of emergent vegetation and to a lesser extent due to addition of water from the catchment area.

Nalsarovar dried up in summer of 1988 which was followed by the drought of 1987, and in May, 1992 the summer season was followed by less rainfall.

Table - 4.3 Habitat types (land cover classes) in Nalsarovar bird sanctuary using sattellite data of different years.

(Area in ha)

Category	Area in different years										
	1984-85			1987-88		1991-92			1994-95		
	Nov-84	March-85	Nov-87	Jan-88	April-88	Oct-91	Jan-92	May-92	Nov-94	Feb-95	Mar-95
Open water with high turbidity	7.8	-	263.6	-	-	14.0	157.6	-	32.8	130.4	93.1
Open water with moderate turbidity	1070.9	401.1	-	-	-	1087.5	283.9	-	624.7	1483.9	419.1
Open water with low turbidity	4283.70	3726.1	-	-	-	489.6	1268.9	-	1847.6	1212.4	3056.2
Total open water area	**5362.4**	**4127.2**	**263.6**	**0.0**	**0.0**	**1591.1**	**1710.4**	**0.0**	**2505.1**	**2826.7**	**3568.4**
Emergent vegetation-dense	3873.8	2649.8	-	-	-	5621	3801.7	1380.5	5885.1	5686.2	3751.7
Emergent vegetation-sparse	1014.8	2101.4	-	-	-	1119.5	1488.3	1154.9	1403.9	1133.3	1775.5
Total emergent vegetation area	**4888.6**	**4751.2**	**0.0**	**0.0**	**0.0**	**6740.5**	**5290.0**	**2535.4**	**7289.0**	**6819.5**	**5527.2**
Islets-non vegetated	25.0	-	31.2	293.3	199.7	28.0	64.0	68.6	15.6	28.1	12.5
Islets-vegetated sparsely	170.0	320.2	566.3	352.6	491.4	413.4	368.1	466.8	216.8	319.8	326.0
Islets-vegetated densely	146.6	87.4	53.0	96.7	121.7	132.6	198.1	196.6	126.4	44.6	56.2
Mudflat without vegetation	79.6	-	1855.3	2456.8	1869.0	113.9	388.4	2960.5	234.0	-	174.7
Mudflat with dense vegetation	201.7	919.5	5243.1	4118.8	4089.6	1485.2	1161.4	2113.6	291.7	333.8	615.1
Mudflat with sparse vegetation	275.3	815.8	3244.4	3235.1	3826.7	546.6	1652.1	2620.8	403.8	738.1	786.9
Salt affected area	9.4	223.0	26.5	32.8	42.1	7.8	-	39.0	92.0	70.2	25.0

Salt affected area with vegetation	99.8	23.4	79.6	757.9	673.7	165.4	399.4	3.1	32.8	51.5	124.8
Salt encrustation	-	-	-	-	-	17.2	-	256.1	-	-	-
Cropland	71.8	59.3	187.2	39.0	-	229.3	157.6	190.2	393.0	421.2	181.0
Fallow land	436.8	449.4	335.4	496.3	552.3	397.5	488.4	428.7	213.7	176.3	421.2
Prosopis-dense	26.5	18.7	7.8	32.8	20.3	109.2	37.4	39.0	126.4	88.6	53.0
Prosopis-sparse	139.1	134.2	118.6	95.2	108.3	59.3	135.7	113.9	39.0	82.7	124.8
Herbaceous-dense	68.7	42.1	23.4	12.5	-	26.5	28.1	14.0	57.7	53.0	54.6
Herbaceous-sparse	88.7	109.2	54.6	70.2	87.4	10.9	10.9	43.7	29.6	35.9	38.6
Barren area	-	-	-	-	-	-	-	-	-	-	-
Waterbody	-	9.4	-	-	7.8	15.6	-	-	23.4	-	-
Total area	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**	**12090.00**

Nalsarovar dried up completely in January, 88 during the winter season which was followed by the severe drought of 1987. As per ground truth information, Nalsarovar did not dry up even in May, 1995, however, it dried up in May, 92. Thus the area under open water during summer season has bearing mainly on the rainfall, the extent of open water during winter and withdrawal of water for irrigation purpose.

The highest per centage of open water area with lower turbidity was observed in good rainfall year of 1984 & 1994 whereas the highest per centage of open water area with medium turbidity was observed in October, 1991. Among the turbidity classes in different seasons the fluctuating trend has been observed, however, the area under low turbidity was highest in March, 1985, January, 1992 and March, 1995 due to settling of suspended particles.

4.3.1.2 Aquatic emergent vegetation

The analysis of satellite data has indicated that the area under dense and sparse emergent aquatic vegetation was about 46 sq.km (covering 38% of NBS) in November, 1984. It has been increased by 21 % in November, 1994 which was also a good rainfall year.

It is worthwhile to mention here that inspite of less than normal rainfall in 1991, the area under dense emergent vegetation has been marginally less, about 264 ha., than that of area in November, 1994 whereas it is more, by 2030 ha. than the area of same category in November, 1994 being good rainfall year.

In October, 1991, the emergent vegetation was also observed in the open water area which remained as an open water area in 1984 and 1994. This is another significant change observed in case of emergent vegetation. This may be due to profuse growth of macrophytes on water surface. However, the most of the emergent vegetation disappeared from this particular area in January, 1992 and transferred into open water area.

In the severe drought of 1987, the area under emergent vegetation was absent in November. However, the emergent vegetation might have come up in small and scattered patches during the rainy season, but it might have been affected by biotic pressure or adverse climatic condition prevailing due to drought.

The emergent vegetation has been observed mainly on south, south-west part of NBS and open water area. There had been pockets of such vegetation on open water area, near Dharabla islet in 1994 in north of NBS.

During the ground truth visits, it was found that the emergent vegetation mainly consists of *Cyperus spp.* and *Typha angustifolia.* The emergent aquatic vegetation seems to be the most efficient macrophytes in trapping the silt from land run off (Gaudet, 1974). Pearsall (1921) has pointed out that along the margins of lakes in shallow water, rooted plants hasten the basin filling process by trapping and consolidating the sediments. Moreover, macrophytes rooted in shallow water protect shores of lake subjected to large changes in water level (Gaudet, 1974).

Regarding seasonal change, it has been found that the dense emergent vegetation reduced drastically in January, 1992 by about 18.2 sq.km as compared to October, 1991. However, it has been marginally reduced in February, 1995 as compared to the area of November, 1994. Similar trend has been reflected in 1984 - 85.

The analysis of seasonal data has reflected the decreasing trend of the emergent vegetation cover after post monsoon period. From mid winter to summer period, the area under this cover has reduced sharply. Thus, the presence of higher water condition in the wetland for longer period had influence on seasonal spread of emergent cover.

4.3.1.3 Other classes

(1) The area under mudflat with and without vegetation cover was highest in 1987-88 being severe drought year. Overlay of thematic map of 1987-88 and 1984-85/1991-92/1994-95 indicates that the most of the area of mudflat with and without vegetation observed in 1987-88, has been mainly under emergent vegetation. Transformation of emergent vegetation into mudflat class has been pronounced from January 1992 to May, 1992. During this period, it has been observed that the mudflat area has become more than double.

(2) Islets- The area of islets shows fluctuating trend depending upon the water level in particular year and season. Dharabla islets has given prominent signature of vegetation due to presence of trees mixed with herbaceous cover on it. The major areas of islets have been sparsely vegetated and barren which are resting, roosting, and /or feeding sites for waterfowl.

(3) *Prosopis* cover- The area under *Prosopis* cover has increased by 29 hectare in March, 1995 as compared to April, 1988. Major area of *Prosopis* has been confined to north and south of Ranagadh village.

(4) Cultivation - Table 4.3 indicates that the area under cultivation (cropland and fallow land) has increased by about 98 ha. in 1994-95 as compared to 1984-85. The cropland area was highest in February, 1995 reflecting that the major area might be under cultivation of wheat, gram and cotton crop.

4.3.2 Environs of NBS

It covers the area between NBS boundary and first surrounding village. The total area of environs is 196.5 sq.km. In November, 1995, the wetland area was about 49% of environs. The detail of land cover/land use classes has been given as under.

4.3.2.1 Cultivation

Table 4.4 shows that major part of environs area was under cultivation in 1995. The area under cultivation (cropland and fallow land) has been increased by about 3500 ha. The area under the cropland was highest in February, 1995. Such trend indicates that the dominant crops might be wheat, gram and cotton.

Table - 4.4 Habitat types (land cover classes) in environs of Nalsarovar bird sanctuary using satellite data of different years

(Area in ha.)

Category	Area in different years										
	1984-85		1987-88			1991-92			1994-95		
	Nov-84	March-85	Nov-87	Jan-88	April-88	Oct-91	Jan-92	May-92	Nov-94	Feb-95	Mar-95
Open water with high turbidity	-	7.8	-	-	-	35.9	-	-	62.4	40.6	7.8
Open water with moderate turbidity	593.6	266.7	-	-	-	261.1	155.0	-	193.0	863.5	131.0
Open water with low turbidity	773.0	658.3	-	-	-	236.1	92.5	-	781.4	190.3	905.3
Total open water area	**1366.6**	**932.8**	**0.0**	**0.0**	**0.0**	**533.1**	**247.5**	**0.0**	**1036.8**	**1094.4**	**1044.1**
Emergent vegetation-dense	5127.9	1045.3	-	-	-	3433.1	2745.7	425.7	4628.7	2844.2	1942.7
Emergent vegetation-sparse	1749.3	5343.4	-	-	-	913.7	944.3	991.1	1410.3	1704	2190.8
Total emergent vegetation area	**6877.2**	**6388.7**	**0.0**	**0.0**	**0.0**	**4346.8**	**3690.0**	**1416.8**	**6039.0**	**4548.2**	**4133.5**
Islets-non vegetated	-	18.7	71.8	71.8	82.7	49.9	62.4	12.5	45.2	6.2	9.4
Islets-vegetated sparsely	144.2	140.4	174.7	157.6	301.4	257.4	124.8	271.4	42.1	107.6	160.7
Islets-vegetated densely	3.1	42.1	49.9	134.1	-	57.7	82.6	59.3	40.5	21.8	34.3
Mudflat without vegetation	422.4	210.6	2006.8	1723.2	1399.1	70.2	628.6	1475.5	675.6	21.8	277.7
Mudflat with dense vegetation	1138.3	818.4	2960.8	1854.4	2666.1	609.0	842.9	1675.1	383.1	263.7	837.9
Mudflat with sparse vegetation	1619.9	3022.5	5592.8	5102.0	4954.6	3582.8	3748.6	4535.1	1000.8	2993.7	2798.6
Salt affected area	109.7	76.4	90.5	898.8	443.4	6.2	29.6	60.8	316.7	65.5	92.0
Salt affected area with vegetation	597.5	256.6	671.0	1504.1	1247.6	357.2	145.1	249.6	142.0	358.8	135.8

Salt encrustation	-	-	-	-	31.2	45.2	54.6	197.1	-	-	-
Cropland	1310.6	359.0	894.6	429.0	391.1	2195.6	2349.8	886.0	2618.3	3933.8	2201.6
Fallow land	4382.7	5929.6	5967.9	6511.0	6873.6	6256.1	6608.2	7828.5	6411.8	5275.7	6963.8
Prosopis-dense	283.0	273.0	273.0	213.7	146.6	468.0	274.4	167.10	230.0	244.4	234.4
Prosopis-sparse	643.1	569.5	652.0	868.5	928.2	421.2	573.7	699.7	431.0	421.2	436.1
Herbaceous-dense	152.9	191.2	26.5	-	-	192.0	85.8	-	56.2	84.2	84.2
Herbaceous-sparse	332.3	384.6	183.4	161.5	171.9	175.1	101.4	110.8	154.4	182.5	184.1
Barren area	-	-	-	4.7	-	-	-	-	-	-	-
Waterbody	266.5	35.9	34.3	15.6	12.5	26.5	-	4.7	26.5	26.5	21.8
Total area	**19650.00**	**19650.00**	**19650.00**	**19650.00**	**19650.00**	**19650.00**	**19650.0**	**19650.0**	**19650.00**	**19650.00**	**19650.00**

4.3.2.2 Aquatic emergent vegetation

It has been observed that this class was another dominant class particularly after monsoon except in 1987. The area drastically reduced in May 1992 when the lake dried up, however reduction in area was not so considerable in 1984 and 1994, being good rainfall years.

4.3.2.3 Open water

The area under open water was more in 1984-85 and 1994-95 than the area in 1987 and 1991-92. It has been observed that the area under open water was completely dried up in 1987 and May, 1992 just like NBS.

The dominant part of open water area had been located in northern part of environs.

4.3.2.4 Other classes

(1) Mudflat with sparse vegetation has increased gradually except in 1987-88. Mainly emergent sparse vegetation and mudflat with dense vegetation has transformed into this category.

(2) The fluctuating trend has been observed in islets area which depended mainly on rainfall and water level in the lake. The area under sparse growth of vegetation has been more in mid winter season.

(3) As per 1995 data, the area under *Prosopis* and herbacious cover remained around 670 ha. and 621 ha. respectively.

4.3.3 Catchment area of Nalsarovar

The catchment area of Nalsarovar (without NBS) is 3082.5 sq. km. Landuse/landcover pattern is shown in fig. 4.4. The cropland area in the catchment was about 1321.19 sq. km whereas the area of fallow land was about 1250.52 sq. km in November, 1995.

4.3.4 Limitations

In case of 1984-85, LANDSAT MSS data have been used which have resolution of 79 m. Therefore, it had been difficult to identify small size area and certain categories. For 1987-88, LANDSAT TM data have been used which have the resolution of 30 m In case of 1991/1992 and 1994/1995, IRS-1B, FCCs have been used and resolution of the data is 36.25 m. In addition to better resolution the tonal distinction was sharp in the FCCs of 1991/1992 and 1994/1995.



5.1 Algal study

The distribution, density and diversity of algae in any aquatic ecosystem is result of interactions of various factors influencing the system. Algae connot survive without water, as it has accepted water in its environment and as habitat. The distribution of algae at different level depends mainly upon light and turbidity apart from the properties of water. Blooms generally develop on the surface of water and it can develop in any season. This indicates that any physico-chemical factor may become prime one to develop blooms on water surface.

In the aquatic ecosystem, algae play an important role. Apart from influencing availability of oxygen in water, various species of algae can influence the fauna which consume these species. For many species of fish, zooplanktons and zoo-benthos and many species of birds, algae is an important source of food. So far, no study has been done as regards to the algal flora of the lake and hence the present study reveals very valuable information not only from EIA point of view but for other purposes also.

5.1.1 Distribution and composition of algal flora of the lake

During the study period, total 48 species belonging to 4 groups have been recorded as shown in Annexure-1A. Cyanophyceae is represented most with 25 species forming 51.6% of the total species, while Chlorophyceae, Bacillariophyceae and Euglenophyceae are represented by 38.2%, 6.0% and 4.2% of the total species respectively. Though the diversity of algal flora appears to be less as compared to the macrophytes, its composition appears to be well represented in comparision to other wetlands. At Keoladeo N.P. (Bharatpur), though composition of phytoplankton had been found varying from year to year, Mixophyceae was found dominant while Chlorophyceae was co-dominant during most of the years (Vijayan, 1991).

As far as the distribution pattern of algal species is concerned, no definite pattern had been observed, except for the epiphytic species which was found on macrophytes. There appears to be more impact of water level on the distribution than any other factor. Even the seasonal changes observed in successional development of algal species are also mainly due to the water level, turbidity and time required for spores to develop and up to certain extent on the chemical properties of water.

5.1.2 Periodicity of occurrence of algae

In the beginning of the monsoon, the newly received water remains turbid because of sediments and soil particles which water has brought. Due to this, algal growth does not take place initially as the penetration of light is adversely affected. Algal growth starts taking place immediately, once the sediments and other particles settle down at bottom.

It is observed that during August to October the algal species from Cyanophyceae group are more in number. Generally the algae from Cyanophyceae and unicellular forms of Chlorophyceae develop after the receipt of first shower of monsoon. Gradually with increase of water in the lake, chlorophyceae starts showing abundance.

It is worth mentioning that as early as 1906, Fritsch has pointed out that the algal flora appearing and flourishing in a given waterbody, the total effect observed is the resultant outcome of several factors acting simultaneously. This also applies to Nal lake. In monsoon when the Nalsarovar is full of water many of the chemical parameters and hardness of water are at lower concentration as water flows from catchment area. This water is more turbid. The turbidity cuts the light and hence no algal growth takes place during July and August. After the settlement of sediments the lake becomes glassy transparent, still and stagnant and macrophytes along with algae come up and grow/establish well. During September the Cyanophyceae algae are more in number species wise while Chlorophyceae have less number of form. This may be due to following reasons :

1. The more depth of water.
2. The spores of Cyanophytes grow very immediately after receiving water.
3. The low level of dissolved CO_2 and oxygen.

Commenting upon the periodicity of Charales, Gupte (1961) states they occur in different seasons in different localities, e.g. Pal (1932), Dixit (1931,1930), Biswas (1950) reported their occurrence in August-October, whereas Gupte (1961) recorded charales occurring in September-October. In Nalsarovar they flourish between October-March.

Moreover during these months the colonial forms of epiphytic algae like *Chroococcus,Gloeocapsa, Aphanocapsa, Aphanothece, Merismopedja, Coleochaetae, Bulbochaete* are found growing in abundance. Other filamentous forms of Cyanophyceae like *Oscillatoria, Phormidium,* and *Scytonema* are also seen during these months near the islands and growing even as epiphyte on macrophytes. The forms of blue green algae or Myxophyceae, possess a high range of tolerance of temperature and chemical parameters of water. With lowering down of the temperature in winter and increase in Ca, Mg, Na and Cl *Oedogonium, Cladophora, Pithophora, Spirogyra, Zygnema, Ulothrix* start appearing and growing. *Ulothrix* and *Oedogonium* grow as epiphyte. *Coleochaete, Bulbochaete, Stigoclonium* are also seen growing as epiphytes on macrophytes-*Najas* sps.

During the months of October to December, *Najas gracilens* and *N. Marina* start growing as submerged vegetation. Certain patches of *Chara ethyrhrogyan* along with *Chara alobulance* and certain patches of *Nitella accuminata* are also found. Gradually by the month of January, they all occupy almost entire bottom of Nalsarovar. Many epiphytic algae of Cyanophyceae like- *Lyngbya, Aulosira, Oscillatoria* and *Rivularia* are growing on these plants along with *Oedogonium. Bulbochaete* and *Coleochaete* form Chlorphyceae as epiphytic algae.

As volume of water shrinks, the chemical parameters of water chlorinity, hardness etc. show high value. The increase in Ca, Mg and alkalinity influence the distribution and occurrence of algae. *Cladophora* and *Pithophora* grow abundantly during pre-summer and summer (when alkalinity is on increase). During January to March the low temperature is also effective for gamete formation hence *Chara, Nitella* like advanced algae looking like macrophytes develop their sexual reproductive structures and undergo the process of fertilization. The sporeling of *Chara* and *Nitella* are observed during October and March. These algae grow to their full form and are spread over a very large area of bottom of the lake during December to February.

During the early winter *Oscillatoria obscura, O. princeps, Phormidium bohneri, Chroococcus minor, Nitella accuminata, Eustrium elegence* etc. are found. The presence of Euglenoides flagellates, *Phacus* sp. and *Euglena* sp. indicates almost neutral pH values. Microphytes grow abundantly with increase of pH or more chloride or very high organic matter. With a shift in pH, there is also a corresponding change in algal flora, e.g. abundance of *Nitella* and appearance of euglenoides.

During summer *Chaetophora, Rivularia, Merismopedja, Gloeotrichia* are found growing on macrophytes like *Cyperus* and *Typha* (sedges and reeds) as epiphytes. These algae area having very thick mucilagenous covering or sheath. This type of covering protect the algae from high intensity of light and high temperature and from getting desiccated. pH values between 6.5 to 8.4 are suitable for algal growth while pH range below 5 and above 9 are detrimental for growth of algae (Ellis, 1937). Phytoplankton growth is maximum at pH range 5 to 8.5 (Robert et al., 1974).

(Along with mucilagenous algae, tuft of *Cladophora* is also found near island, during pre-summer and summer. This algae can withstand even high alkalinity, so when other chlorophyceae can not tolerate and hence are not observed, *Cladophora* and *Pithophora* are seen and in the mats formed by the filaments of this algae, many bulb of mucilagenous algae are seen entangled in it, thus providing a habitat niche.)

From the foregoing observations, the following periodic distribution/occurrence (i.e. periodicity) of algae is enumerated.

June - July	Nil
Aug. - Sept.	*Oscillatoria, Cytonema, Oedogonium, Spirogyra* (Veg.), *Ulothrix, Anabaena, Aulosira, Mougetia, Coleochaete* etc.
Oct.- Nov.	*Cladophora, Rivularia, Stigeoeclonium* (occasional) along with vegetative growth of *Chara, Nitella* etc. along with the above mentioned algae.
Dec. - March	*Chara, Nitella* in reproductive stage, *Spirogyra, Zygnema, Oedogonium, Cladophora, Pithophora, Lyngbya, Aulosira, Cosmarium* and many Euglenoids etc.
March - April	*Chaetophora, Gloeocapsa, Rivularia, Gloeotrichia, Aphanocapsa, Aphanothece,* etc.

A separate list is given mentioning algae with their abundance, habitat etc., in Annexure-1-A. Quantitatively, the growth of algae in terms of density, density of *Nitella* was recorded highest during the months of December to February, while during the summer, higher density of *Cladophora, Gloeotrichia* and *Rivularia* was recorded. Because of increase in alkalinity and temperature the thick musilage containing form of Cyanophyceae grow in abundance along with *Cladophora*, during summer, *Aphanocapsa, Aphanothece* and *Rivularia* along with

Microcystis ellens are found entangelled in the filaments of *Cladophora*. Microcystis appear to be of an exceptional occurrence, as it was found only at one place nearby a temporary hut built by local people to attract tourists.

5.1.3 Scum formation and algae

Scum formation is a very important phenomenon which is the result of death and decay of submerged vegetation by attack of aquatic fungi and other microbial organisms. On the lower surface of scum many Cyanophyceae algae area growing. Most of them are unicellular or colony of unicellular forms e.g. *Chroococcus Merismopedja, Microcystis, Gloeocapsa, Aphanocapsa,* etc. along with these, some filaments of *Oscillatoria, Lyngbya, Aulosira* and *Phormidium* also grow.

Because of scum formation, penetration of light in water is slightly affected. Scum formation cuts off photosynthesis.

Because of the scum formation and the chemical and biochemical reaction below it, the surface of water become more nutrient rich. This allows number of Cyanophyceae algae to grow. This is evident by dominance of Cyanophyceae among the species found growing in the scum. Macrophytes on disintegration or decomposition form a mucilagenous scum in which a number of fungi besides algae are seen. These algae on scum are *Oscillatoria*, *Aulosira, Chroococcus, Merismopedja, Johnbaptistia, Gloeocapsa, Cosmarium, Cloestarium* etc.

5.2 Macrophytes on bets and on the shoreland

Macrophytes, i.e. Pteridophytes and Angiosperms occuring in the area clearly indicates habitats and condition prevailing in the area of its occurrence. They indicate swampy, muddy, saline or sandy habitats and appear either seasonally or perennially.

It is observed that some of the species occur simultaneously on bets having specific condition, e.g. *Cressa critica* occupy saline niches, *Alhagi* sp. occupies sandy, etc.. In the extreme conditions of summer, only reed-meadow-sedges and grasses survive. *Aieurops, Suaeda, Tamarix, Alhagi, Solanum xanthocarpum* etc. also survive in dry habitats. Thus the floral diversity is rich in terms of macrophytes on bets as compared to that in the water body. Aquatic vegetation is dominated by *Najas* spp. which occupies most of open water zone, followed by *Vallisneria* and *Hydrilla*. At this stage, it is difficult to establish any correlation between the quality of water in the lake and the aquatic macrophytes occurring in the area.

It is observed that near most of the bets, there appears reed-meadow sedge, a seral stage where due to siltation, sedges, grasses and cattails grow abundantly. These include *Cyperus bulbosus* ('Thek') and *C. rotundus* ('Chiyo') which are also taken as food by local people. These plants also play an important role of air circulation in the lake, as they are hollow and possess aerenchymous tissues. They help in gaseous exchanges of CO_2 and oxygen, which are thus made available to the submerged species.

Najas spp. seem to be major species providing food to most of herbivorous avifanuna as their seeds are one of the major food items for such group of birds. Reeds and sedges provide resting, roosting or nesting habitat for many species apart from providing an excellent cover to many birds which take shelter in such habitats. A list of macrophytes recorded so far is given in Annexure-1 B.

Among the tree species *Prosopis juliflora* dominates on most of the bets, most of which are of shrubby appearance, seldomly attaining a height of more than 5 meters. On Dhrabla and Panvad bets, *Salvadora spp.* which have been planted a decade ago is thriving well, but are in bushy form. *Tamarix sp.* is not uncommon all over but its distribution is very sporadic. This species has been found as if it is struggling for survival, *Zizyphus* bushes are found mainly on Dhrabla and Chera bets.

It is worth mentioning here the names of two bets, 'Nana Chera' and 'Mota Chera' on northern part of the lake wich establish the occurrence of mangrove plant, 'Cher' (*Avicinia* spp.) in the area in distant parts. However, at present, it is absent.

The presence of *Ceasuilia axilloria, Ammania* spp., *Bacopa* sp. etc., in most areas along the shoreline indicates better soil conditions with less salinity and wet conditions. These species continue to exist till water is retained in the soil. Plants like *Pedalium murex, Physalia sp., Cleome sp., Polycarpea corymbosa* etc. appear during monsoon period and soon dries out once the monsoon is over. *Xanthium stromarium* an abnoxius weed appears at places along the shore and on some bets, which is indicative of excessive grazing in the area.

Within the tourist complex at Vekaria, Neem (*Azadirachta indica*) and few trees of *Kigelia pinnatta* and *Parkinsonia accuminata* are found, along with few *Eucalyptus* trees. These trees are extensively used by egrets, black ibis, crows, doves etc. for roosting. They are also used for nesting by crows, doves etc.

In the vicinity of the lake, outside the sanctuary area, *Prosopis juliflora* pre-dominates. 'Neem', 'Deshi baval', 'Pilu', *Prosopis cineria* etc. are other common trees found in the area. Any kinds of orchards do not exist in the vicinity.

6.1 Definition and general characteristics

Animals that inhabit the water column of ocean, lakes and rivers and lack the means to counteract transport currents are known as zooplankton as opposed to phytoplankton which are of plant nature. Bottom dwelling invertebrates and vertebrates or their larvae, filter feeding on detritus substances at the bottom of the waterbody are called zoo-benthos.

They constitute a major link between primary producers and higher trophic levels in aquatic ecosystem (Food-web of Nal fig.6.1). Many zooplanktons are capable of strong swimming movements and may vertically migrate to any depth. Even these good swimmers, however, lack the ability to maintain their position against the movement of large water masses.

Zooplanktons, like all organisms, have a range of environmental conditions to which they are adapted. The optimum environment for one species may be barely tolerable to another. Physical and chemical boundary conditions, including turbulence, light, temperature and salinity gradient are important in determining species make up zooplankton community.

6.2 Methodology

For the purpose of studying zooplanktons and zoobenthos, the entire lake area was divided into four zones, viz, (i) Vekaria zone (ii) Dhrabla zone (iii) Ranagadh zone and (iv) Brahmni river zone. Samples were collected from these zones, randomly during the periodic visits to the area during 1994-1996, and observations were recorded. In addition, samples were also collected from other sites whenever it was felt necessary. For identification of the planktonic forms, microscopes were used in the field and study was done *in situ*. Collection and preservation of various samples was done and such samples were brought to the laboratory for further study.

6.3 Occurrence and distribution

During the study period 76 species of zooplanktons and zoo-benthos have been recorded from the area. Occurrence of these species and their status is presented in Annexure - 4.

The diversity of zooplanktons shows four major realms in relation to physico-chemical aspects of Nalsarovar water during cycle of a year. They are as under. :

i) Free swimming or floating pelagic forms during the monsoon months (mostly microplanktons and mesoplanktons).

ii) Lotic forms are confined to the Brahmni river area.

iii) Lentic forms are more or less uniformly spread out in lake areas (mostly megaplanktons).

iv) Detritus feeder or detrivores are in abundance in post-winter months when the lake is drying. They are mostly benthos (mostly meso and microplanktons).

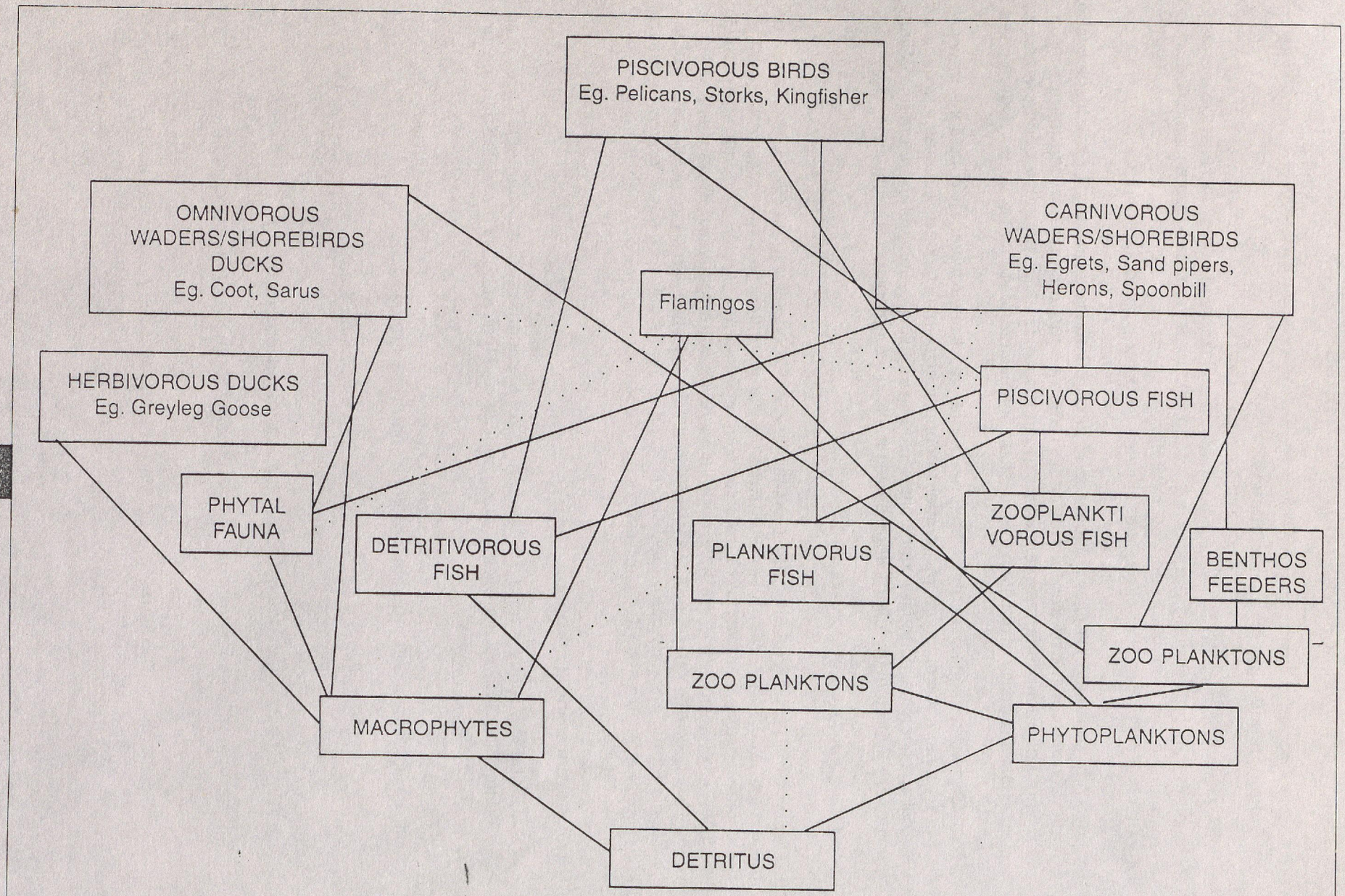
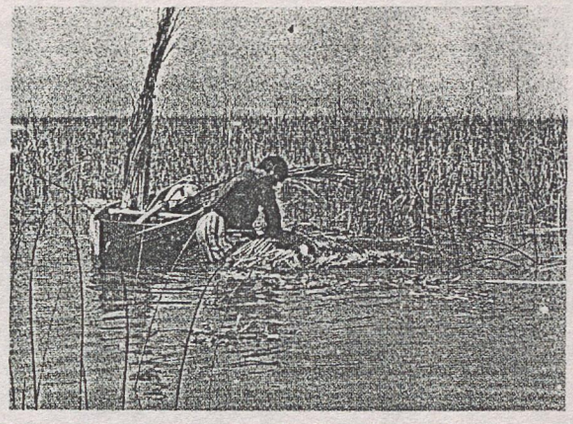


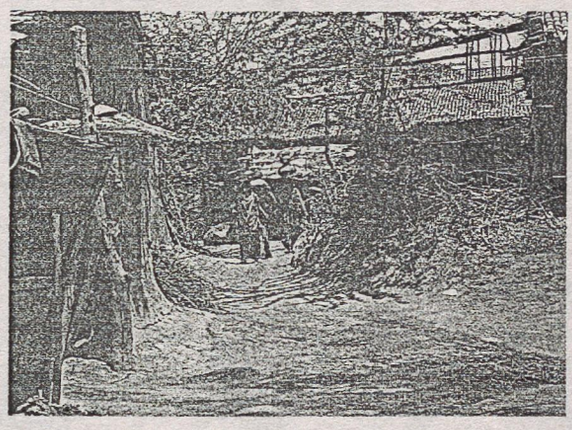
Fig. 6.1 Food chain and Tropic levels in Nal ecosystem



A. Local people collecting 'Gondaro', the predominent species of emergent vegetation, as fodder for buffalo and thatching material for the huts. This indicates the dependency of local people on the Nal.



B. Collection of fish is one of the major economic activities by local people including 'Padhar' community.



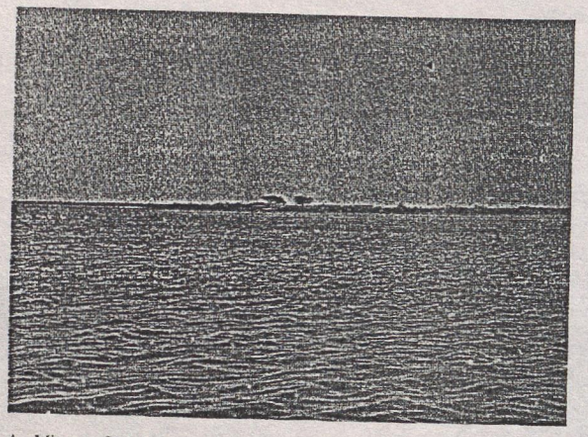
C : Serene village of 'Padhar' community whose life is interwoven with complex ecosystem of Nalsarovar.



D. Splendid Nal is the important potential site for eco-tourism. Being near to Ahmedabad, about 1.5 lakhs people visit the Nal every year.



Spoonbill



A. View of Nalsarovar with open water, emergent vegetation and thickly vegetated Dharabla Islet.

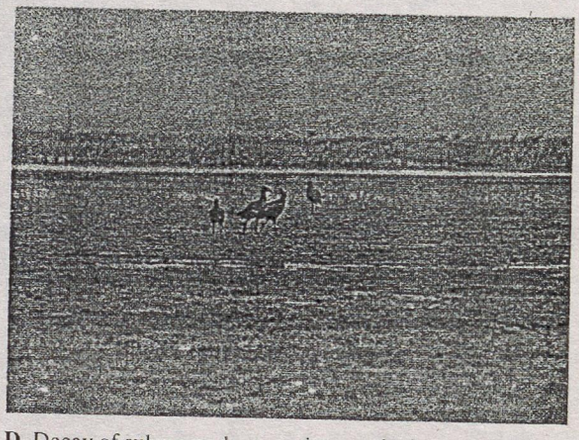


B. Nesting of resident birds on *Prosopis cineraria* (Khijado) in environs of the Nal. Some of the area of environs get submerged during monsoon.

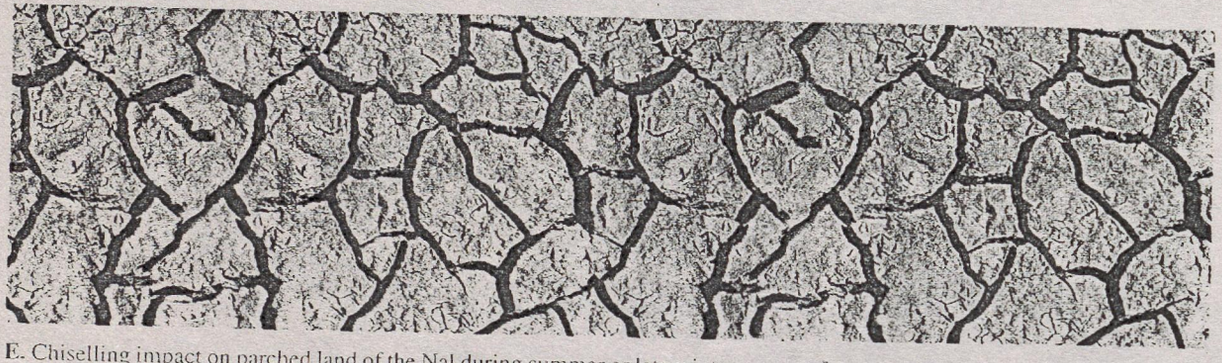
B .



C. Submerged vegetation of algae plays vital role in formation of habitat for the migratory birds.



D. Decay of submerged vegetation results into scum formation.



E. Chiselling impact on parched land of the Nal during summer or late winter

These four realms of zooplankton in the lake coincide with the chemical status of water as well as the temperature, depth and turbidity of the lake. Light as a whole has little effect on zooplankton, as the lake is shallow and there is no aphotic zone in the lake. Only phytoplanktons respond positively to photo-periodism and trophic level in the lake.

Among zooplanktons ciliates like *Paramoecium* and *Codonella* and flagellates like *Euglena* do occur in open water. They are in abundance in coastal (nereitic) regions. True planktons seldom survive in flowing water, as they are likely to be washed away from habitats near surface. Many of the protists found in streams and rivers live in close contact with the surface either as attached forms or as creeping forms maintaining contact with the surface with pseudopodia or thigmotactic cilia of flagella. Many other protozoans, especially bacterivorous species live epizoically on animals of various phyla. Often the protozoans are sessile forms. Such forms may appear on the gills of crustaceans or on insect larvae. Motile epizoic forms include *Kerona* on *Hydra* and many peritrichs on the skin and gills of fish. This condition is not seen at Nalsarovar because of its temporary (non-perennial) nature.

At the Brahmni river site, where the flow is rather slow, and sediment/silt deposition takes place, the general habitat is very much akin to benthic type. Anaerobic conditions prevail in sediments. Under these conditions large populations of microaerophilic ciliates like *Loxode, Spirostomum* and *Prorodon* etc., follow up into the water, migrating periodically between the bacteria-rich anaerobic water below the oxycline and the less nutritive aerobic water above.

Protozoa, rotifers, cladocerans and copepods are the chief groups contributing to fresh water zooplanktons. *Arcella* and *Difflugia* are two rhizopod protozoans found on the surface of mud, rich in organic matters. *Trichocerca* sp. and *Keratella* sp. are two free *swimming* rotifers; their posterior spines assist to keep them buoyant. Cladocerans of the wetland include the well-known genus of water fleas, *Daphnia,* a filter-feeding zooplankton. Copepod crustacean are usually larger than cladocerans. They may be filter-feeders like *Diaptomus* or predatory like *Cyclops*. Phytoplanktons are relatively evenly distributed in fresh water and investigation of their production is therefore easy, but the zooplankton community, comprising a large number of species, distributed unevenly, shows marked difference in diet and feeding habits, varying both between individuals of different species as well as between different ages of the same species. The vertical migration by some planktonic crustacean, such as *Daphnia* is an interesting activity. The diurnal movement of planktons provide food and protection to them.

6.3.1 Ecology of zooplanktons and zoo-benthos

6.3.1.1 Protozoa and protists

Saprobic conditions : Under detritus condition, the benthic fauna exhibits three sub-ecosystems viz.(i)Polysaprobic condition (ii) Mesosaprobic condition (iii) Oligosaprobic condition

Polysaprobic condition : A large number of prolistrous individuals occur in this. The bacterivorous forms tolerate very low oxygen level. Flagellates such as *Oikomonas* and *Bodo*, ciliates like *Paramoecium putrinum* and *Vorticella microstoma* and few photosynthetic forms like *Euglena* thrive under such condition.

Mesosaprobic condition : A richer and more diverse range of protists occur in this condition. This includes pigmented flagellates like *Chlamydomonas* and *Chryptomonas* as well as colourless flagellates such as *Peranema, Chilomonas*, ciliates like *Colpidium, Vorticella, Stentor, Euplotes and Amoeba* like *Arcella*.

Oligosaprobic condition : Autotrophs predominate this condition. These include desmids and diatoms, flagellates such as *Dinobryon, Gonium, Volvox* and *Ceratium* and also rather sparse fauna of herbivorous and detritus-eating ciliates and amoebae.

These conditions indicate the transition from one type of sub-ecosystem to another. This shows that protists and planktons are of detritus-feeding nature and have a definite role to play to keep the ecosystems dynamic.

6.3.1.2 Porifera and coelenterates

These two phyla are poorly represented in water of Nalsarovar. *Spongilla,* a fresh water sponge and *hydra* are only two animals collected occasionally. *Spongilla,* because of its fixed position is invariably found in stagnant water of river Brahmni, particularly during the months of January, February and March when water level is receded and pH is above 8.5. More often they are found attached to the plant structure which is in various state of decomposition. They filter feed on periphyton of plants such as mixture of epiphytic algae, bacteria, protozoa and detritus. The sponge produces a large amount of gemmules which on dispersal form new colony on appropriate substratum. The presence of fresh water sponge is the indication of alkalinity of the medium.

Hydra (coelenterata/cinidria) occurs in Nalsarovar when the water is fresh, i.e. just after the monsoon months. It is mostly found attached to aquatic leaf blade or stem. It is a predator and feeds on *Daphnia* (Crustacea).

6.3.1.3 Rotifers and worms

Rotifers are in varied shape and size, and are mostly suspension feeders. Their name comes from the rhythmically beating, apparently rotating 'wheel' of cilia close to the mouth. These direct water with there suspended fine particles into the gut. Some rotifers may have more complicated food gathering mechanism. They feed on phytoplankton either by filtration of the small one or by grasping and chewing the large ones, or if carnivorous, on each other. The suspended organic detritus brought in continually from upstream form the available food for this zooplankton. Predators like fish, preferably feed on larger zooplanktons such as *Cladocerans* and *Copepods* and thereby the rotifers escape predation till the larger crustaceans last. For this reason rotifers are seen in Nalsarovar almost till water exits and in the form of pools and puddles. Rotifers and smaller *Cladocerans* are readily eaten by carnivorous zooplankters and by insect larvae such as those of *Dipteron* fly. However, they reproduce rapidly by parthenogenesis and meet their losses by high production. Rotifers can survive at water temprature as high as 45^0 C, whereas at 40^0 C most of the amphibians and fish can hardly survive.

Brachionus angularis - a cosmopolitan in alkaline water is reported from all over India is also present in Nalsarovar water in Brahmni river water. *B.calyciflorus*, *Keratella tropica*, *Philodina roseola*, *Asolanchna* sp. etc. are common rotifers collected from Nalsarovar.

6.4 Zooplanktons and lake ecosystem

The amount of oxygen present is far more critical for organisms in standing waters than in terrestrial habitats, because even when saturated, the amount of oxygen which can be held in water is small compared to that present in air. The quantity of oxygen (dissolved oxygen) is estimated by the 'Winkler method'. Its quantity present in static water ecosystems depends upon :

i) The circulation of water within the system and,
ii) The amount of oxygen generated and used by the organisms present.

In Nalsarovar, which is shallow and well weeded, the fluctuations of oxygen is great. Super saturation occurs during the day time, but at night it is lowered down. Being shallow, the temperature difference during day and night or from season to season varies. At higher temperature the oxygen in solution is depleted. Light is the most important factor because of its diverse effects, both direct and indirect, in influencing the distribution and number of organisms, particularly the planktons. Light intensity constantly varies as per the depth. However at Nalsarovar, because of its shallowness, light penetrates almost upto its bottom, though its intensity varies. Herbivorous zooplankton graze on primary producers. The essential nutrients such as phosphorus and nitrogen, occurring as soluble salts are assimilated by the phytoplanktons and are made available to zooplanktons. Thus occurrence or abundance of zooplanktons in time and place primarily depends on the availability of nutrients.

As the water in Nalsarovar recedes, particularly after February, the concentration of mineral salts in lake water increases. This brings about a gradual change in the algal composition in lake water. In the months of October/November when the lake is full of fresh water the pH is near 7.5 wheres chlorides in river is less. The predominant algal communities are unicellular algae such as *Cosmarium*, diatoms, colonial forms such as *Pandorina* and *Chlorella*. Among the zooplanktons the main communities are *Euglena*, *Paramoecium* and some dinoflagellates.

Later on in post-monsoon period and upto the month of February unicellular and colonial algae are mostly replaced by filamentous forms like *Spirogyra*, *Oedogonium*, *Nitella*, *Chara*, *Cladophora* etc. During this period the pH is almost the same but carbonates are on increase, the water is rather brackish. The zooplanktons of previous period persist, but many more new species appear, particularly the epiphytic zooplanktons.

In post-winter or in the beginning of spring season, there is further rise in alkalinity in winter season. With the receding water level and increase in turbidity and rise in overall temperature, cyanophyceae algae, aquatic fungi and some bacteria associate to form scum in the lake. This situation favours the occurrence of heterotrophs, scavanger and detrivorous zooplanktons along with epiphytes and epizoic forms.

In the beginning of summer months, March-April, the lake is reduced to puddles or channels from Vekaria Tourist Centre to Ranagadh village across the lake. The water is most turbid and algal vegetation is scanty and most disturbed. At that time the turbid, muddy and dirty water is full of detritus phytoplanktons and zooplanktons, protozoans and some nematodes are predominant, but rotifers decline. In the puddles and ditches that still have some silt and mud, the larvae of mosquitoes and *chironomas* larva along with scavanger *Euglena* and detritus species of *Paramoecium* are in abundance.

In the scorching summer heat when the Nal lake dries up completely, it is still not completely devoid of organic life. Algal elements are represented by resting spores and angiospermic flora as seeds in dry sandy or silty soil. Many of the zooplanktons undergo aestivation or summer sleep as cysts. Few of the aquatic insects surpass the summer in the egg stage which can withstand desiccation. Most of the filamentous algae dry up and form highly saline incrustation spread up all over dry lake flats.

With the return of monsoon by July-August the phytoplanktons and the zooplanktons reappear from their dormant stage and start their active life cycles.

6.5 Insects and other arthropods

Generally insects are terrestrial but a number of them are aquatic too occurring almost entirely in fresh water. Five insect orders are entirely aquatic and seven others comprise families and genera that are primarily aquatic. These aquatic insects constitute an important part of the biota of fresh water communities. The benthic aquatic insects are important as they form a part of the diet of cultured fishes. Some large insects or their larvae are predator of fish fry. This aquatic fauna of Nalsarovar thus, play an important role in the food web of Nalsarovar.

The qualitative and quantitative estimations of these insects were made in the laboratory after fixing the insects in 5% formalin. It was seen that physico-chemical conditions of Nal lake and biotic factors greatly influence the insect life. Generally, the insects were found living among the vegetation of aquatic plants -such as grasses, sedges and algae.

Aquatic insects that commonly occur almost on all islands and on coastal ditches are *Garris spinole, Corixa hieroglyphica, Belostoma indica, Ranatra filiformis, Cybister confusus, Hydrophylus* spp. *Chironomes tentans* (larvae), *Culex fatigan* (larvae & pupae), *Aedes, Anopheles, Ephemeralla*, spp. (Mayfly nymph) *Hagenus* spp. (Dragonfly nymph) and *Archilestes* spp. (Damselfly nymph).

6.6 Molluscan fauna

About 16 species of molluscs have been recorded in the area of Nalsarovar and its surroundings. The diversity of fresh water molluscs is far less than their counterparts in marine habitats. All the molluscs have exo-skeleton of $CaCO_3$. The fresh water molluscan species are from the classes *Palecaepoda* or *Lamillaebranchs* and *Gasteropoda*. The adult molluscs do not fall under the category of zooplankton, but their larvae and eggs do. These molluscs are either herbivores, grazing on grass blades or bottom filter feeders or sometimes predators. Fresh water mussel, clams snails, slugs etc., are the fresh water species commonly occurring

in river water or in lakes. It has been observed in most of the shelled animals that those species living in water rich in calcium salts have thicker and harder shell and that is why the species in river water have their shells thin and brittle than those occurring in calcium rich lake water or sea water.

Both the zooplanktons and the adult molluscans play an important role in food-web of aquatic ecosystem. They constitute a major food source both for fish and the avian fauna. What insects serve as a major food source to terrestrial animals, the molluscs do for fish and aquatic birds.

6.6.1 Ecology of molluscs

The molluscs that commonly occur in Nal lake area are *Lemnacea acuminata* and *Planorbis exustus*. They are more abundant at Dharabla island site and Brahmni river bank. *Vaginullus* sp. is common at Vekaria tourist garden site and the Brahmi river. *Pila globosa* though occurs almost at all sites of Nalsarovar, it is rather abundant on Limsi, Surbet and Lhasa island sites. It is a herbivorous aquatic animal grazing on aquatic plants. *Lamellidens marginalis* and *Unio* sp. are rather more on Brahmi river site. The former is an aquatic detritus feeder whereas *Unio* feeds on phytoplanktons. Among the gastropods periwinkle (*Littorina* sp.) is most abundant almost everywhere. *Limpets* are common every where. Mud snail *Nass* sp. Occurs only when the water turns brackish in late winter and early summer, i.e. when water level is fast receding.

In early monsoon eggs and larvae are found in great abundance. The egg-mass is found attached on submerged aquatic vegetation. The *Glochidiam* larvae are the typical free swimming larvae of bivalves floating on the pelagic zone.

When the lake dries up or the water level begins to recede, the empty shells are found in abundance along the muddy coast. The shells of almost all types of palecepods and gastropods spread out as white patches on dried mudflats is a common feature seen in Nalsarovar area. Most of these empty shells indicate the abundance of these species. These patches of shells not only indicate the abundance or common occurrence of molluscs, but also the feeding grounds of aquatic birds-mostly waders that visit or inhabit Nalsarovar. Every year fresh stock of these molluscs come along with first rain water, but it seems likely that the egg-mass remain dormant and remain burried to pass the dry summer months.

7. FISH STUDY

Fish is one of the major components of the wetland ecosystem. It is important in the ecosystem due to its role as (i) source of food for piscivorous avifauna (ii) a consumer in the food chain and (iii) a source of income for local population. Due to this multidimensional contribution, studies related to fish and fisheries become important.

7.1 Fish fauna of the Nal

It has been observed that the diversity of fish in Nalsarovar is relatively poor. Only 19 species have been recorded form the area during the study period, as listed in the table 7.1.

Table 7.1 Fish fauna of Nalsarovar

Sr. No.	Common name	Scientific name
1.	Catla	*Catla catla*
2.	Rohu	*Labeo rohita*
3.	Mrigal	*Cirrhinus mrigala*
4.	Shingi	*Heteropneustes fossilis*
5.	Scampi	*Macrobrachium resenbergii*
6.	-	*Channa marulius*
7.	-	*Wallugo attu*
8.	-	*Seccobranchus sp.*
9.	-	*Mystus shingala*
10.	-	*Punitius sp.*
11.	Featherback	*Mulia sp.*
12.	-	*Ophiocephalus sp.*
13.	-	*Ophiocephalus sp.*
14.	-	*Cyprenus carpio*
15.	White carp	*Cirrhinus cirhosa*
16.	Milk fish	*Channa chanos*
17.	-	*Channa stratiatus*
18.	-	*Labeo calbasu*
19.	-	*Clarias sp.*

The low diversity combined with relatively low abundance as compared to the size of the waterbody is mainly due to the shallowness of the lake, non-perennial nature of the waterbody and unscientific fishing practices carried out in the area. It has also been observed that the major carps show a retarded growth in the lake unlike in the fresh waters of fluvial or lacustrine media. The predatory fin-fish of Nal, like *Channa spp., Wallago attu, Saccobranchus sp.* etc., are considered as resident species as they can survive even under the most adverse conditions.

7.2 Impact of climatic conditions

It is found that during the drought years, the water is not retained in the lake throughout the year. In the past, for some years, Nalsarovar was completely dried up. Thus, the water level of the lake is highly dependent on the rainfall in the catchment area. Therefore, the water column is not dependable for the sustenance of the fish fauna.

The main source of fish resource in this lake seems to be the Brahmini and the Vadhavan-Bhogavo rivers and the fish in throughout other catchment source. Also, during the monsoon when the Fatehwadi Canal, is flooded plenty of Major Carp fingerlings are observed. The dead end of the canal may also drain into Nalsarovar during monsoon along with the fingerlings of the source fish. Such influx of fish seed is sustained subsequently in Nalsarovar. It may also be possible that some euryhaline species of fin-fish and shell-fish enter the mixed up waters of Nalsarovar and the rivers from the Gulf of Khambhat. The Scampi is one among such species found in the catch composition of Nalsarovar. The possibility of Grey Mullets (*Mugil spp.*) and the Cock-Ups (*Latus calcarifer*) entering the lake also cannot be ruled out. Nevertheless, this waterbody being by and large gets cut off, it would be always advisable to stock it with culturable fin/shell fish, like the Indian major Carp and the Giant Prawn.

As the lake water has variable parameters from time to time and season to season, the living mass therein are rather compatible to the environmental variations. During the monsoon the lake contains fresh water, which gradually becomes salty and at last completely saline. The biotic mass of the Nalsarovar consists of various fauna and flora, showing seasonal and/or perennial existence in the lake. Similarly, depending on the changes in the water quality, the quantity of fish catch also varies.

During monsoon and early winter, the catches of Major Carp is found to be abundant, at the different fishing centers of the lake viz., Vekaria, Darji, Shahpur, Meni, Katechi, Ranagadh, etc.. The Scampi weighing 100 to 150 gms is also seen to be available during this time. During the late winter and summer, the catch of major Carp dwindle and the catches of Cat fish and other predatory fish increases.

7.3 Impact of hydro-biological factors

7.3.1 Dissolved Oxygen (DO)

All waterbodies have two main sources of dissolved oxygen (DO). The first and normal source is through absorption from the water surface and the second through the process of photosynthesis by the aquatic flora in the water mass. The oxygen production and consumption within the system requires to be balanced in order to maintain the DO concentration to the compatible level for the sustenance of all living organisms. Any surplus of aquatic flora will result in the diurnal fluctuation in the DO content.

7.3.2 Turbidity

Suspended matter and planktonic abundance are the major factors contributing to the turbidity level of any waterbody.

Turbidity normally restricts the penetration of sunlight and reduces the photosynthesis of the plants. The suspended particles could also absorb considerable amount of nutrients like the nitrogen, phosphates and potassium, which is detrimental to the primary production. The colloidal particles may influence the temperature by restricting the penetration of sunlight and scatter it. Unfortunately, no systematic studies have been carried out to asses the tolerance of the fish fauna to the turbidity factors. It is found that most of the experimental fish are reported to tolerate the turbidity level of 100,000 ppm for a week or longer period. However, the higher rate of turbidity can choke the gills affecting the respiratory process of the live fish.

7.3.3 Temperature

Variations in the atmospheric and the water temperature are reported to influence the aquatic life to a great extent. It affects the metabolic and physiological activities, the speed of chemical changes in the soil and water, and the content and pressure of the dissolved gases.

Most of the tropical fin-fishes, especially the Indian major carps are reported to tolerate wide range of temperature. Normally, they thrive well in a temperature range of 18.3 °C to 37.8 °C. The temperature below 16.7 °C and above 39.5 °C are reported to be fatal to the Indian major carps. However, the upper level of lethal temperature is reported to be 39 °C to 41 °C in the case of the air breathing fishes, such as *Channa punctuates, Heteropneustes fossilis, Puntius ticto, Rasbora deniconius, Mystus tangara* etc.

7.3.4 pH value

Hydrogen ion concentration of natural water is an important parameter in so far its productivity is concerned. Normal pH value of pond waters would be around 7. The pH value is not normally affected by the natural salts, especially those of strong acid and strong base. It should be mentioned here that in the buffer system, dissolved carbon dioxide plays an important role in the maintenance of the pH value from natural point down to 5. The bi-carbonates dominate in the pH values ranging from 7 to 9 and carbonates in the pH value form 9.5. The pH value undergoes changes during the night hours and become most acidic just before day break. Normally, a pH level above 11 is fatal to the fish fauna.

7.3.5 Pollutants

The pesticides vary greatly in their chemical composition, toxicity and environmental persistence. The presence of pesticides in the aquatic systems obviously leads to water pollution. The water polluted with pesticides get used for consumption. Among the pesticides the Chlorinated hydrocarbons, Organophosphates and Carbonates are commonly used. Chlorinated hydrocarbon is widely used for insecticides like the DDT, Toxaphene, Eldrin etc. Endosulphan is reported to be most toxic to fish among all the Organochlorine insecticides which are widely used in agriculture. The effects of the toxicity of the pesticides is exclusively dependent on the types of pesticides and its concentration in waterbody.

7.4 Food and feeding habits of some commercial fin fish

(i) **The Catla** (*Catla catla*) : The major carp is a surface-feeder and planktophagus and mainly feeds on the zooplankton. Its food comprises water fleas, planktonic algae, crustaceans, rotifers, insects and vegetable debris.

(ii) **The Rohu** (*Labeo rohita*) : This fish is by and large a column feeder and feeds upon the vegetable debris, microscopic plants and detritus.

(iii) **The Mrigal** *(Cirrhinus mrigala)* : It is a bottom feeder and omnivorous and feeds upon the decayed plant and animal matters, algae, detritus, mud, etc.

(iv) **The Shingi** (*Heteropneustes fossilis*) : This cat fish is an omnivorous bottom feeder and feeds upon the insects, worms, ostracods, debris and algae.

(v) **Other predators** : Other main predators are *Wallago attu, Mystus shingala* and *Channa marulius*. They are highly carnivorous and predacious in their food habits. They prefer water-fleas, insects, fly and fingerlings of small and medium fin-fish.

(vi) **The scampi** (*Macrobrachium resenbergii*) : The scampi is omnivorous, feeding on detritus, animal and vegetable matters.

7.5 Bio-commercial significance

7.5.1 The major carps

Amongst the Indian major carps , three important species Catla, Rohu and Mrigal contribute to the major fish catch of the Nalsarovar. They are fast growing, easily available and widely accepted among the fishermen and the consumers as well. They are known to breed in running waters and in major reservoirs, where turbulent condition are generated on account of monsoon floods. They also breed in artificially constructed bund like tanks, where fluvial conditions are simulated during the spawning seasons. Their spawn/seed are also naturally collected from some of the major rivers of India, such as the Godavari, Ganga, Yamuna, Tungabhadra, Sutlej, Narmada, Tapi, Mahi etc.

Today the technique of breeding and propagating the Indian major carp through "Hypophysation Technique" is successfully carried out throughout the country. So far as the Gujarat State is concerned, there are nine Chinese (Circular) hatcheries operating during the monsoon season for the production of the Indian major carp seed through "Hypophysation technique" presently. The spawn (hatchlings) produced in such hatcheries are transferred to different satellite farms for nursering/rearing.

They are grown to a length of about 40 to 100 mm so as to enable them to be stocked in the waterbodies such as rural ponds, lakes, reservoirs and other waterspreads, in order to culture and conserve them.

7.5.2 Scampi

The Scampi is the most valuable crustacean resource of Nalsarovar and plays a vital role in the economic viability of any fishing activity in the region. This species normally attains a length of 200 mm, weighting about 150 to 250 gms. The IQF frozen Scampi enjoys a great demand in the western European and American markets and hence the fish fetches about Rs. 200 per kg in the foreign market.

The natural habitat of this species is fresh water. However, during the breeding season, they migrate to the higher salinity ranges of the estuarine regions of the river mouth for breeding/ spawning. Once when the larvae grow to a size of juveniles (20 to 30 mm), they ascend the rivers for the lesser saline/fresh water regions for sustenance.

7.6 Stock maintenance and exploitation

Water of Nalsarovar is being stocked with the fingerlings of the Indian major carps by the State Fisheries Development Agencies in order to maintain the fish fauna stock.

7.7 Social scenario

Nalsarovar is by and large used by Padhar and Muslim fishermen, living on the periphery of the lake. The State Fisheries Commissionerate undertook a survey of these villages and assessed the villagewise data of the fishermen population of this locality and the parameters deployed for their livelihood.

Most of the Padhar community is engaged in agriculture, earthdigging, and fisheries. There are as many as 11,139 fishermen, of which 4732 are active fishermen. It is reported that about 608 flat-bottom boats are deployed for fishing purpose. The fishing gears are generally the gill-nets, cast nets and hooks and lines. The gill nets are estimated to be around 14,244 units and the cast nets around 899.

7.7.1 Fishery co-operatives

There are eight fisheries co-operative operating on the periphery of the Nalsarovar, of which 5 were established in Ahmedabad District and the remaining in Surendranagar District.

7.7.2 Marketing arrangements

As the primary co-operatives are not effective on account of their financial weaknesses, the fish marketing is by and large is carried out through private fish merchants. These merchants provide financial advances to the fishermen and bind their output for the next fishing season at price decided by themselves, based on the prevalent market prices.

7.8 State support

The State Government of Gujarat has introduced many schemes for the economic and social welfare on the Padhar Community engaged in the fishing operations in the Nalsarovar.

The State Fisheries Commissionerate provides the fishing craft, gear, bicycles, insulated boxes, synthetic water tanks, hand trolleys and weighing balance at subsidized prices for the fish capture and marketing. The seed stocking of the lake also is carried out by the State Fisheries Commissionerate through the 'Padhar' community by providing suitable incentives.

7.9 Impact of fishing practices on the ecosystem

The present fishing practices in the lake have been reported to be adversely affecting the ecosystem, mainly because of two reasons, viz. (i) practice of catching fish without observing regulation of net size and fishing season, and (ii) practice to use fishing nets for poaching.

The fishing nets which are being used at present by the local fishermen is of very small mesh size, even as small as 1 cm x 1 cm. This practice does not allow fish to attain the maturity, as the young stock is captured. This results into relatively low catch size against the total inputs and also into higher entropy. Moreover, it results into reduction in the availability of food for piscivorous avifauna, as most of the species consume relatively small size fish.

It has also been revealed from the enquiry of local people that their attitude is hostile towards piscivorous avifauna, particularly towards pelicans. They strongly believe that pelican is competitor for them because it depletes fish in the lake. This is an excuse put forward by them for using nets of small mesh and their resorting to fishing even before the end of monsoon, so that they can be able to catch whatsoever available before it is consumed by birds.

Attempts are required to be made to deviate them from their policy of "a bird in hand is always better than two in the bush". The efforts of conservation are undoubtedly conflicting with fisheries activity, but it is not impossible to strike a compromise leading to achievement of the dual goal. Probably regulation of mesh size and the observation of the close season is the answer for it, provided the lake do not dry up considerably during the period beyond the closed season.

Nalsarovar is known for its high diversity and high population of birds. The main reason for why the birds are attracted to the area is, naturally, due to the diverse habitat conditions available within the area.

As stated earlier, the total area in and around the sanctuary under submergence during monsoon is about 350 sq.km in the years of good rainfall. However, the total area available to the most of waterfowl, is only about one third of legally notified area of the sanctuary, i.e. submerged area under water during winter, which depends mainly on the quantum and pattern of the rainfall within the catchment area. As the rainfall determines the area undergoing submergence, it also determines habitat availability for different species of waterfowl, which varies with the change in the water level. It has been observed that the utility pattern for the area gets changed due to variation in the water level. This is due to changes occurring in aquatic vegetation as well as in invertebrates inhabiting it which vary with the change in water level. Moreover, different species have different set of adaptations due to which they require certain types of habitats only. Hence, the habitat suitable to one set of species may not be equally suitable to another set of species. Thus, the foremost requirement is identification of habitats in relation to various species of waterfowl.

Identification of habitat types is also felt necessary from the EIA point of view, as there is a need to identify optimum water level and area under water spread. This is particularly important in light of how best water from SSP canal can be utilized for the sanctuary, if at all necessary. For this purpose also there is need to identify what kind of habitats in relation to the water level is formed and to find out habitat preferences of various species of waterfowl.

8.1 Habitat types

Habitat is the natural home of any living form, may be an animal or a plant. It is the external environment to which the species has become adapted in the course of evolution. An assessment of specific habitat requirement of individual species is vital for management of the species. It is known that habitat preference may be one form of imprinting in birds. However, Mc Farland (1980) suggested that birds respond to a summation of many factors and habitat selection thus, has some variability within a species. According to him (i) the characteristics of the terrain, (ii) nesting, feeding and drinking sites, (iii) food availability, and (iv) other animals, are important factors influencing habitat selection.

The sanctuary offers several macro and micro-habitats suitable for the large number of species. It has been observed that some species show particular preference to certain habitats while some can be seen in wide range of habitat. Therefore, identification of various habitat types was the prerequisite for determining preference by various species.

Tatu (1995) has attempted to identify certain habitat types and their distribution as well as monitoring changes therein with the help of satellite imageries. However habitat assessment models developed by him were for only two representative species viz., the Rosy or White Pelican (*Pelecanus onocrotalus)* and the Chestnut Bittern (*Ixobrychus cinnamomeus*). The former one being the most abundant species and the later one being the rarest species in Nal as per the 1992 mid-winter waterfowl census carried out in the area by the Forest Department. He had also identified various structural components of the wetland and changes therein. However, it did not include in detail the different requirements of different waterfowl species.

Nalsarovar, being a wetland, variation in habitats is largely related to the water level and vegetation occurring in the area. Sivasubramaniam (1992) has classified habitat types according to the dominant plant community and water regime in Keoladeo Ghana National Park, Bharatpur. However, he had not mentioned exact depth of water, while classifying habitat types. Vijayan (1991) had identified 7 habitat types in the same area on the basis of the composition of the vegetation therein, and also found the preference for them by 9 species of waterfowl. He also studied preference of water depth by 18 different waterfowl species and found that the most preferred depth for many waterfowl species is in the range of 21 to 60 cm, while the Common Pochard, Indian Moorhen and Cotton Teal prefer depth between 60 and 80 cm. He also found that the Coot utilizes the water depth even more than 100 cm.

Nalsarovar, being a natural lake, is quite different and unique as compared to Keoladeo National Park where the area is divided into blocks by dykes and bunds and certain habitats are maintained by managerial skill, artificially. At Nalsarovar habitat formations is highly dynamic, to the extent that habitats get changed from one type to another even within the same year due to change in the water level. However, on the basis of water level and vegetation, 8 habitat types have been identified, out of which at least two types are outside the sanctuary boundary but adjacent to it. These habitat types are as below.

(i) **Deep open water habitat (DOW) :** These are the areas where depth of water is more than 60 cm without any emergent aquatic vegetation. This type of habitat supports submerged vegetation and some amount of floating vegetation also. However, compared to shallow open water habitat, their density is less. This kind of habitat attracts surface feeding and diving birds including the Coot, various species of Pochards, Wigeon etc.. as also the Pelicans. Piscivorous species get adequate amount of fishes in this type of habitat while surface feeding herbiovorous species feed mainly on the vegetative material of submerged plants like *Najas, Hydrilla* etc..

(ii) **Shallow open water habitat (SOW) :** These are the areas where depth of water is up to 60 cm without any significant emergent aquatic vegetation. However, at places, emergent aquatic vegetation occurs in small and scattered patches. Submerged vegetation is more dense in this kind of habitat, dominated by *Najas spp.* and algae like *Chara sp.*. Species like *Vallisneria* and *Hydrilla* also occur in some of the areas. This kind of habitat mainly attracts surface feeding birds like Common Teal, Pintail, Shoveller, Cotton Teal etc., as also species like Flamingos, Spoonbill and some herons, while other waders are attracted by more shallow water areas.

(iii) **Emergent aquatic vegetation (EAV) :** These are the areas where depth of water is variable but the surface of water is apparently not visible due to the dense growth of emergent aquatic vegetation. The vegetation is dominated by *Typha* spp and *Cyperus* spp. Dense growth of these species obstructs easy swimming due to which the area is not suitable for divers and swimmers, which usually occur in large flocks. Moreover, the emergent vegetation reduces penetration of light and also due to the competition, the density of submerged vegetation is relatively less. This type of habitat is suitable for bitterns, herons, egrets, moorhens etc..

(iv) **Muddy habitat (MH) :** This kind of habitat is formed in shallow zone of the lake after receding of water from the area. The soil remains wet and muddy with small puddles in patches. Emergent vegetation is sparse, ground cover is either negligible or covered by sparse to moderate carpet of prostrating herbs which are mesophytic in nature. In puddles, species like *Marsilea* comes up, while at bottom various algal species may come up. This type of habitat is mainly used by waders, e.g. sandpipers, stints, stilt, plovers etc..

(v) **Shoreland and island (SH) :** These are the areas on the periphery of lake as well as bets which remain above the water level for the most part of the year. Most of these areas are almost flat or with very gentle slopes. The vegetation is dominated by grasses, herbs and sparse scrubs, most of which are mesophytic due to high water table. This kind of habitat is suitable for species like pratincoles, lapwings, migratory cranes, warblers etc.. Only a few species of waterfowl are found in such areas. Scrubs include *Prosopis* also, which provide nesting and perching sites to birds, if other factors are favourable. The potenitial of *Prosopis* at the Nal as nesting site for the resident waterfowl is a matter of further investigation. Its potential as a nesting site can not be completely be denied (e.g., at Victoria Park, Bhavnagar, many species of herons do nest on *Prosopis*.)

(vi) **Cultivations in surrounding areas (CSA) :** Agriculture land surrounding the lake area also forms distinctive habitat as many species utilise it for foraging while they roost or rest in the lake area. Moreover, particularly in the southern part of the lake various crops are cultivated in the lake soon after receding of the water from the area. Again, such type of cultivation in the lake area depends upon the rainfall. Species of cranes, herons, egrets and storks utilise this kind of area for foraging, while the habitat is also suitable for many terrestrial birds.

(vii) **Fallow lands in surrounding areas (FSA) :** There are large patches of fallow land and wasteland surrounding the sanctuary area. Some of the areas may go under inundation during the rains. Such areas are mainly grasslands, interspered with scanty to dense patches of scruby vegetation which forms distinctive habitat. Such areas are utilised mainly by species of cranes, egrets, storks, sandgrouse and other terrestrial birds.

(viii) **Woodland habitat (WH) :** These are the areas with woody vegetation surrounding the lake as well as on bets, which form a distinctive habitat. Such areas are potential breeding/nesting sites for many resident species, especially for herons, egrets and storks. Moreover, trees are useful as perching, roosting and resting sites for many species.

8.2 Evaluation of habitats

Habitat types identified above can be evaluated on the basis of utilisation pattern and preference to it by various species of waterfowl. The utilisation pattern and preference of habiat

depends mainly on two factors viz., availability of basic requirements i.e. food and shelter and adaptation of the species for accessing the resources available in the particular habitat.

The area being a wetland-based bird sanctuary, the habitat preference is to be viewed mainly for waterfowl species. As the migratory species do not breed within our limits and similarly certain local migratory species do not breed within sanctuary area, the avialability of food becomes a critical factor deciding the preference of the habitat type. Availability of various kind of food had direct bearing with the water level, as occurrence of food species varies with the change in the water level. Based on various studies and observations made in the area, nine food types have been identified which are consumed by various bird species found in the area. Table 8.1 shows occurrence of the food type in various types of habitats. The list of various food types consumed by various species of waterfowl is given in Annexure - 5.

From Table 8.1 it is evident that the occurrence of food items does not vary significantaly within the submerged area. However, due to variation in feeding habits of different species, preference for the habitat and utilization pattern of the habitat varies from species to species. On the basis of the observations made during the study period and on the basis of other records and studies, habitat preference of various species in relation to the habitat types identified in the study area is given in the Annexure - 6. An abstract showing habitat preference of waterfowl is presented in Table 8.2.

Annexure-6 also shows the species which can be considered as potential breeders within the area if suitable conditions prevail. These are the species known to breed within the state and many of them are breeding regularly in nearby areas of the sanctuary, including parts of Ahmedabad and Kheda districts. Total dryness and high salinity are the main reasons which make conditions unsuitable for breeding of many species.

From Table 8.2., it is evident that the muddy habitat (MH) and the shallow open water habitat (SOW) are the most preferred habitats to maximum number of the species. However, other habitats are also equally important as they provide a distinctive niche to a separate set of species. Entire habitat utilization pattern is such a complex phenomenon, coupled with variability and adaptability of various species, that increase or decrease in one kind of habitat may adversely affect to one set of species while it benefits to other set of species.

Table 8.2 clearly shows that the shallow open water and muddy habitat are the most perferred and/or most extenstively used habitats, while the wooded areas are least preferred habitat for most waterfowl species, particularly for migratory species. The utility of wooded areas for resident and local migratory bird species is mainly in relation to roosting, resting and nesting sites. Similarly, the importance of shore as a habitat is to be viewed from its utility as resting and foraging areas as well as its importance for terrestrial species. Thus, each type of habitat has its own importance.

Another aspect which deserves mention is, importance of *edges* which have always remained vital as far as their utility is concerned. This is because of the fact that edges form distinctive ecotones where two or more kind of habitats are available. At Nalsarovar, like at most of other wetland habitats, edge area consists of shoreland, muddy areas, shallow water

Table - 8.1 Occurrence of various food items in different habitats of Naisarovar

Food item	Open water		Emergent aquatic vegetation	Muddy area	Shore-land	Surrounding		Wooded	Total habitats
	Deep	Shallow				Crop land	Fallow land		
Fish	*	*	*	-	-	-	-	-	3
Frogs	*	*	*	*	-	*	*	-	6
Aqu.insects	*	*	*	*	-	-	-	-	4
Worms snails, crustacens, molluscs	*	*	*	*	*	-	-	-	5
Insects	-	-	-	-	*	*	*	*	4
Reptiles & lizards	-	-	-	*	*	*	*	*	5
Rodents & small birds	-	-	-	-	-	*	*	*	3
Algae, Aqu. plant	*	*	*	*	-	-	-	-	4
Material, Seeds Shoots, crops, terrestrial veg.	-	-	-	-	*	*	*	*	4
Total food items	5	5	5	5	3	6	5	4	

Table - 8.2 Abstract showing habitat preference of waterfowl for various habitats of Nalsarovar

		Open water		Emergent aquatic vegetation	Muddy area	Shore-land	Surrouding		Wooded.
		Deep	Shallow				Crop land	Fallow land	
Resident & Local migratory	*	4	1	16	19	35	17	16	3
	**	2	13	9	22	12	8	5	7
	***	8	21	10	24	8	3	5	5
Total R/LM		**14**	**35**	**35**	**65**	**55**	**28**	**26**	**15**
Migratory	*	0	11	24	25	25	5	7	0
	**	0	2	8	5	6	4	4	0
	***	7	15	10	16	4	2	3	0
Total migratory		**7**	**28**	**42**	**46**	**35**	**11**	**14**	**0**
Grand Total	*	4	12	40	44	60	22	23	3
	**	2	15	17	27	18	12	9	7
	***	15	36	20	40	12	5	8	5
		21	**63**	**77**	**111**	**90**	**39**	**40**	15

Notes :

Total species	134	***	Most preferred/Extensively used habitat
Resident and local migratory speices	81	**	Moderately preferred /Moderately used habiatat
Migratory species	53	*	Less preferred/less used habitat

habitats and other habitats, interspersed together. Interspersion and juxtaposition of these habitats derive its total utility.

As the formation of habitats varies mainly with the water level, the area under various kinds of habitats varies according to the water level, and fluctuation occurs not only from year to year, but within the same year also, due to evaporation, seepage, pumping of water from the lake etc.. However, the extent of the wetland area under various kind of habitats will depend mainly in relation to the water level in deeper most part of the lake. Thus, if the area under deep water is less, naturally the total area under submergence will be less.

8.3. Population of waterfowl

Population of various species found in an area usually indicates the suitability of the area for the species, while the changes taking place in the population can indicate impacts of the management practices as well as impacts of other factors on the population.

Prior to 1992, no systematic attempts were made to estimate population of waterfowl in the area. During January, 1992, for the first time an attempt was made to estimate population of waterfowl in the area by adopting stratified unistage circular systematic sampling method. Thenafter, by adopting the same methodology, population estimation was made in the year 1996. Attempts were also made in the year 1994, but due to unavailability of the cloud-free satellite data, extrapolation of sampled data could not be done. The population estimation was organised by the Forest Department in which all the technical assistance were provided by the EIA study team. Results of the population estimation carried out in 1992 and 1996 are presented in Annexures 7 and 8 respectively, while the comparative analysis according to the group of species is given in table-8.3.

From the annexures and the tables, it is evident that the area fulfills the important criteria for its consideration as a wetland of international importance as per Ramsar Convention. It also shows the importance of the area which supports such a large number of population of waterfowl with the unique diversity.

However, the 1992 population estimation had also shown some limitaitons of the methodology adopted, particularly in relation to pelicans, for which the results have been felt erroneous, showing unrealistically high population of the species. Realising this, in 1996, methodology was modified for such species, and total counts of such species were taken instead of sample counts. Even though, if we assume that the entire population of pelicans in the area was restircted within the sampled area, total number of pelicans actually counted were more than 6300 in 1992.

On the auspice of Asian Wetland Bureau (AWB) mid-winter waterfowl census is being carried out in the country since 1987 with the help of various organisations and volunteers. Unfortunately, no one has attempted to carry out census at the Nal so far. Not only that, but the estimates of 1992 census had also not been included in the report published by AWB, probably due to some communications gap as they were sent to BNHS and not to the AWB or their regional co-ordinator. However, a comparision of data published in the report with the population estimated at Nal during 1992 reveals very interesting results.

Table - 8.3 Groupwise estimated population of waterfowl at Nalsarovar during 1992 & 1996 winter (January)

Sr. No.	Name of the group	1996 Openwater* population	1996 Shoreland** population	1996 Total	1992 Total	Density per Ha 1992 (3375 ha)	Density per Ha 1996 (1875 ha)
1.	Grebes	20	120	140	738	0.219	0.075
2.	Pelicans	-	-	1813+	6367++	1.886	0.967
3.	Ducks & Geese	25159	21069	46221	25074	7.429	24.651
4.	Rails, Coots. Crakes	2060	12283	14343	19292	5.716	7.649
5.	Jacanas	-	-	-	144	0.043	-
6.	Cormorants	-	101	101	785	0.232	0.054
7.	Herons, Egrets, Bittern	5421	3960	9381	8010	2.373	5.003
8.	Storks	34	72	106	590	0.175	0.056
9.	Ibises & Spoonbill	6526	15018	21544	12062	3.574	11.49
10.	Flamingos	4159	-	4159+	10413+	3.085	2.218
11.	Cranes	-	-	22012+	32548+	9.644	11.74
12.	Waders-Shorebirds	5573	10233	15811	63836	18.914	8.432
13.	Gulls	217	5127	5344	2575	0.763	2.85
14.	Terns	35	509	544	1983	0.587	0.29
15.	Kingfishers	0	15	15	65	0.019	0.008

16. Others	-	-	-	3252	0.963	-
Grand Total	**49204**	**68505**	**141534**	**187734**	**55.622**	**75.483**

Notes :

\+ - Not included in the sample-count but counted separately.
++ - Actual numbers observed in sample plots.
** - Shoreland : Sampled plots/area having shoreland/bets atleast on in some parts which are above water level.
* - Open water : Sampled plots not bounded by any land areas and are fully sumerged.

During the winter of the year 1992, of the total 181 wetland sites surveyed in Gujarat, total counts were carried out in 103 sites while the rest were partially counted. The total population of waterfowl in these 103 sites was 1,88,323, while the Nal alone harboured atleast 1,87,735 birds (Total estimated population 2,24,245 - 36510 excessive estimation of pelicans). Thus, the Nal alone supported as many number of birds as enumerated in 103 sites of the State. Even specieswise comparision shows that Nal is very important wetland. In the year 1992 total 4350 pelicans were encountered in the State, while in the Nal alone they were more than 6300. Similar is the case for many other species including the Coot and migratory ducks.

Results of 1996 mid-winter waterfowl census are yet to be pubiished by AWB, and hence comparision is not possible. A comparision between 1992 and 1996 population census for the area shows very interesting results.

During 1992, the total area under the submergence was about 3375 ha., while during 1996 it was hardly 1875 ha. Despite of this, there had been increase in population of many species of waterfowl as can be seen from the table 8.3. Moreover, the density of most species had increased, but the population of waders, flamingo and cranes have declined considerably. In any case, the increase has been observed in the over all density, showing the impact of rainfall as well as importance of this wetland.

From the above discussion, it is evident that despite of the less rainfall and reduction in the size of the waterbody, the area supported relatively larger population. This is probably due to adverse or unfavorable conditions prevailing in other wetlands of the State during that period. Ultimately, it is the impact of the rainfall. In the years of good rainfall, waterbodies in the region have better quantum of water due to which habitat availability increases. In such conditions, waterfowl disperse in wider range, resulting into relatively less density in the sanctuary. In the years of less rainfall, due to less availability of habitats in the other areas, their concentration increases in the sanctuary. However, in the servere drought years, the lake remains almost dry by winter and the area gives a deserted appearance in absence of water and waterfowl.

8.4 Rainfall, topography and extent of habitats

As stated earlier, the Nal, is a natural lake and is fed through rivers and surrounding catchment area. Hence the quantum of water within the lake depends upon the rainfall, while the level in the lake also depends upon the topography of the area. To determine exact area under various water level, contour map of narrow interval is required for the entire area. The SOI toposheets had shown contour level upto RL.10, which also includes low lying area outside the sanctuary which gets flooded during rainy season. With a view to get more precise data, SSNNL was requested to provide detailed contour map, which they have prepared for permanent submergence area shown on SOI toposheets. As per the survey, areas under various RL depth is shown in the table 8.4.

Table - 8.4 Submergence according to depth classes at various RL in Nalsarovar

Water level in the lake RL (m) in meter	Area under submergence (ha) in different Water depth classes				
	water depth classes (cm)				Total submergence for different RL
	0-20	20-40	40-60	60-80	
8.20	41.2	-	-	-	41.2
8.40	453.1	41.2	-	-	494.3
8.60	802.2	453.1	41.2	-	1296.5
8.80	1179.2	802.2	453.1	41.2	2475.7

Note : It is assumed that water depth for most of the submerged area of Nal at water level of RL 8.20 m is less than 20 cm.

Thus, in the moderate rainfall years, the maximum area under permanent submergence during winter is about 2475 ha. The area of submergence between RL 8.80 and 10.00 is not available. However, the lake overflows between these levels and if a bund is constructed at RL 10 as shown in the fig. 2.2., the total area under submergence is 9475 ha., in addition to 11000 ha. area of the Nal lake, as per the findings made by SSNNL. It is felt that this figure is over estimated, and actual area under submergence is likely to be much less. Moreover, this submergence would be of temporary nature and would shrink gradually with the time and the area under submergence during winter and summer would be less than the projected figures.

From the available satellite data, the maximum area under submergence at the beginning of winter. i.e. November, 1984 was 102 sq.km, while the study made by Tatu (1995) revealed that during October, 1990, the total area under submergence was about 60 sq.km., i.e. about half of the notified sanctuary area.

Satellite data had also shown the trend in reduction in submergence area after monsoon to summer as discussed in section 4.3, chapter - 4.

From all these information and findings, it is felt that the lake filled somewhere upto the level between RL 9 and 10, can provide maximum area with the desirable water depth for waterfowl during the winter, i.e. depth in the range of 21- 60 cm*. This is also clear from the trend seen in the table 8.4. At this depth, combination of various habitat types is felt ideal, looking to needs of various types of waterfowl.

This aspect is very important, for considering the optimum water level required to be maintained in the lake, and more specifically in the light of how best water from SSP canal can be utilized for the lake, if at all felt necessary.

8.5 Canal network vis a vis habitat and waterfowl

The canal network surrounding the sanctuary area as shown in the fig.2, shows that though the area falls within the command area, any canal is not passing through the sanctuary. or the surrounding area. However, looking to the drainage pattern of the area, it is obvious that even without any direct linkage, water released through various escapes and excess from tail distributors is likely to drain into the sanctuary area. Hence, the impact of canal network is to be viewed mainly from following aspects :

(i) Quantum of water likely to be drained in the area and the season/period of the drain.

(ii) Change in the water table surrounding the sanctuary.

(iii) Quantum of water to be supplied in villages surrounding the sanctuary which otherwise utilize lake water for irrigation.

(iv) Extent of formation of additional wetlands in the surrounding area.

(v) Whether canal water can be utilized for the sanctuary and if yes, in what manner.

For assuring above mentioned aspects a thought is to be given on what is experienced in some similar projects or comparable situation; e.g. wetlands situated in Mahi command area and Keoladeo Ghana National Park. In Mahi Command area there are many wetlands, though smaller in size as compared to the Nal but otherwise of considerable range/size are fed through canals. These areas support large number of waterfowl population. Moreover, highest population of Sarus Crane in the State is found in this region, which breeds in paddy fields and other wetlands. Keoladeo National Park is also known for maintaining/regulating water level in the area through canals from nearby Ajan bund. These experiences have shown that discreet use of water by the management can bring positive results, particularly for waterfowl.

* The remark of the Director, Wildlife Institute of India (WII), Dehradun in connection with the suggestion of retaining water upto the RL 9 and 10 is as follows : 'It is our suggestion that to maintain the waterfowl diversity in Nalsarovar, regulated release of water in the lake should be insured and only when there is failure of monsoon, one should think of getting some water from canal as recommended in the report and the water level in the Nal should not go beyond RL 9.4.

9.1 General demographic characteristics

There are 12 villages on the boundary of the sanctuary, of which 8 villages are in Limdi taluka of Surendranagar district, 3 are in Dholka taluka and one in Viramgam taluka of Ahmedabad district.

Total population of the villages in the Nalkantha (periphery of Nal) is nearly 34000, of which 52.4 per cent are males and 47.8 per cent, are females. This gives an average male female ratio of nearly 910 females per thousand males.

There is a sizeable difference in household size in these talukas. This works out to 5.2 in case of Limdi taluka, 4.9 in case of the Viramgam taluka and 7.1 in case of Dholka taluka. The average per household size for all the Nalkantha villages works out to 5.6 persons.

Similarly, the village population also indicates wide variation. This comes to nearly 2336 persons per village in the Limdi taluka, 4078 in case of Viramgam taluka and 3269 in case of Dholka taluka. The overall per village population works out to 2848 persons. The overall per village number of households works out to 507. Thus, a typical Nalkantha village has nearly 1491 males and 1357 females, distributed in nearly 500 households, where on an average, in each household there are nearly 2.9 males and 2.7 females.

9.1.1 People

Between the censuses of 1961-81, the population of 'Padhars', the only tribals in Gujarat who live in plains, has increased. The sex-ratio of the community has improved from 938 to 950 during three censuses. The growth rate in this population has been that of around 93 per cent for the last reported decade. A few points of interest emerge here.

The total Padhar population forms 39.2%, 38.7% and 42.3 % of the total population for the respective census years in 1961,1971. and 1981.

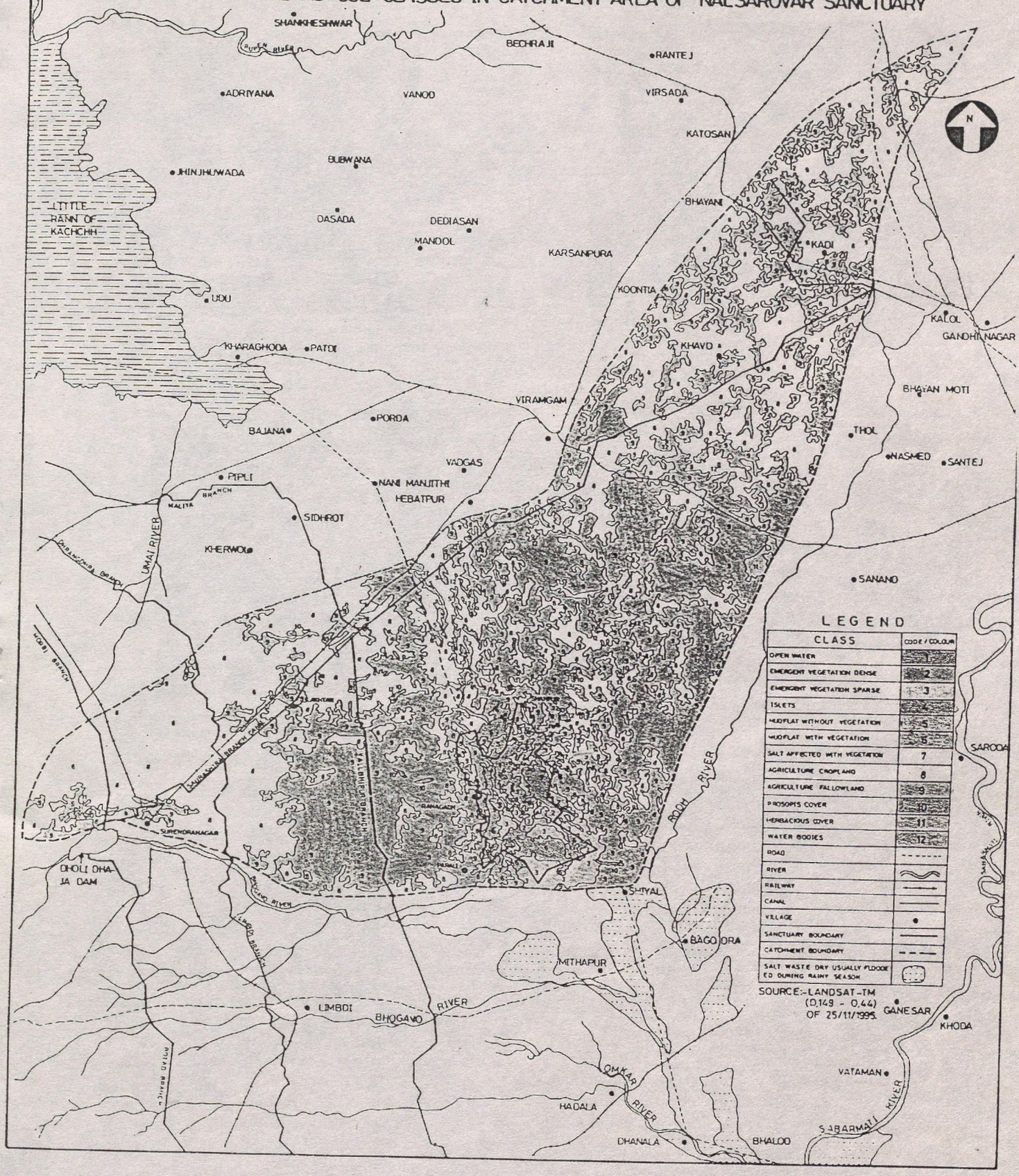
Between 1971 and 1981 (a decade) increase in both total and Padhar population has been comparatively low. They were 18.4% and 16.5% for the total and Padhar population respectively. But in the next decade i.e. between 1981 and 1991 the per centage increase has been much faster being 30.5% and 43.2% respectively for the total and Padhar population. Thus, the increase in the Padhar population is much faster compared to the overall increase.

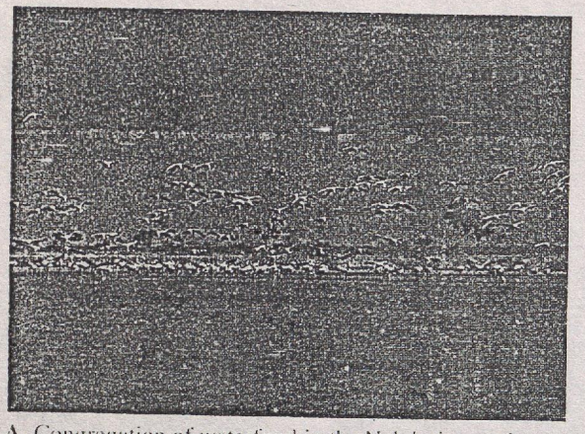
9.1.2 Population

According to the survey, the population has increased from 22,153 to 38,894 between 1971 and 1995. Male population increased by nearly 78% while the female population has increased by nearly 74%. Per village population in 1995, works out to 3242 persons made of 1675 males and 1567 females.

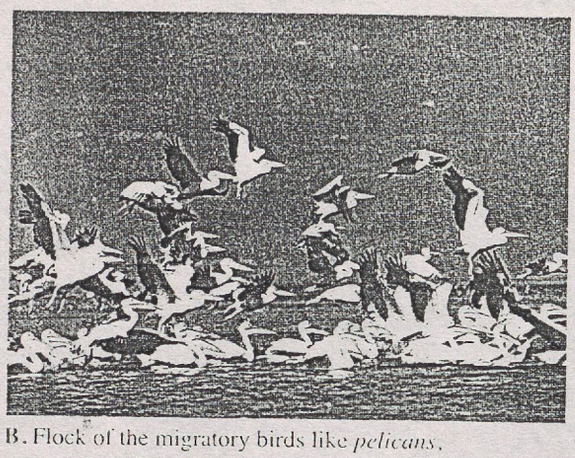
This population is living in a total of 7017 households. Average number of households per village works out at 585 in case of all twelve villages. In case of the four sample villages, the average number works out at 804.

LAND COVER/LAND USE CLASSES IN CATCHMENT AREA OF NALSAROVAR SANCTUARY

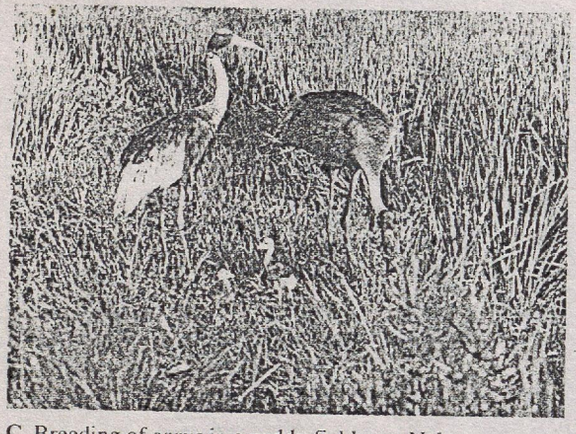




A. Congregation of waterfowl in the Nal during peak season.



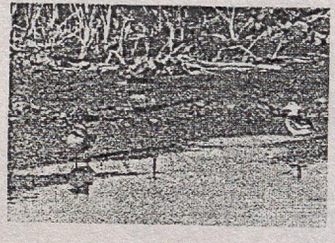
B. Flock of the migratory birds like *pelicans*, *coots* and *ducks* enjoys the ecosystem of Nalsarovar.



C. Breeding of *sarus* in a paddy field near Nal.



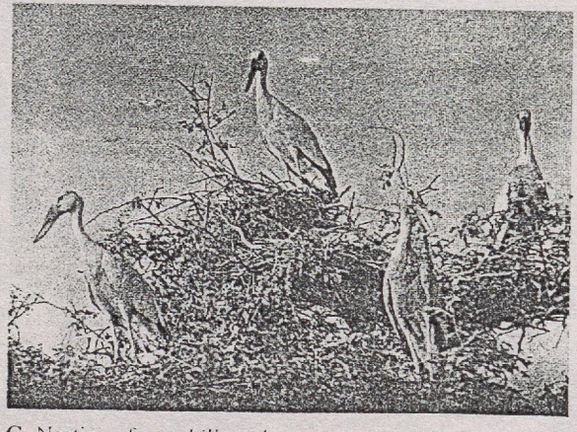
D. Big group of *sarus* seen exceptionally in the region during monsoon. Such congregation may be occuring in the environs of the Nal being potential breeding ground for *sarus*.



E. *Garganey*, a rarely seen migratory bird, visits Nalsarovar in winter.



F. Nesting and breeding of *black winged stilt* in Nalsarovar Sanctuary.



G. Nesting of *openbill stork*.

As the data suggest, the total number of 38,894 persons are living in 7017 households distributed in all twelve villages. The median number of households is 549 while the median population is 3189 persons. The average number of members per household works out at 5.5 persons.

9.2 Educational profile

According to the survey, between 1990 and 1995, the proportion of boys enrolled in primary schools has gone up by 25% while that of girls has gone up by 22%. Thus, the educational opportunities are being distributed more equitably between the sexes at this level.

Ashram Shalas are also established in some of the villages in the area. A total of 92 boys and 18 girls were studying in three Ashram Shalas in 1990. In 1995, the number of boys has increased to 96, while that of girls to 28.

Number of boys and girls who can undertake secondary education is understandably low. Only 57 boys and 7 girls undertook this education in 1990. Their number was 61 and 15 respectively for boys and girls in 1995.

It was also observed that enrollment is fairly wide-spread in both the communities and there does not exist much of the sex bias in enrollment either. However, the proportion of girls becomes less as level of education goes up. It is further observed that the school drop outs are found mostly in case of the lower community people. The situation thus, highlights the point that the upper community students have a much greater opportunity of availing the education.

9.3 Land use pattern

The villages are spread over total of 54,783 ha. Most of this is under cultivation. The area does not have forest cover worth the name. This has to be taken seriously as environmental upgradation of the area requires much wider spread of forest cover. One has to consider the problem of soil siltation in this context.

It is observed that there is a vast cover of waste land which is as much as 45% of the total area. Added to this is another 12% of the area which is fallow. This gives a total of nearly 57%, a large part of which could be used for the purpose of plantation of various grasses and tree species.

9.4 Agriculture

The soil of the area is light black. The land is not much undulating and most of it is flat. Only at the banks of the lake, there is a gentle slope.

Considering the soil and weather conditions, the area supports a few natural grasses. They are locally known as 'Godari' 'Beed' and 'Gadar'. 'Thor' also comes up naturally in this area. Trees like 'Baval', 'Piloo', 'Khijado', Limdo' and 'Amli' also come up naturally. These grasses are important components of the ecological balance of the area.

During the kharif season crops like bajra, jowar, cotton, paddy and groundnut are taken. Wheat, mung, moth, channa, etc,, are winter crops of the area.

9.4.1 Structure of crop agriculture

9.4.1.1 Land ownership

The Padhars own only 1.8 ha. land per household, and their per capita availability of land comes down to a meager 0.29 ha. Highest average land ownership is reported by those belonging to the category, 'others' who own 5.72 ha. per household and 1.0 ha. per capita. Next in the line is the community of Koli Patel. They own an average of 4.4 ha. per household and 0.71 ha. per capita. Finally, the Shenva community own an average of 2.66 ha. and 0.46 ha. respectively, for a household and individual member, which can be seen from details presented in Annexure -11.

9.4.1.2 Cropwise output and marketed surplus

Cotton, rice, pulses, jowar and bajra are the main kharif crops of the area. Besides, during winter, crops like wheat, barley and some spices are also grown. However, there does not seem to be much diversity in this regard.

As could be expected, 100% of cotton is marketed, while marketed surplus in case of rice works out to 58.4% . Only 30.6 % of pulses and 19 per cent of bajra are marketed.

In case of the winter crops, 100% of 'Suwa' and more than 92% of 'jeeru' crops are marketed. These are spices which are commercial crops. Less than 30% of wheat is marketed, while jowar is not marketed at all.

In all, the households require marketing facility for a total of 162.4 tonne of farm output at the end of the kharif season. At the end of rabi season, the requirement is for 30.6 tonne. However, it was found that 83.8% of the households effect the sales in the village itself. Since cotton commands the largest quantity to be marketed, the marketing is highest in the month of March when 62.2% of the quantity is marketed. During the winter months of October to December, nearly 20% of marketing takes place.

9.4.1.3 Farm Income

In addition to the income generated during kharif season some income is also available as a result of the winter crops. However, such income is available to only 29 households.

It could also be observed that only five households can go for the cultivation of jeeru, who can earn an average per ha. income of Rs. 10800. This is the highest income that can be earned from any single crop as the second highest income is earned by planting cotton per acre income in which case is Rs. 8080.

9.4.1.4 Labour cost

According to the survey results, in kharif season, per acre use of the family labour is 5.24 and during rabi it is 2.90. Again, absorption of outside labour on the per ha. basis, works out to 25 persons during kharif and 16 persons during the rabi season. Thus, the per ha. use of labour is quite reduced during the rabi season. The prevailing wage rate in the field at the time of survey was ranging between Rs. 25 and Rs. 30.

9.4.1.5 Use of fertilizers and pesticides

During kharif, 224 households have used 648 kg of urea, 30 households have used 91 kg D.A.P. and 129 households have used 395 cart loads of cow dung. In all, the per hectare use of urea works out to 65 kg, that of D.A.P. to 45 kg, and that of cow dung to 410 cart loads. In terms of financial cost, the per ha. cost works out Rs. 261 for urea, Rs. 388 for D.A.P. and Rs. 221 for farm yard manures. Thus the per ha. financial cost of fertilizers/manures comes to Rs. 1201.

In the same way, the per hectare cost of pesticides works out to Rs. 142.

9.4.1.6 Cost of cultivation

On an average, a household spends Rs.2356 during kharif and Rs.2151 during the rabi season on these activities. Per ha paid out cost, in case of ploughing and planting activities, works out to Rs. 655. This is nearly 56 per cent of the total cost of such operations. Thus, nearly forty four per cent of the cost component is from the household itself. Similarly, the per ha. cost of the other operations like harvesting, inter culture,. weeding, spraying of pesticides and giving fertilizers is Rs. 815. As against this, the paid out cost for these operations works out to Rs. 530. This is 65% of such cost.

9.4.1.7 Cost of marketing

On an average a household spends Rs. 87 on labour required for this purpose. Another Rs.103 are spent on sacks required for packing. Besides this, another Rs.187 are spent on transport. Because of the poor transport and road net work, expenditure on transport form a very high proportion; being nearly 73 per cent. Because of this high cost involved, the number of households that venture out for marketing remains low, being nearly 60 only.

9.4.1.8 Income from farming

This income is derived for three sets of households. There are some households which have shown farming as their main activity in their case average per household income works out to Rs. 32,451. The second set of households have shown farming as subsidiary activity and in their case it works out to Rs.14,721. There are still others for whom farming is shown as other activity, in their case it amounts to Rs.6,636 only.

9.5 Livestock component

Total five types of animals are reared in this region. They are, cow, buffalo, bullocks, sheep and goat. Per household ownership of cows is the highest, being 3.8. This is followed by buffaloes, which number 3.3 per household. Number of sheep and goats is not much; being just one or about two per household.

Ninety eight households were producing milk. Their average weekly output was of nearly 34 liter. Out of these, 52 households were sellers of milk. The average sale for these limited number of households was 35.31 litre per week.

Average income earned from the sale of milk works out to Rs.1836 per household. It is found that milk is sold at an average rate of Rs.5,.61 per liter, while a solitary household has also reported having sold curd at an average rate of Rs. 8.00. Nearly 55% of milk and 86% of curd was sold. No other dairy product was sold by these households.

9.6 Irrigation

Irrigation in this area is not very common (Annexure-12). It was observed that the local people, who grow paddy along with many other crops, use the differences in the water level in an ingenious way. If the rainfall in the upper reaches is high, their fields are submerged in the lake during some days of monsoon. As soon as the water starts receding, they go to their fields and plant paddy. This crop can come up well under two rather stringent conditions.

a) The water level in their fields should not rise much otherwise their crop may be submerged.
b) The water level should not recede too fast, otherwise their crops may wither away.

9.6.1 Community-wise irrigation

Highest amount of irrigated land per household is available to the Koli Patels, where it is 2.67 ha. (Annexure-11). The lowest per household irrigated land is available to a Padhar household, where it is 1.0 ha. The distance between the highest and the lowest is 1.67 meaning thereby that the Padhars belong to the lowest rung and the highest in the hierarchy are about 2.7 times ahead of them. Since the Padhasr own lowest size of land the proportion of irrigated land to owned land shows second highest proportion in favour of the Padhars (39.68 percent).

The second set of issues relates to the societal problem of degradation of ecology. At the moment, the sub-soil water may not contain salt particles beyond the tolerable limit of the crop. However, over the time it may make the top soil loss whatever limited, fertility it might have. This can cause ecological degradation.

9.7 Livestock population

Cows, buffaloes, bullocks, calves and goats are the types of livestock which are raised in the villages surrouning of Nalsarovar. Camels and donkeys, though present, are very negligible

in number. Camels are mainly immigrants for short period. Their total number has increased from 5482 (1988) to 11,982 (1993) and to 13,680 (1995). This shows an increase of nearly 250 percent between 1988 and 1995.

9.8 Infrastructure

In case of roads the villages are yet not sufficiently lucky as only four of them are connected by 'pucca' roads. The P.H.C. facility is available in only 4 villages.

It was also found that in all twelve villages, electricity connections were provided. There were 2515 electric connections in these 12 villages giving an average number of 209.58 connections per village. Considering the average number of households per village, about 36 percent of the households have received electricity connections.

9.9 Migration

The phenomenon of migration is fairly widespread; in particular amongst the Padhar community. A total of 13,120 persons have undertaken migration. Of this, 10,705 or 81.6% were Padhars. Number of migrants per family is 3.6 for all migrants. However, in case of the Padhars the average number of migrants per family works out to 3.7. It was reported by most of those undertaking migration that they went out mostly during winter and returned before the beginning of monsoon.

Almost all the migrants are found to be doing earth digging. Some of them are also working as construction labour. They received an average wage of Rs.38.33.

But the question is : Did the migrants return home with enough money so that they may not be required to go out again ? The answer does not seem to be in affirmative. It was found that on an average, a household which can send at least two persons out for the work can just cross over the poverty line.

Considering the average per household amount brought back(Rs.5045), and dividing this by the average size of a household, (5.5), a household can provide Rs. 910.65 for each of its members. It was also reported that the migration period was of about 240 days. Thus, the per capita per day income from migration works out to just over Rs.7.50. It is obvious that the households would again be required to incur fresh debt and in order to repay the debt, they will again be going out with the labour contractors. This seems to be an endless cycle.

Along with the human beings, migration of the livestock also takes place. It was observed that in all 830 cows (from 9 villages), 1130 buffaloes (8 villages) and 260 goats (4 villages); had migrated out of the respective villages during the period of study. The migration occurs due to unavailability of the resources. This dose not necessarily pertain to the livestock depending on the Nal. It is equally applicable to those outside the sanctuary area.

9.9.1 Phenomenon of seasonal migration

It has been observed that on an average an individual returned with approximately Rs.1,400. Against this, according to the household level inquiry, the net amount works out to approximately Rs. 2,000/-.

A total of 177 households have reported seasonal migration. 81% of the Padhar community and 63% of the Shenva community have had to migrate because of economic compulsions. In all 482 persons from these 177 migrant households had to go out in search of work. Thus, migrant household an average of 2.7 persons had migrated.

9.9.2 Income earned from seasonal migration

The survey revealed that in all 177 households have sent 482 members out for work. An average migrant household has earned approximately Rs. 16,187. In per capita terms this works out to Rs.5944/- for the entire duration of their stay. Considering a duration of nearly 175 days, as mentioned above, this gives an average per person earning of Rs.33.97 per day. The seasonal migrants have to pull on the eight months of their migration on this amount.

The per capita per day cost of food and shelter amounts to Rs.22.33. This leaves an amount of Rs.11.64; this can be taken either as saving, or as a margin to be used at times of emergencies like sickness, or in order to meet the other requirements like transport.

9.9.3 Role of the labour contractors

In case of seasonal migration it is sometimes suspected that the system of utilising the unorganised labour is operated by labour contractors. Such contractors establish their links with the employers. They also build up a system of traditional bond with the labourers. Such contractors may belong to the same community as well. At times they are the people who have graduated from the mill of such seasonal migration. We have not gone into the socio-economic background of the labour contractors for obvious reasons. However, two related aspects are examined; one of taking a loan from the labour contractor and the other pertaining to going out with the contractor.

It is observed that on the whole 61 per cent of the households go out in search of work with the contractors. Thus, 6 out of 10 migrating households use the conduit that is built up in this informal sector. In case of the Padhar community this proportion is as high as 77 per cent. This system is likely to provide a clout over the labour, both to the employers as well as the contractors.

Only 59, i.e. just one third of the migrating households had taken loans from the labour contractors. Average loan amount works out to Rs. 2739, being the highest in case of the Padhars, where it is Rs. 2932.

9.10 Boats and the lake

An average price of boat works out to Rs.5000 with an average lifespan of ten years and rate of interest on capital cost being twelve per cent per annum, an average monthly opportunity cost of a boat works out nearly to Rs.92.

On an average, though, a boatman is reported to get about 3.5 drives during the season. It was also reported that almost all households (265) per village undertaken fishing. For this purpose also the boats are used.

9.11 Occupation

Nearly 36% of the households are following agriculture as their main occupation. Another equal proportion follows other labour, as main activity. This adds upto a sizeable figure of 72%. Besides, another 28% follow this as secoandary activity.

12.33% get work as agriculture labourers. It is understandable that the agriculturists would be undertaking the operations with the help of the household labour, thus leaving much limited scope for outside labour. However, another 21% of the households have been doing agriculture labour on a part time basis.

Animal husbandry and dairying is undertaken by 8.33% as main activity and 11% as a subsidiary activity.

Six per cent of the households have reported fishing as their main activity. That is to say, only 18 households, in the sample population of 300 households rely on this resource. Another 6.45% have been undertaking this as a sub activity.

Only 0.33% report boat driving as their main occupation. This point is worth noting as Nalsarovar, which is a famous bird sanctuary, really does not provide much of an employment to the inhabitants on the banks from the angle of tourism, excepting to those who are residents of Vekaria. As Vekaria village is not considered as Nalkantha village, it has not been inlcluded in this study. However, as reported in the management plan of the sanctuary (Suthar *et al.*, 1991) there are about 300 canoes and 50 flat bottom boats in the villages surrounding the area. The flat bottom boats are used mainly for tourists and for carrying passengers and cargo. These numbers might have increased by this time. Most of flat bottom boats are owned by residents of Vekaria who have almost monopolise the tourism boating.

On balance, considering the occupations of the households, it could be seen that there is very limited additional advantage accruing to the local people from the Nal lake as a resource or as a bird sanctuary.

9.12 Employment

For all the communities, on an average, employment is available for 277 days. Most of the employment is available during winter (108 days), being followed by summer (92 days). There are some community based differences, however, Padhar, the main community receives employment for 267 days in a year. Highest employment, though, is available to the Ghanchi Vora community.

9.13 Housing condition

The average number of rooms per households ranges between 1.2 in case of Padhars and 1.8 as in case of Ghanchi Vora. In case of Padhars, mud and grass as thatching materials are taken from Nal lake. These residential houses are only one storied buildings and their floor, ceilings and walls are mostly made of the local materials. (Annexure-10)

9.14 Water resource

The households are required to spend less than 2 hours for obtaining drinking water. Time requirement varies across season for example, it is found that the highest time required is during drought, when it take nearly 2.7 hours, compared to this, minimum time is taken during monsoon (1.2 hrs) and maximum in summer (1.87 hrs).

Variation in time requirement is due to the fact that the boundary of the lake recedes during seasons other than monsoon. During drought, the households are required to walk a distance of 1.22 km which is almost double the distance required during monsoon, when it is 0.63 km. During winter, the water line recedes by 0.12 km and during summer it requires a walk of 0.91 km. The households have no complain regarding quality of drinking water being supplied to them.

9.15 Sickness

Households in this area do not seem to be enjoying good health. These households are required to spend an amount of approximately Rs.2500 on sickness on average, per year. At community level of course, there is some variation; for example, Padhars spend nearly Rs.2400 as against Ghanchi Vora who spends Rs.3317.

Most of the treatment is undertaken at the hands of private doctors. It is observed that 252 individuals go to the private doctors regularly and another 24 occasionally whenever they are sick. Use of PHCs, Govt. Dispensaries, Ayurvedic treatment, etc. are not very common.

9.16 Awareness regarding Narmada Canal

It is observed that almost all households are aware of the benefits of the Narmada Canal. Such awareness is 100% in case of Ghanchi Vora and Shenva. 97% of Padhars and 95% of Koli Patels and other are aware of the benefits.

However, the respondents and village elders opined during our visits that much depends on the monitoring of the level of water in the lake. As in case of some of the farmers, their land is situated on the lower slopes of the lake, if the water delivered into the lake is more, the fields may be submerged for long durations. This will make it difficult for them to take crops. On the contrary, if the water level is properly maintained, the farmers may also benefit immensely as they can take paddy crop, as was possible during the most favorable monsoon of 1994.

9.17 Dependence on the Nal ecosystem

It is believed that the Padhar community, which is a tribal community living in this area, depends on fishing and poaching of birds. Since the area is declared a bird sanctuary, there is a wide spread belief amongst the Government officials of the concerned departments that the poaching activity is undertaken by the Padhars (Extent of poaching in the area has not been studied in detail. However, it may be noted that three methods of poaching are used).

Besides, birds and fish, it is believed that the local community in general, is engaged in the activity of boating. The community may also be benefiting from the use of other natural resources, like bid, grasses, fuel wood, silt of the lake, etc. Dependence of the local communities on these natural resources is an important area of enquiry.

Dependence of the local households on the resources of the Nal lake ecosystem is an important issue requiring detailed inquiry. The basic issue of the resource use pertains to the discussion regarding use of the common resources. Nal lake has some common resources which are to be utilised for the economic sustenance of the inhabitants of the villages on its perimeter. The lake as an environment has a few positive externalities. Such externalities pertain to water, mud from the bed of the lake, fishing, boating, digging out bid for human consumption, grass and grazing for the livestock, etc. It also has many negative externalities. Breeding grounds for mosquito is one such thing as the area is infested by malaria. Though not exactly in the form of negative externally, but more as a constraint, the area has not benefited much from road transport. As a result, the cost of transport of materials is rather high, it adds to the problem of marketing of agricultural and other products.

The effect of the ecology has to be considered in light of the rainfall parameter of the area. As mentioned earlier, the entire lake may go dry if there is a sequence of droughts. On the other hand the villagers may benefit from bumper harvests if there is just enough rainfall. It was mentioned by one of the village elders during our visit, that the monsoon of 1994 was immensely favorable. The farmers, whose fields were nearer to the lake just planted their fields with paddy crop. Thenafter, they hardly did any other field operations. Yet, they reaped bumper harvest. This was so because it rained just enough to keep their fields under sufficient water. This provides an important lesson for us. If the Nal lake is filled up just enough so as to fill up the paddy fields, then the effect of this will be sizeable. However, first priority should be given to migratory birds rather than paddy cultivation for any filling operation.

In order to understand the importance of Nal lake in terms of its economic value for the resident households, we have attempted a small exercise. The details of this are interesting.

For the purpose of conducting this exercise we have tried to arrive at the economic value in case of the consumption of grass, fish, mud and roofing, other repair materials for the housing, boating and irrigation. Of course, the households are also using Nal waters for the purpose of drinking both for the humans and livestock. However, since we did not receive information separately for the water availed of from Nal and the usual supply by the GWSSB, it was not possible to include this into calculation.

Next, in case of grass used for the purpose of grazing, we have used a few assumptions. From the household survey, we had information regarding amount of dry fodder purchased along with use of concentrates etc. Now, for each type of livestock certain amount of green fodder is considered to be the requirement. The difference between what is availed and what aught to have been given is considered to be the quantity of grass going to the livestock by way of grazing. Value of such grazing works out to Rs. 6,98,427. We have also worked out these details for each community separately also. Thus, for example, others have much greater use of this particular externality of Nal, as they internalise nearly 63 percent of the total value of grass.

In case of fish, mainly Padhar community is known to be catching it. The total per annum realised income from the sale of fish works out to nearly Rs. 3,00,000/-. Besides, the households are also keeping a part of the catch for their household level consumption, this does not show their total capacity to catch fish. One can add another value of Rs.50,000/- that they might have kept for the purpose of own consumption.

In case of use of the housing material like mud and grass(to cover roof), the value is worked out to Rs.1,10,160. For the purpose of working out this figure, first of all number of houses which had used the material were identified. Considering the local cost of such material, and the quantity of such materials required, the value of building materials was worked out. Average life of the dwelling was put at five years. The houses also required repairs and maintenance. An average of Rs. 6252 was the amount that could have been used for this purpose. (Annexure-10)

Next, boating is an activity which also provides some income to the local community, viz,. the Padhars. Only ten Padhar households were found to be undertaking this activity. This activity gave them an additional income of Rs.23,900.

Lastly, we undertook to find out the economic value of irrigation. In order to find out this, we found out the difference in value of crop output realised in an ha. of irrigated land and an ha. of unirrigated land. In case of Shenva, no one had any piece of irrigated land and hence, we have not been in a position to provide data for this community. In case of others it was found that irrigation form sources other than Nal were also available. Hence we have not considered them. The figure of Rs. 89.4 shows per ha. per year value of crop output arrived in this way.

Finally, the total value of Nal resources available to the users as shown in Annexure-9 works out to Rs. 11,32,000. The total irrigated area of all communities except those classified as 'others', is 147.10 ha. Considering the per ha. value addition, use of Nal waters for the purpose of irrigation adds Rs. 82,000 to their income. Adding all these the value comes to Rs. 12,14,000.

This does not seem to be at all on the high side. Divisions of the amount mentioned above by 365 days yields an amount of Rs.3325.36 which is the amount of average daily income. Further dividing this by the sample of 300 households, we get a figure of just Rs.11.09. This then, is the amount that a household receives by way of externality of the lake. One has to make serious thinking about this externality.

We do not want to add any ring of finality about this figure. There could be studies which could be designed for the specific purpose of finding out the ecological implications and one can encompass other details also like negative externalities arising from the lake; malaria being one such serious externalities. One can also refine the methodology. However, we have made an effort to gauge the extent of dependence on the Nal ecology by various communities; we do not think that a change in these figures to the extent of even ten times will alter the brunt of the argument. The ecology can be made to play a much significant role in the economies of the households of the area.

9.18 Conclusions and recommendations

Nalsarovar is an important wetland of the western region. A variety of migratory birds flock to this lake during winter. For certain species, this is a refuelling site, where a few days are passed by birds during the onward journey. For many others this is a wintering habitat. Due to this fact the lake and its environs calls for detailed study and understanding.

The thumbnail sketch presented above permits us to look for approaches and actions for the improvement of the area. It is obvious that the improvement of the area is to be viewed in a totality of the system. While the Nal ecology is important for the migratory birds and the related aspects of the ecosystem, the lives of the people in the area has also to be supported and made viable.

In this light we recommend the following from socio-economic point of view.

(1) A canal from the SSP may be joined with the lake when it brings positive impacts. This will provide an opportunity for all round improvement in the lives of the people. Such a canal can provide a safeguard against the fragility of the ecosystem. As the system is dependent on rainwater only, whenever there is a drought, the system shows serious strain on it. Direct and indirect benefits of the canal can be visualised as follows:

a) If the lake remains full for major part of the year, people will get the benefits of the positive externalities of this common resource for a longer time in the year. Thus their reliance on migration will be much less. But this should be judged from the requirement of habitat.

b) When migration will be much less. the area-based and target group oriented aspects of development planning. Literacy levels could be expected to go up; besides, the schemes related with women and child development like DWACRA or other programmes of development like Indira Awas Yojana and TRYSEM can benefit the local people. This can help them updating or acquiring skills.

c) Effect of drought will be either minimised or removed. Thus, whenever there are instances of serious drought, consecutively for a few years, the lake dries up making the 'wetland' unattractive for the birds. A canal from the SSP can assure continuous water supply and can thus contribute immensely in the maintaining and strengthening of the ecosystem.

d) All these can be accounted in the form of social benefits from the SSP. Value of such social benefits are going to be sizeable.

e) Forestry has a unique role to play in the ecology of this region. Conscious efforts are required to plant carefully selected tree and other vegetative species so that the ecology is upgraded. Indigeneous species can be planted. It may include species like *Salvadora*, *Acacia* and *Ficus.*

Simultaneously. it is also necessary that the local community is made partner in the process of development. This activity can be anticipated to provide local employment while meeting some of the needs of the local communities like those of fuel wood and fodder.

(2) In particular, the 'Padhar' is the community which catches and sells fish. This community should be imparted skills and necessary materials as wells as the financial support to raise inland and sweet water fish in a more scientific way. Such effort can take away the load from the lake and the conflict between the birds and man can be resolved.

(3) Villages of this area are not sufficiently developed from the angle of infrastructure. This should be developed fast enough and also in a well integrated fashion. Only then marketing for fish and milk can become more beneficial to the people. The present nexus between money lender and trader has to be broken; but this can hardly be achieved if the transport and communication net work is not sufficiently developed.

(4) Development of the local people is very much connected with development of the resources. It is usual to find that economic development takes place only at the cost of ecological balance. This needs not to be a necessary condition. We have found that the lake ecosystem is large enough and it's resources are not over-exploited by the local people. It can be made more supportive too. One such measure is that of developing tourism in a well planned and organised manner. Indeed, unplanned intrusion of people scares away the birds. For this, some area for the tourists should be demarcated and tourists should be provided with a facility for a guided tour. Tourist zone may preferably be avoided in heavy bird concentration areas. They may go upto outside the periphery. A small natural history museum with bird and other life forms should be attached to the present facility provided by the Forest Department. There also could be a video programme for the people so that the tour is not taken only for fun and food but helps in propagating better understanding of the Nal ecosystem.

(5) Padhars, in a particular and young boys and girls in general should be trained for the purpose of providing understanding of the local ecosystem to the tourists. This will generate necessary income for them while making fuller use of their own understanding of their habitat. The locals, can not be considered aliens in their own habitat.

(6) Present system of collection of fees at the entrance of the lake at Vekaria point should be continued. The rates of the fees should be hiked up from the present level of Rs.5/- per person to Rs.10/-. Similarly other rates for cameras, binoculars etc. should also be revised. There also should be a specially high rate for foreign tourists. Income generated in this regard should be utilised to create natural history museum, video programmes, training Padhar youths in tourism, etc.

(7) It is essential to take a holistic view of the situation and find out parameters for the speedy development of the local communities, in particular, the Padhars. There is a tale of exploitation by the traders and other brokers of their physical labour. This has been going on for so many year now. We recommend that the task should be developed a perspective for the development of the area.

In previous chapters, existing scenario of the study area had been described and discussed through collection of extensive baseline information. Various components of the environment which are likely to be affected by the proposed canal network and the project proposals, have been included in it. The overall aim of the efforts made in this direction is to assess and analyse various impacts, both adverse and beneficial, of the proposed project on the Nal ecosystem. The ecosystem in the question is unique in the sense that it is a natural wetland where depth of water plays a major role in deriving its utility as a waterfowl habitat. As compared to many other areas, here the complexity in terms of interrelationships among various components is quite different.

Prediction of impacts is a process to forecast the future environment scenario of the study area due to the project implementation based on historic record. (Rao and Kaushik, 1993) For the Nal, historic data practically does not exist. Barring one or two studies made in the last decade, the area was never studied before. This has led to starting almost from a scratch. While presenting the data collected during the study period in previous chapters, some indications regarding likely impacts have been included. In order to have a holistic view in the prediction, it would be necessary to recapitulate and reform them here.

10.1 Salient features of the ecosystem

i. The sanctuary is a relict sea converted into a natural lake due to siltation of the creek and also due to geological movements.

ii. Being a natural lake the area under the submergence as well as the depth of water depends upon the rainfall. Ultimately the formation of habitats depends upon the quantum and pattern of rainfall in the catchment zone.

iii. A major portion of the lake out of about 120 sq.km of the notified sanctuary area dries up by winter and even in the years of good rainfall, water remains in less than 50% of the area during the winter. The lake almost dries up in the summer.

iv. Water in the lake is potable during monsoon. It is potable in post-monsoon period also during the years of good rainfall. It gradually becomes brackish due to oozing out of salts. Chlorinity and alkalinity rise with the shrinkage in lake area and oozing out of salt, and reaches at its peak during late winter and summer.

v. The significance of the area is mainly due to the extralimital migratory, local migratory as well as resident waterfowl species.

vi. The diversity, distribution and population of waterfowl in the area depend upon the water level in the lake, and to certain extent availability of habitats in the entire ecological zone.

vii. Formation of habitats in the area is a dynamic process which keeps on altering within the same area round the year.

viii. Dependency of local people on the wetland ecosystem is tremendous. Apart from fishing, grazing, grass collection, they use the area as water way and also drain sizable quantity of water for irrigation.

ix. The people also earn their livelihood through tourism, mainly by boating and setting up the catering stalls.

x. The process of drying up of the lake is a natural process, which up to certain extent causes distribution of flora, algae, zooplanktons and zoo-benthos etc.

xi. Southern part of the lake had more area under emergent aquatic vegetation as compared to other areas.

xii. Out of about 360 bets only 36 individuals have sizable area which do not get submerged even during better rainfall years. Only 3 bets have some tree cover on it.

While making predictions for the impacts of canal network surrounding the sanctuary, these features are to be kept in center. Before the predictions, it would be necessary to look into the project proposal and criteria taken into consideration while framing it.

10.2 Salient aspects of the SSP canal network around the Nal.

(i) Canal or any other structure is not proposed to be passing through the sanctuary.

(ii) The area falls in the command area of Saurashtra Branch Canal and sub branch canals.

(iii) The project proposes to provide structure known as "Escape" about 15 km north-west to the lake near Bhaskarpura at chainage 57.78 km on Saurashtra Branch Canal for taking care of mismatching of flow, sudden failure of pumps and electropower supply.

(iv) The escape is designed for full capacity of Saurashtra Branch Canal, which is about 319 cumecs (about 11000 cusecs). The escape water is proposed to be released in Bhaskarpura tank.

(v) The tank is shallow, having 30 m broad spillway with discharging capacity of 31.82 cumecs. The surplus water is passing through the spillway towards Nalsarovar and ultimately in Gulf of Khambhat through Nalsarovar.

(vi) Total length of the drain from Bhaskarpura to Nalsarovar is about 17 km.

(vii) With full capacity discharge of SBC, i.e. 319 cumecs of water, it will require approximately 5 hours to fill the depression of Bhaskarpura tank and 17 hours for filling depression between Bhaskarpura and Nani kathechi, if a temporary structure for storing water near Nani Kathechi is made.

(viii) If the discharge from SBC is continued for more than 22 hours, the additional water will flow into Nal lake, as per the proposal of the project without any modification therein.

(ix) The present capacity of Nal lake is about 66 million cubic meter (MCM^3) that is equivalent to 2.4 days discharging capacity of SBC.

(x) Initial proposal for increasing the storage capacity above RL 10 is now considered to be dropped as it has been felt counter productive.

(xi) The Nal can be linked with the SBC by providing link between Narsingpura branch canal and Ghoda feeder canal and the project proposes to provide water to the sanctuary, if felt necessary.

(xii) Apart from Bhaskarpura escape, it is likely that some amount of water may flow into the Nal through natural drains, in which excess water may flow through tail distributories of the command area.

(xiii) Water for irrigation is to be supplied in planned and controlled manner.

10.3 The impacts

Accuracy in prediction of the impact can be made when the provisions are implemented as per prescriptions in the plan. It does not happen in reality in our country due to negligence on part of the organisation or inefficiency inbuilt in the system. Problem of lack of efficient system of surface irrigation has been studied in the country which may be a lesson to the authority in this case. Arrangement in this case has to provide full assurance and guarantee with well defined roles and responsibilities that the canal water would be managed efficiently, and any unnecessary flooding or flow of water has to be avoided at any cost. Nature is very sensitive and even a small negligence in this regard may cause irreparable loss. Prediction in this chapter has been made on basis of certain assumption that water would be provided under a full control system.

10.3.1 Anticipated changes

The entire catchment area falls in the command area of the SSP. The changes in the lake environment with the implementation of the project can be anticipated in relation to two major factors, i.e.. (i) likely changes due to inflow of water from the catchment area and (ii) likely changes due to release of water through the proposed escape. Following changes are anticipated.

i. Irregular and unpredicted changes in the water level and submergence area of the lake due to release of water from the proposed escape. Resultantly changing the floristic and faunal composition, particularly aquatic ones.

ii. Change in physico-chemical properties of water due to inflow of the Narmada's water.

iii. Increased use of pesticides and insecticides in the catchment zone.

iv. Change in cropping pattern and agricultural practices.

v. Change in waterbodies, ponds etc., in the ecological zone of the lake. Such bodies will have more quantity of water and will retain water for longer period.

vi. Changes in the microclimate.

vii. Changes in the land use pattern as a result of increased availability of water.

viii. Increase in human activities and anthropogenic pressure.

10.3.2 Resultant impacts

The set procedures for predicting impacts normally envisage predictions in two categories, viz. positive impacts and negative impacts. However, the interrelationships among various components are at times complex, to the extent that certain changes might be beneficial to one component and simultaneously adversely affecting another component of the ecosystem. In such a condition, listing of all such impacts will be a prerequisite before weighting them and comparing them for arriving at some conclusion. Following the procedure adopted in most EIA studies, positive and negative impacts of SSP canal network on the ecosystem of Nalsarovar Bird Sanctuary are outlined hereafter.

10.3.2.1 Positive impacts on the Nal

i. Reduction in the salinity of water of the lake.

ii. Part of the lake may become perennial instead of seasonal.

iii. Increase in submergence area (water-spread) and rise in water level, leading to more conducive conditions for certain species of waterfowl.

iv. Increase in availability of certain types of habitat in the entire region.

v. Increase in tree cover due to increased availability of water and reduction in the salinity.

vi. Increase in availability of food for piscivorous birds due to increase in fish production resulting from increased area under submergence and also due to increased duration of the submergence.

vii. Change in the cropping pattern in the surrounding area may enhance availability of certain kind of resources for certain species, eg. Sarus cranes as in Mahi command area.

viii. Regulated inflow of fresh water may lead to make situation more conducive for most of resident as well as migratory species.

ix. Desired habitat can be maintained by using canal water during drought years.

x. Increase in the biodiversity of the area, especially plant.

xi. Introduction of new phytoplankton, zooplankton and other minor flora and fauna in the lake due to propagules carried by canal water.

10.3.2.2 Positive impacts on socio-economic environment

i. Improvement in agriculture production in the surrounding area due to intensification of cultivation.

ii. Expansion of agriculture in fallow lands.

iii. Increase in income through fisheries due to increased fish production, within the sanctuary as well as in the command area of the canal network.

iv. Increase in income through tourism activity. Increase tourism of well-regulated and controlled may even help this sanctuary from getting denotified in future.

v. More employment generation due to work related to canal network, longer period under agricultural activity and development of other economic opportunities.

vi. Decrease in seasonal migration due to increased availability of resources and employment.

vii. Increase in milk production, reduction in migration of livestock for grazing and general improvement of economic condition and standard of living of the people.

viii. Improvement in the availability of drinking water.

10.3.2.3 Negative impacts on the Nal ecosystem

The Nal is an unique wetland; different from many other wetlands due to the geo-climatic condition. Canal water would bring major change in micro-climate and environment of the area which in turn will make conditions difficult for the management to maintain the uniqueness of the lake.

(i) Irregular, unpredicted and non regulated release of water through 'escapes' and from tail distributories can drastically alter the ecosystem, and can wash off existing flora, algae, thereby greatly altering food and other rescurces

available to waterfowl. The situation will not likely to arise as the canal is to be operated as per the fortnight flow pattern. According to this planning and carrying capacity of canal, the maximum discharge of SBC is 319 cumec (for the second fortnight of September only) and the minimum discharge of 59.14 cumec will be released. For the operation of canal system, it is planned to provide latest control and communication system along the canal linking all regulated structures.

(ii) Release of water into the lake during the period between November to March may alter the ecosystems which develop gradually due to gradual reduction of water. This may adversely affect waders, surface feeders, and herbivorous bird species. Canal water should especialy be used during seriuos drought years and years of scanty rainfall.

(iii) Increase or decrease in the water level from the optimum level with maximum area under 21 to 60 cm water level during winter months would be adversely affecting most species of waterfowl.

(iv) Raising the storage capacity of the lake, beyond RL 9.4 will be adversely affecting the ecosystem.

(v) Drying up process in certain parts of the lake is felt necessary. Hence keeping the lake full to the brim throughout the year would be adversely affecting the ecosystem.

(vi) Draining water from the lake can bring negative impact on the ecosystem.

(vii) Fishing activity in the lake area itself is detrimental. Increase in fishing activity will further accelerate the problem of management and disturbance to the birds.

(viii) With increased availability of water for irrigation, cropping pattern and agricultural practices will be changed. This change will result into increased use of fertilizers, insecticides and pesticides. Nondegradable residues from these sources will consistently and continuously accumulate in Nalsarovar. Over a period, the level of concentration of chemicals will increase in soils of the Nal, which may be transmitted in birds through the food chain. This may bring negative impacts on birds, including those on their fertility and reproduction.

(ix) Water is a limiting factor during winter and summer in the catchment area of the Nal. Increased production of agriculture, development of allied activities and availability of canal water would provide opportunities for industrial development. Being located near Ahmedabad, some of the industries would be shifted in the area. This will result into pollution. Any pollutant added in the catchment area of the Nal would accumulate in the lake which would work as

sink for pollutants. Over time, toxicity of soil would increase and pollutants would be transmitted to birds through food chain, bringing negative impacts on them. Diversion of land for industries would also reduce the availability of habitat for birds.

(x) Development of agriculture and allied activities will provide a lot of economic opportunities to people which may result into tremendous growth of human population and anthropogenic activities around the sanctuary. This will destroy the natural wetlands in the region causing adverse impact on avifauna.

(xi) Increased tourism activity will adversely affect the ecosystem.

10.3.2.4 Negative impacts on the socio-economic environment

i. Irregular, unpredicted and non-regulated release of water through 'escapes' can cause hardships to the inhabitants and cultivators in the zone of the water-spread.

ii. Increasing the storage capacity of the lake beyond RL 10 will submerge certain areas of habitations and cultivated land. Even at RL 10, certain areas presently outside the sanctuary can go under temporary submergence, as at present.

iii. Waterlogging in the areas in the vicinity of the canal may occur due to seepage and flood irrigation but this situation may not arise due to lining of the canals and conjunctive use of ground water.

iv. Change in the cropping pattern due to availability of the canal water may decrease production of cotton and wheat while increasing production of other crops, particularly paddy.

v. Waterlogging and moist environment may cause water borne diseases resulting into health hazard.



In the previous chapter, likely impacts of the canal network, particularly Saurashtra branch canal and 'escapes' proposed thereon, have been discussed. Various positive and negative impacts have been identified and listed. The main objective of the entire study is to identify all such impacts with a view to minimise the negative impacts and maximise the positive ones. Usually, any kind of trade-off is debatable and controversial, particularly when it is related to environmental aspects. The area under the study in an inland wetland habitat supporting one of the largest concentration of waterfowl, which are depending upon the spread and depth of the water in the area, particularly during the winter. At a first glance, any activity which can increase the area under the waterspread appears to be beneficial to the ecosystem. However, the findings narrated in previous chapters have shown that the answer is not as straight forward as it appears. On the other hand, some hard-core environmentalists may advocate for preserving and keeping the natural entity of the area, not allowing any kind of human intervention in it, even if it is beneficial or can be made beneficial to the area.

Before proceeding further in this regard, a thought is to be given on what is experienced in certain other areas from which some guidelines can be obtained for the area under the study.

11.1 Experience of Mahi Command in Kheda.

Within the Mahi Command Area, especially in Matar Taluka, between Kheda and Tarapur zone, many village tanks have been connected with the canal of Mahi project. These tanks are filled through the canal and further irrigation channels are provided from these tanks. Some of the tanks are quite large in the size. e.g. Kanewal, Pariej, Narda, etc.. It has been observed that the areas as well as surrounding areas of these lakes and tanks, support large number of a variety of waterfowl every year. Not only that, this belt is probably supporting largest number of certain species of waterfowl as well as most preferred breeding ground of Sarus Crane in the State. However, due to more depth than the ideal depth suitable for most of the waterfowl, population of certain species is much less as compared to that in Nal, as evident from data published for mid-winter waterfowl census. The most beneficial impact from waterfowl habitat point of view is that these areas have relatively less impact of drought and/or less rainfall, as these areas receive water through Mahi canal. However, negative impacts in the form of growth of weeds like *Typha* and *Eichhornia* (water hyacinth) are also observed in these tanks which is not preferred by many species of waterfowl.

11.2 Experience of Keoladeo Ghana

Keoladeo Ghana National Park, Bharatpur, is considered as one of the best wetlands and bird habitat in the country. This is the area where natural shallow depression has discreetly been converted into ideal wetland habitat by constructing Ajan bund, a reservoir constructed more than a century ago. Several earthen bunds and sluice gates have been constructed to maintain and regulate water level. Here, the water is drawn through a canal from Ajan bund during the monsoon. Barring severe droughts, water spread area of the Park is almost constantly maintained during every season, from year to year, and at desired level. However, the release of water from the bund to the Park is only during July to September, seldom upto October. Not only that, but the excessive water from the Park can also be released outside the Park so that the water can be maintained at the desired level.

While comparing this experience with the Nal, a natural lake, is not divided by dykes and bunds and having quite large area than that of the Keoladeo. The maximum water spread area in the national park is not more than 11 sq.km (Vijayan, 1991), whereas the Nal is almost ten times larger. But there exists a combination of other habitats like woodland, grassland etc., which is practically absent in the Nal. Hence, Keoladeo N.P. supports high diversity of avifauna.

The Nal is unique, and different from the above wetland. Hence, adequate precautions will have to be taken before adopting any strategy based on above experiences.

11.3 The canal network and management of habitat

From the aforesaid discussion, it evidently appears that wetland habitats can be improved and better managed if the water level is maintained at optimum level by supplementing required quantity of water.

In case of the Nal, apart from maintaining an optimum water level, process of drying up would also require to be maintained so as to allow natural process and maintain the vegetation as well as faunal component depending upon it. This means that, an ideal compromise has to be made in a way that maximum area under water spread is available during the winter with varying depth to meet requirement of various species and also certain parts dries up during the summer. Such kind of the arrangement will have minimum negative impact, provided water is not released into the area during the winter and summer.

Inflow of water in the lake after the rainy season will have negative impact on the ecosystem. Apart from inflow of fresh water having chemical and physical properties different than that in the lake, it is likely that algae and other aquatic vegetation may get washed off as well as get altered which will have negative impact on the fauna of the lake. Hence, it would be necessary to fill the lake at the desired level soon after the end of the monsoon and not to allow any further release into the lake.

Based on the available information, various aspects discussed above and on the basis of remote sensing study (Chapter 4, para 4.3), it would be ideal to decide the area under water spread during the month of September and the shortfall observed should be met from the canal. Moreover, this may require repairs of the existing bund, locally known as "Dakthali No Palo" which is near Sanknera ness in south of the sanctuary.

11.4 Measures for utilising positive impacts

11.4.1 Repair of the exiting bund (Dakthali no palo)

An earthen bund, known as 'Dakthali no palo' is existing in south of the sanctuary area. Information regarding exact period of its construction could not be obtained but as per the information of the local people this bund was constructed around 1965-70. This bund has been damaged thenafter and is not capable of retaining water. This bund should be repaired and should have at least 4 cemented overflow at RL 9 m with a provision of gates to maintain water level between 9 to 10 m RL. Due to this it will be possible to maintain the area under water spread at RL 9 m and 10 m and will help to prevent drainage beyond this level. Thus at RL 9, the maximum depth of water at the deeper-most contour would be about 1.5 m.

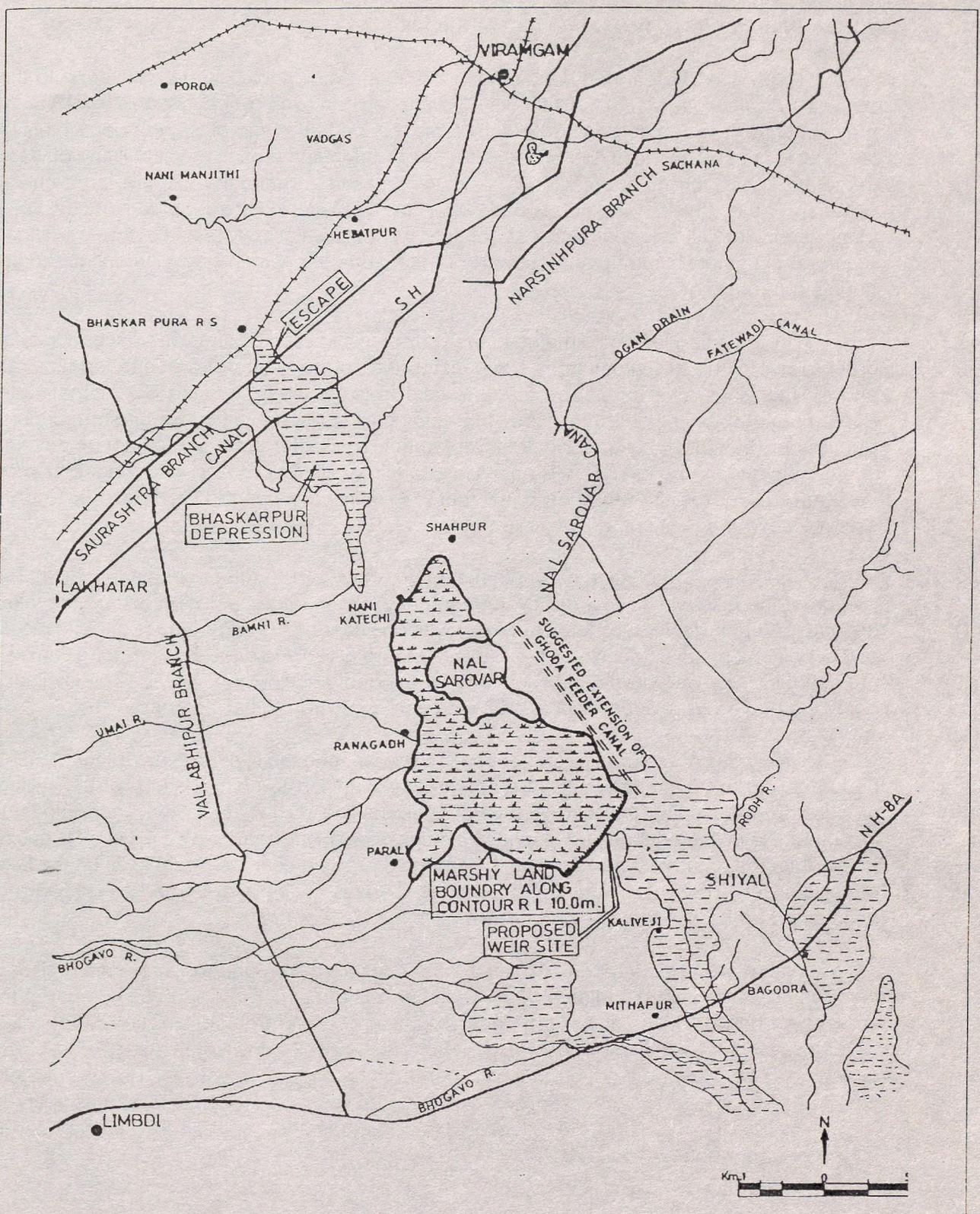


Fig. 11.1 Map showing canal network and proposed site for escape and its management

11.4.2 Water level to be maintained in the lake

Repairs of the earthen bund mentioned above will enable to retain water up to the RL 9 and 10. In-flow of water in the lake during monsoon can overflow beyond this level. Over-flow may continue for about a month after monsoon. i.e. up to the end of September. At this water level, after considering loss due to seepage, evaporation and present level of lifting of water for irrigation, during the month of winter, i.e. November to February, the average area under the water spread is likely to be around 40 to 60 sq.km. This level is felt adequate as at this level an ideal condition with different kinds of habitats will be available. Moreover, this will allow the natural process of drying up in most part of the lake as the waterbody will continue to shrink during summer month.

The question is how to maintain the water level in case of drought or scanty rainfall. In order to overcome this situation, it is suggested that in the years of drought and less rainfall and for that sake even otherwise also the lake is to be filled by using SSP canal water in September month. The shortfall below RL 9 is to be filled through canal water either during mid September (15\9) or in the last week of September. Then after there should not be any further release of water in the lake. This is necessary to allow natural process of drying up of most of the area. Filling the lake through canal water is only as a supportive measure, to prevent extreme severe conditions arising due to drought.

The above suggestion on implementation, may lead to the condition in which a small portion of the lake will have water even during the summer, hence, to that extent the lake will become perennial instead of seasonal. However, considering the experiences of other wetlands and conditions prevailing at Nalsarovar, this measure is likely to create better conditions which are conducive for waterfowl as a whole and for resident species in particular. The likelihood of nesting/breeding of resident species will increase apart from other benefits.

Drought is a recurrent phenomenon in the area, and the Nal remains dry for most of the period during the scarcity years. This provides a condition to control some of the biological processes, maintaining the historical uniqueness of the area. Due to the uncertainties and incomplete knowledge about the response of ecosystem in the changed condition, it is desirable to maintain the natural status of the Nal. Although a provision can be made to fill up the lake up to certain height by mid-September, complete dryness of the lake should be allowed to be maintained in the consecutive drought years.

With waterlogging, due to irrigation of agriculture field round the year, micro-climate of the area will be changed and air and soil moisture will remain always high as compared to the present scenario. With availability of canal irrigation, there are all possibilities of reduction in withdrawal of lake water for irrigation. All these factors will bring some effect on the rate of drying up of the Nal and it will be much slower than the present rate. In the background of this fact, it has become further necessary to allow the maintenance of complete dryness of lake for long period, for once or twice in a decade. However, this should be studied in the interest of conservation of natural wetland.

11.4.3 Management of water from 'escape'

As stated earlier, an 'escape' is proposed on SBC near Bhaskarpura. The escape is very much necessary to take care of mismatching of flow of water in the canal, failure of electricity, pumps etc. These are the factors which can not be predicted and thus time and period of release of water through escape cannot be predicted. The water released thus, is likely to be drained into Nal lake if any regulating measures are not taken, which can adversely affect the entire ecosystem. Hence, it would be necessary to take up measures for regulating the flow of water from the escape. As per the information furnished by SSP authority canal is to be operated as per the fortnight flow pattern. According to this planning and carrying capacity of canal, the maximum discharge of 319 cumec (for the second fortnight of September only) and minimum discharge of 59.14 cumec will be released. For the operation of canal system, it is planned to provide latest control and communication system along the canal linking all regulated structures.

The 'escape' will be required to be operated to dispose of the surplus water during emergency situation. The duration for release of water through escape will also minimum and it can be controlled through gates. Nal lake is about 17 km far from location of escape on SBC. Therefore, the water released through escape will first absorbed by the Bhaskarpura tank and enroute depression between the Nal lake and location of escape. Considering all these facts the water released through escape will not affect the ecosystem of the Nal lake adversely. Although SSP authority has planned for control of SBC flow, in order to overcome the remote chances of excess flow from SBC to Nal after monsoon, the measures suggested as under should be taken :

(i) The capacity of Bhaskarpura village tank as envisaged by SSP authorities is around 319 x 5 = 1595 cumec., i.e. about discharge of 5 hours at the full capacity of SBC. However, if the tank already has some quantity of water in it, the capacity of the tank to contain water of escape will be reduced up to that extent. This kind of situation is likely to arise, more so during the monsson. During monsoon, i.e. up to mid September, their is no harm if the water is allowed to drain further up to Nalsarovar, as the excessive water beyond the prescribed RL, i.e. around 9.5, is going to overflow from the lake. After monsoon, the release from the escape, if any, will be firstly released into Bhaskrpura tank. It can safely be presumed that after monsoon, at any time, the tank will have maximum 50% storage of water and it is capable of retaining 2.5 hours release of water from the escape, i.e about 800 cumecs of water. Hence, the first 2.5 hours release can be hold by Bhaskarpura tank.

(ii) The capacity of natural depression between Bhaskarpura to Nani Kathechi has been worked out to be of 17 hours of disharge, i.e. 319 x 17 = 5423 cumecs of water, if a temporary structure near Nani Kathechi is made. Hence it is suggested to construct structure like bund or weir near Nani Kathechi for retaining the release from the escape. The design of this structure should be such that it can allow the drainage of water during monsoon in Nal lake, so as

to allow natural drainage into the Nal. Thus, it will need a structure having facility of opening and closing gates. These gates should remain closed from 15th September to 15 th June.

The depression between Bhaskarpura and Nani Kathechi will become an extended waterbody, providing additional habitat for many species of waterfowl. This area under the depression can act as extension of the sanctuary. With a view to provide better protection to birds inhabiting in this area and for better management it is suggested that this area should also be declared as the sanctuary. However, existing rights of fishing, grazing, lifting water etc., should be allowed to continue in the area so as to avoid any other complications and hardship to people having rights.

(iii) Aforesaid two arrangements will able to store/retain water up to 19.5 hours discharge from the escape, which in most case will serve the purpose, as during this period other remedial measures can easily be taken. However, with a view to cope up with any kind of exigencies of releasing additional water, it is suggested to modify and extend the existing 'Ghoda feeder' canal, and to link the canal with Narasingpura branch canal. The 'Ghoda feeder' canal should be extended up to Shiyal, beyond the existing 'Dakthali no Palo'. Excessive water from SBC is to be released into 'Ghoda feeder' canal through Narsingpura branch canal and ultimately it can be released into natural drainage beyond 'Dakthali No Palo'. This extended part of the 'Ghoda feeder' canal, if required can be aligned almost parallel to the sanctuary boundary, on the edge of the sanctuary.

(iv) The structural designs for suggestions made at above (i), (ii) and (iii) and selection of sites for it, is to be judged by technical experts of SSNNL. It would be necessary to make provision for release into Nal lake as suggested under para 10.4.2, in the designs of structures at Nani Kathechi as well as in Ghoda feeder canal. Moreover, desilting of canals, parts of the depression etc., will have to be prescribed as per the requirement.

11.4.4 Regulation of fisheries

Various recommendations made above will result into expansion of the waterbody and extended period of submergence, ultimately resulting into opportunity of increase in fish production. Fishing activity in the sanctuary area itself is felt detrimental as at present fishing is uncontrolled and unregulated in the practical sense. The management plan of the sanctuary area prepared by the Forest Department envisages certain regulations on this activity, particularly regarding usage of fishing nets of certain mesh size and season of the fishing. Following suggestions are made keeping the management plan prescriptions in the focus.

1) No fishing should be allowed in the present sanctuary area during mid September to February, so as to avoid disturbance as well as possibilities of poaching during the season of stay of migratory birds.

2) Present 'Sanctum Sanctorum' area, i.e. Dhrabla bet and its surrounding, is too small. The basic aim of declaring sanctum sanctorum area is to keep area free from grazing, fishing, grass collection etc.The sanctum sanctorum area is to be enlarged and should include the area bounded by Panwad, Limsi, and other bets. Fishing, grazing and grass cutting should be totally prohibited in this zone.

3) During the open season, i.e. from March to September, fishing may be permitted in other areas. However, nets having mesh size less than 75 mm x 75 mm should not be allowed to be used. This will facilitate growth and development of fishery as fish of smaller size will be escaped, and only large sized grown up fish will be caught. Ultimately, it will benefit communities involved in fishing.

4) Considering the decrease in the salinity level, and with a view to enhance the production of fishes, fingerlings of fish species occurring naturally in the area is to be done every year, in consultation with the fisheries department. No new species of fish should be introduced in the area. However, with water from the canal, it is likely that some species may enter the lake area.

11.4.5 Regulation of tourism

As the sanctuary area will have more water spread and some part may have water round the year, tourism activity is likely to increase. At present practically there is no control over the movement of tourists in the lake, except regulating entry during night and the mandatory provision of recovering entry fee. Unrestricted and uncontrolled movement of visitors in the sanctuary causes great disturbance to birds inhabiting the lake. Hence following measures are suggested.

(i) Tourism zone should be defined and demarcated in the areas where heavy bird concentration does not occur usually.

(ii) The visitor should be allowed to move in the specified area which should be demarcated. The tourism zone thus specified should include deeper most part of the lake so as to facilitate boating and also keeping distance of movement in mind though it may exclude the areas suggested to be declared as sanctum sanctorum.

(iii) The management plan for the area envisages an interpretive programme as well as training to local people to act as boatman cum guide. This programme should be implemented at the earliest with requisite modifications, if any, by the sanctuary authorities.

(iv) All the boatmen desirous of using their boats for tourism purpose should register their boats with the sanctuary authorities as envisaged in the management plan.

(v) Attempts should be made to create a co-operative society of boatmen and this society should be assigned the task of providing boats to tourists at the prescribed rates. Otherwise the sanctuary authorities should regulate this aspect. This suggestion is felt necessary as at present there is no control or regulation of boat and boatmen. Visitors are gheraoed by boatmen and at times they put the visitors in embarrassing situation

11.4.6 Other regulatory and mitigating measures

(i) Draining of water from the sanctuary area should not be allowed and in no circumstances it should be permitted between 15th September to 1st March of the year. With the canal network and due to extension of 'Ghoda feeder canal' it is likely that most of the requirement of water for irrigation will be met through the canal network.

(ii) All the minors, sub-minor and distributories in the area will be lined, as per SSP planning so that chances of seepage and waterlogging will be minimum. It is planned to provide limited quantity of surface water to the farmers. It is also planned for conjunctive use of ground water so that there will be least possibility of seepage and waterlogging.

(iii) With a view to provide resting, roosting and nesting sights to birds, it is suggested that deepening around certain small islands within the proposed sanctum sanctorum area should be taken up in the phasewise manner, thereby making small islets of about 10 m x 10 m x 2.5 m size. However, the deepening should not extend more than 60 cm. so as to cover wider area under the deepening. Such islets should be taken up for raising tree species indigenous to the area in the next monsoon. Initially the distance between two islets should be minimum 100 m.

(iv) Industries, particularly those which discharge pollutants of any kind e.g. chemical, paper etc. should not be permitted in the catchment zone of the lake, even though if they have provision for treatment of pollutants, as a measure of safety.

(v) Use of biofertilizers, biopesticides and bioinsecticides should be encouraged, particularly in the catchment zone.

(vi) Already a trend has taken place in which present agricultural land and other areas are being encroached upon for developing tourists resorts, farm houses etc., which is a threat to the ecosystem. Such trend is required to be discouraged in the longer perspective in the interests of the sanctuary.

11.4.7 Monitoring of impact

Monitoring of predicted impacts and various mitigation measures is vital for any project, particularly when it is related to living entity and dynamic ecosystem. According to Kesker et al (1993), monitoring is the continuous or periodic review and surveillance by management to oversee the impact of an activity. Monitoring is not a one time job and is a continuous process. Hence, it is suggested that impacts of various suggestions made for utilising positive impacts as well as mitigative measures for negative impacts should be monitored continuously. Sanctuary authorities should be assigned the task for monitoring impacts on the sanctuary ecosystem, while for other aspects task may be assigned to university or other institutions etc.

Periodic review of monitoring programme and its outcome should be made and any adverse impact if noticed should be attended immediately and remedial measures should be taken up. Necessary changes in the activities or works suggested should be made if required. It would be appropriate if a committee including experts of various fields is constituted for first five years of the post project period to look after the implementation and monitoring of various measures and its impacts.

Bharkarpura tank and depression between Bhaskarpura to Nani Kathechi would be perennial wetland after the implementation of the project. This opportunity should be used for developing this area as habitat suitable for breeding of resident birds. Combination of unique natural wetland of Nal lake and artificial perennial water bodies at Bharkarpura would provide variation of habitats suitable for both, resident and migratory birds.

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Annexure - 1 A
List of algal species recoreded at Nalsarovar

Sr. No.	Name of species	Remarks
	Cyanophyceae	
1	*Anabaena sphaerica*	Moderate in soil and epiphytic on plants
2	*Aphanothece saxicola*	Moderate, epiphytic
3	*Aphanocapsa montena*	Moderate, floating and epiphytic
4	*A. pulchara*	Abundant among other algae
5	*Aulosira prolifica*	Abundant, on plants and soils
6	*Chroococcus macrococcus*	Abundant in the scum
7	*C. minor*	Abundant, epiphytic on Chara
8	*Gloeocapsa atrata*	Abundant, epiphytic on Najas
9	*Gloeotrichia sp.*	Abundant, epiphytic on plant and floating scum
10	*Johannesbaptista pellucida*	Epiphytic, moderate
11	*Lyngbya aeruginieo coerulea*	Abundant, epiphytic and also on scum
12	*L. puteallis*	Abundant, epiphytic
13	*Merismopedia convoluta*	Moderate
14	*Microcoleus subtorulosus*	Moderate, epiphytic
15	*Microcystis flosaque*	Abundant, floating but sometimes epiphytic
16	*Nodularia sp.*	On scum and epiphytic on plants - moderate
17	*Oscillatoria obscura*	Abundant, floating on the soil and epiphytic
18	*O. princeps*	Abundant on soil
19	*O. subbrevis*	Abundant, floating
20	*Phormidium bohneri*	Moderate, epihytic on scum
21	*Rivularia sp.*	Abundant, epiphytic and floating
22	*Scytonema coactile*	Abundant, mixed with other algae
23	*S. jaganicum*	Abundant, forming scum and on soil
24	*Spirulina subilissima*	Moderate, floating
25	*Tolypothrix sp.*	Moderate, epiphytic
	Chlorophyceae	
26	*Bulbochaete sp.*	Abundant, seasonal epiphytic
27	*Chara erythrogyna*	Abundant
28	*C. globulans*	Abundant
29	*Eudorina sp.*	Few, floating and epiphytic
30	*Eustrium elegence*	Abundant, entangled in the scum and or mat or other algae
31	*Cladophora cristata*	Abundant, forming dense mass

32	*Cosmarium contractum*	Moderate, free floating
33	*Coleochaetae scutata*	Moderate on Chara and other plants
34	*Mougetia sp.*	Occasional, floating and on plant parts
35	*Nitella accuminata*	Abundant
36	*N. transilis*	Abundant
37	*Oedogonium multisporum*	Moderate, epiphytic
38	*O. tyroticcum*	Moderate, epiphytic
39	*Spirogyra gratima*	Few, free floating
40	*S. prentensis*	Abundant
41	*Ulothrix contrata*	Moderate, epiphytic
42	*U. zonata*	Moderate, epiphytic
	Bacillariophyceae	
43	*Zygnema sp.*	Abundant, free floating
44	*Cymbella sp.*	Abundant, epiphytic
45	*Fragillaria sp.*	Abundant, epiphytic
46	*Navicula sp.*	Occasional, epiphytic
	Euglinophyceae	
47	*Euglena sp.*	Abundant, free floating
48	*Phacus sp.*	Abundant, free floating

Note : 'Abundant', 'Moderate', 'Occasional' and 'Few' are relative terms showing abundance/ occurrence of species during the study, in various parts of the lake.

Annexure - 1 B

List of plant species (macrophytes) recorded at Nalsarovar

Sr. No.	Name of species	Local name	Family	Occurrence	Annual (A) or Perennial (P)	Form
1	*Marsiliea quadrifolia*	-	Marsileaceae	Aquatic	A	Herb
2	*Cleome viscosa*	Pilitilvan Pili tanvani	Capparidaceae	Bets, Sandy soil	A	Herb
3	*Tamarix dioica*	Achhil aigoparas Bhuripras	Temaricaceae	Bets	P	Herb
4	*Bergia odorata*	Jaljambvo Gandharo Okhrad	Elatinaceae	Dried mud flats	A	Herb
5	*Corchorus olitorius*	Borchhuchh	Tiliaceae	Bets, Dry areas	A	Herb
6	*Corchorus aestuans*	Chunch Chhadhari	Tiliaceae	Bets, Dry areas	A	Herb
7	*Tribulus terrestris*	Bethu Gokhru Mithu Gokhru Akanti	Zygophyllaceae	Bets, Dry mud-flat, sandy areas	A	Herb
8	*Alysicarpus rugosus*	-	Papillionaceae	Bet, Shoreland	A	Herb
9	*Alhagi pseudalhagi*	-	Papillionaceae	Sandy areas	A	Herb
10	*Aeschynomene indica*	-	Papillionaceae	Moist place	A	Herb
11	*Crotolaria medicaginea*	Abdaumethi Ranmethi	Papillionaceae	Bets, Shoreland	A	Herb
12	*Indigofera enneaphylla*	Fatakiya Bhonygal	Papillionaceae	Common	A	Herb

13	*Sesbania aegypltiaca (Sesbania sesban)*	Sevri, Jayanti	Papillionaceae	Common	A	Shrub
14	*Prosopis Jiliflora*	Gando Boval	Mimosaceae	Bets	P	Tree
15	*Prosopis sineria*	Khijdo	Mimosaceae	Bet, cultivations	P	Tree
16	*Ammannia baccifera*	Aganbuti	Lytheraceae	Damp place	A	Herb
17	*Ludwigia perenmis*	-	Onagraceae	Common	A	Herb
18	*Trianthema portulaca*	Satodo	Aizoaceae	Shoreland	A	Herb
19	*Caesulia axilloies*	-	Compositeae	Damp places	A	Herb
20	*Eclipta alba*	Bhangro	Compositeae (Asteraceae)	Damp places	A	Herb
21	*Vernoia cinerea*	Sahadevi Sadedi	Compositeae	Shoreland	A	Herb
22	*Xanthiam Strumarium*	Gokhru Gadariya	Compositeae	Common	A	Herb
23	*Enicostema littorale (Enicostema hyssopitolium)*	Mamejevo	Gentianaceae	Bets, Shoreland	A	Herb
24	*Heliotropium indicum*	Hathi sundha Hathi sundho	Boraginaceae	Mud-flats, Damp areas	A	Herb
25	*Heliotropium ovelegheia*	-	Boraginaceae	Mud-flats, Damp areas	P	Herb
26	*Evolvulus alsinoides*	Kali shankha vali Zini Fudardi	Convolvulaceae	Common	A	Herb
27	*Cressa critica*	-	Convolvulaceae	Common	A	Herb

28	*Convolulus sp.*	-	Convolvulaceae	Common	A	Herb
29	*Physalis purparea*	-	Solanaceae	Among grass	A	Herb
30	*Solanum xanthocarpum (Solanum rurattense)*	Bhoringni	Solanaceae	Common	A	Herb
31	*Solanum nigrum*	Piludi	Solanaceae	Common	A	Herb
32	*Bacopa monnieri*	Bam, Jalnaveri	Scrophulariaceae	Moist ground	-	Herb
33	*Peplidium martimum*	-	Scrophulariaceae	Salt affected area	A	Herb
34	*Pedalium murex*	Ubhu Gokharu Motu Gokharu	Pedaliaceae	Sandy coast	A	Herb
35	*Justicia procumbens*	Pitpapdo	Acanthaceae	Moist sandy area	A	Herb
36	*Phyla nodiflora*	Ratvello, Ratalio	Verbinaceae	Common	A	Herb
37	*Boerhavia rependa*	-	Nyctaginaceae	Common	P	Herb
38	*Boerhavia diffusa*	Satodi	Nyctaginaceae	Common	P	-
39	*Achyranthes aspera*	Andhedo Anghedi	Amaranthaceae	Common	A	Herb
40	*Celosia argentia*	Lambdi Lampdi	Amaranthaceae	Common	A	Herb
41	*Suaeda maritimum*	Luno, Lano	Chenopodiaceae	Saline area	A	Herb
42	*Polygonum plebeium*	Ratnajoth Zincookhard	Polygonaceae	Moist place	A	Herb
43	*Polycarpia corymbosa*	-	Caryophyllaceae	Sandy area	A	Herb

44	*Euphorbia hirta*	Durnell	Euphorbiaceae	Common	A	Herb
45	*Commelina benghalensis*	-	Commelinaceae	Moist area	A	-
46	*Commelina nodiflora*	Shishmuli	Commelinaceae	Moist ground	A	Herb
47	*Typha angustata*	Ramban Ghabanjaria Janglibajn	Typhaceae	Moist, Marshy land	P	-
48	*Cyperus alterneplia*	-	Cyperaceae	Moist areas	A	-
49	*Cyperus arenarius*	-	Cyperaceae	Sandy ground	A	Herb
50	*Cyperus bulbosus*	-	Cyperaceae	Common	P	Herb
51	*Cyperus compressus*	-	Cyperaceae	Sandy loam soil	A	Herb
52	*C. difformis*	-	Cyperaceae	Common	A	Herb
53	*C. esculentus*	-	Cyperaceae	Common	P	Herb
54	*C. elauanoides*	-	Cyperaceae	Common	P	Herb
55	*C. exalta*	-	Cyperaceae	-	A	Herb
56	*C. haspan*	-	Cyperaceae	Among grasses	P	Herb
57	*C. niveus*	-	Cyperaceae	-	P	Herb
58	*C. pangonri*	-	Cyperaceae	Dampy areas	P	Herb
59	*C. rotundus*	Moth chidho	Cyperaceae	Common, Moist areas	P	Herb
60	*C. triceps*	-	Cyperaceae	Moist areas	P	-

61	*Eleocharis dulicis*	-	Cyperaceae	Submerged water -logged soil	A	Herb
62	*Fimbristylis dicotoma*	-	Cyperaceae	Common	P	Herb
63	*Scirpus maritimus (Scipus tuberosus)*	-	Cyperaceae	Common	P	Herb
64	*S. grossus (S.kysoor)*	-	Cyperaceae	Common	P	Herb
65	*S. littorelis*	-	Cyperaceae	Common	P	Herb
66	*Aleuropus logopoides*	-	Poaceae	Sea coast common	P	Herb
67	*Apluda mutica*	-	Poaceae	Common	P	Herb
68	*Bothriochloa sp.*	Dharjo	Poaceae	Common	P	Herb
69	*Cenchrus sp.*	Motu Dharmnu	Poaceae	Common	H	Herb
70	*Dichanthium sp.*	-	Poaceae	Common	P	Herb
71	*Saccharum sp.*	Sarkhant Hadol, Munj	Poaceae	Dry sandy soil	P	Grass
72	*Setaria sp.*	-	Poaceae	Common	A	Herb
73	*Sporobolus*	-	Poaceae	Common	A	Herb
74	*Vetiveria zizanoides*	Valo, Khus	Poaceae	Common	P	Herb

Annexure - 2
Checklist of birds of Nalsarovar

Sr. No.	Common English Name	Scientific Name	Occurrence
	Podicipedidae : Grebes		
1	Grebe, Great Crested	*Podiceps cristatus*	O
2	Grebe, Blacknecked	*Podiceps. nigricollis*	R
3	Grebe, Little	*Podiceps. ruficollis*	C
	Pelicanidae : Pelicans		
4	Pelican, Rosy or White	*Pelicanus onocrotalus*	C
5	Pelican, Spotbilled	*P. philippensis philippensis*	R
6	Pelican, Dalmatian	*P. philippensis crispus*	UC
	Phalacrocoracidae : *Cormorants and Dater*		
7	Cormorant, Large	*Phalacrocorax carbo*	C
8	Cormorant, Little	*P. niger*	C
9	Shag, Indian	*P. fuscicollis*	O
10	Darter	*Anhinga rufa*	UC
	Ardeidae : Herons, Egrets, Bitterns		
11	Heron, Grey	*Ardea cinerea*	C
12	Heron, Purple	*Ardea purpurea*	C
13	Heron, Little Green	*Butorides striatus*	UC
14	Heron, Pond	*Ardeola grayii grayii*	C
15	Egret, Cattle	*Bubulcus ibis*	C
16	Egret, Large	*Ardea alba*	C
17	Egret, Smaller or Median	*Egretta intermedia*	C
18	Egret, Little	*Egretta garzetta*	C
19	Heron, Indian Reef	*Egretta gularis*	UC
20	Heron, Night	*Nycticorax nycticorax*	C
21	Bittern, Chestnut	*Ixobrychus cinnamomeus*	O
22	Bittern, Yellow	*Ixobrychus sinensis*	R
23	Bittern	*Botaurus stellaris*	R
	Ciconiidae : Storks		
24	Stork, Painted	*Mycteria leucocephala*	C
25	Stork, Openbilled	*Anastomus oscitans*	C
26	Stork, Whitenecked	*Ciconia episcopus*	O
27	Stork, White	*Ciconia ciconia*	UC
28	Stork, Black	*Ciconia nigra*	R*
29	Stork, Blacknecked	*Ephippiorhynchus asiaticus*	R*
30	Stork, Lesser Adjutant	*Leptoptilos javanicus*	R*
	Threskiornthidae : Ibises, Spoonbill		
31	Ibis, White	*Threskiornis acthiopica*	C
32	Ibis, Black	*Pseudibis papillosa*	C
33	Ibis, Glossy	*Plegadis falcinellus*	C
34	Spoonbill	*Platalea leucordia*	C

	Phoenicopteridae : Flamingos		
35	Flamingo	*Phoenicpterus roseus*	C
36	Flamingo, Lesser	*Phoenicpterus monor*	C
	Anseriformes : Ducks, Geese		
37	Goose, Greylag	*Anser anser*	UC
38	Goose, Barheaded	*Anser indicus*	O
39	Teal, Lesser Whistling	*Dendrocygna javanica*	UC
40	Teal, Large Whistling	*Dendrocygna bicolor*	R*
41	Shelduck, Ruddy	*Tandorna ferruginea*	C
42	Shelduck, Common	*Tadorna tadorna*	R*
43	Pintail	*Anas acuta*	C
44	Teal, Common	*Anas crecca*	C
45	Teal, Baikal	*Anas formosa*	R*
46	Duck, Spotbill	*Anas poecilorhyncha*	C
47	Mallard	*Anas platyrhnchos*	UC
48	Gadwall	*Anas strepera*	C
49	Teal, Falcated	*Anas falcata*	R*
50	Wigeon	*Anas penelope*	C
51	Garganey	*Anas querquedula*	C
52	Shoveller	*Anas clypeata*	C
53	Pochrd, Redcrested	*Netta rufina*	O
54	Pochrd, Common	*Aythya fernia*	C
55	Pochrd, White-eyed	*Aythya nyroca*	O
56	Pochrd, Tufted	*Aythya fuligula*	O
57	Duck, Scaup	*Aythya marila*	R
58	Teal, Cotton	*Nettapus coromandelianus*	C
59	Duck, Comb or Nakta	*Sarkidiornis melanotos*	C
	Acciptridae : Hawks, Vultures, etc.		
60	Kite, Blackwinged	*Elanus caeruleus*	C
61	Kite, Pariah	*Milvus migrans*	C
62	Kite, Brahminy	*Haliastur indus*	R
63	Eagle spp.	*Aquila spp.*	O++
64	Vulture, Longbilled	*Gyps indicus*	O
65	Vulture, Whitebacked	*Gyps bengalensis*	C
66	Vulture, Scavenger	*Neophron percnopterus*	C
67	Harrier, Marsh	*Circus aeruginosus*	C
68	Osprey	*Pandion haliaetus*	O
69	Kestrel	*Falco tinnunculus*	U.C
	Phasianidae : Pheasents, Partridges, Quails etc.		
70	Partridge, Painted	*Francolinus pictus*	O
71	Partridge, Grey	*Francolinus pondicerianus*	C
72	Quail spp.	*Corturnix spp.*	U.C
73	Peafowl, Indian	*Pavo cristatus*	C

	Gruidae : Cranes		
74	Crane, Common	*Grus grus*	C
75	Crane, Sarus	*Grus antigone*	U.C
76	Crane, Demoiselle	*Anthropoides virgo*	C
	Rallidae : Rails, Coots		
77	Rail, Water	*Rallus aquaticus*	R*
78	Rail, Bluebreasted Banded	*Rallus striatus*	O*
79	Crake, Banded	*Rallina eurizonoides*	O
80	Crake, Spotted	*Porzana porzana*	R
81	Crake, Ruddy	*Porzana fusca*	R*
82	Crake, Brown	*Amaurornis akool*	U.C
83	Waterhen, Whitebreasted	*Amaurornis phoenicurus*	C
84	Watercock or Kora	*Gallicrex cinerea*	O
85	Moorhen, Indian	*Gallicrex chloropus*	C
86	Moorhen, Purple	*Porphyrio porphyrio*	O
87	Coot	*Fulica atra*	C
	Otididae : Bustards		
88	Florican, Lesser	*Sypheotides indica*	R
	Jacanidae : Jacanas		
89	Jacana, Pheasant-tailed	*Hydrophasianus chirurgus*	C
90	Jacana, Bronzewinged	*Metopidius indicus*	U.C
	Charadriidae		
91	Lapwing, White-tailed	*Vanellus leucurus*	C
92	Lapwing, Redwattled	*Vanellus indicus*	C
93	Lapwing, Yellow-wattled	*Vanellus malabaricus*	U.C
94	Plover, Grey	*Pluvialis squatarola*	O
95	Plover, Golden	*Pluvialis apricaria*	R
96	Plover, Large Sand	*Charadrius leschenaultii*	O
97	Plover, Ringed	*Charadrius hiaticula*	C
98	Plover, Little Ringed	*Charadrius dubius*	C
99	Plover, Kentish	*Charadrius alexandrinus*	C
100	Plover, Lesser sand	*Charadrius mongolus*	U.C
101	Curlew	*Numenius arquata*	C
102	Godwit, Blacktailed	*Limosa limosa*	C
103	Godwit, Bartailed	*Limosa lapponica*	U.C
104	Redshank, Common	*Tringa totanus*	C
105	Sandpiper, Marsh	*Tringa stagnatilis*	C
106	Green Shank	*Tringa nebularia*	C
107	Sandpiper, Green	*Tringa ochropus*	C
108	Sandpiper, Spotted	*Tringa glareola*	U.C
109	Sandpiper, Terek	*Tringa terrek*	U.C
110	Sandpiper, Common	*Tringa hypoleucos*	C
111	Snipe, Common	*Gallinago gallinago*	C
112	Snipe, Jack	*Gallinago minima*	O
113	Woodcock	*Scolopax rusticola*	O
114	Knot, Eastern	*Calidris canuta*	R
115	Sanderling	*Calidris alba*	R
116	Stint, Little	*Calidris minuta*	C

117	Stint, Temminck's	*Calidris temminckii*	C
118	Dunlin	*Calidris alpina*	R
119	Curlew-Sandpiper	*Calidrus testacea*	R
120	Ruff	*Philomachus pugnax*	C
	Rostratulidae : Painted snipe		
121	Snipe, Painted	*Rostratula benghalensis*	U.C
	Recurvirostridae : Stilts, Avocets		
122	Stilt, Blackwinged	*Himantopus himanitopus*	C
123	Avocet	*Recurvirostra avosetta*	C
	Burhinidae : Stone curlews, thick-knees		
124	Curlew, Stone	*Burhinus oedicnemus*	C
125	Plover, Great Stone	*Esacus mangirostris*	U.C
	Glareolidae : Coursers, Pratincoles		
126	Courser, Desert	*Cursorius cursor*	R*
127	Courser, Indian	*Cursorius coromandelicus*	O
128	Pratincole, Collared	*Glareola pratincola*	U.C
129	Pratincole, Small Indian	*Glareola lactea*	R*
	Laridae : Gulls, Terns		
130	Gull, Brownheaded	*Larus brunnicephalus*	U.C
131	Gull, Blackheaded	*Larus ridibundus*	C
132	Tern, Whiskered	*Chlidonias hybridus*	U.C
133	Tern, White winged Black	*Chlidonias leucopterus*	R*
134	Tern, gullbilled	*Gelochelidon nilotica nilotica*	C
135	Tern, Caspian	*Hydroprogne casipa*	O
136	Tern, Indian River	*Sterna aurantia*	C
137	Tern, Common	*Sterna hirundo*	R*
138	Tern, Little	*Sterna albifrons*	U.C
	Pteroclididae : Sandgrouse		
139	Sandgrouse, Indian	*Pterocles exustus*	O
140	Sandgrouse, Spotted	*Pterocles senegallus*	O
141	Sandgrouse, Painted	*Pterocles indicus*	C
	Columbidae : Pigeons, Doves		
142	Pigeon, Blue Rock	*Columba livia*	C
143	Dove, Ring	*Streptopelia decaocto*	C
144	Dove, Red Turtle	*Streptopelia tranquebarica*	U.C
145	Dove, Spotted	*Streptopelia chinensis*	O
146	Dove, Little Brown	*Streptopelia senegalensis*	C

	Psittacidae : Parrots		
147	Parakeet, Rose ringed	*Psittacula krameri*	C
	Cuculidae : Cuckoos		
148	Cuckoo, Pied Crested	*Clamator jacobinus*	O
149	Koel	*Eduynamys scolopacea*	U.C
150	Crow pheasant	*Centropus sinensis*	C
	Strigidae : Owls		
151	Owl, sp.	*Bubo sp.*	O
152	Owlet, Spotted	*Athene brama*	C
	Caprimulgidae : Nightjars		
153	Nightjar, Franklin's	*Caprimulgus affinis*	U.C
	Apodidae : Swifts		
154	Swift, Alpine	*Apus melba*	O
155	Swift, House	*Apus affinis*	C
	Alcedinidae : Kingfishers		
156	Kingfisher, Pied	*Ceryle rudis*	U.C
157	Kingfisher, Small Blue	*Alcedo atthis*	C
158	Kingfisher, Whitebreasted	*Halcyon smyrensis*	C
	Meropidae : Bee-eaters		
159	Bee-eater, Bluecheeked	*Merops superciliosus*	U.C
160	Bee-eater, Bluetailed	*Merops philippinus*	U.C
161	Bee-eater, Small Green	*Merops orientalis*	C
	Coraciidae : Rollers		
162	Roller, Kashmir	*Coracias garrulus*	O
163	Roller, Indian	*Coracias benghalensis*	C
	Upupidae : Hoopoe		
164	Hoopoe	*Upupa epops*	U.C
	Capitonidae : Barbets		
165	Coppersmith	*Megalaima haemacephala*	C
	Picidae : Woodpeckers		
166	Woodecker, Mahratta	*Picoides mahrattensis*	O
	Alaudidae : Larks		
167	Lark, Redwinged Bush	*Mirafra erythroptera*	U.C
168	Lark, Blackcrowned Finch	*Eremopterix nigriceps*	C
169	Lark, Crested	*Galerida cristata*	C
170	Lark, Syke's Crested	*Galerida deva*	U.C
	Hirundinidae : Swallows		
171	Martin, Dusky Crag	*Hirundo concolor*	C
172	Swallow	*Hirundo rustica*	C
173	Swallow, Wiretailed	*Hirundo smithii*	C
174	Swallow, Redrumped	*Hirundo daurica*	C

	Laniidae : Shrikes		
175	Shrike, Grey	*Lanius excubitor*	C
176	Shrike, Baybacked	*Lanius vittatus*	U.C
177	Shrike, Brown	*Lanius cristatus*	U.C
178	Shrike, Rufousbacked	*Lanius schach*	C
	Oriolidae : Orioles		
179	Oriole, Golden	*Oriolus oriolus*	O
	Dicruridae : Drongos		
180	Drongo, Black	*Dicrurus adsimilis*	C
181	Drongo, Whitebellied	*Dicrurus caerulescens*	O
	Sturnidae : Starlings, Mynas		
182	Myna, Brahminy	*Sturnus pagodarum*	C
183	Rosy Pastor	*Sturnus roseus*	C
184	Starling, Common	*Sturnus vulgaris*	U.C
185	Myna, Indian	*Acridotheres tristis*	C
186	Myna, Bank	*Acridotheres ginginianus*	C
	Corvidae : Crows etc.		
187	Tree Pie, Indian	*Dendrocitta vagabunda*	O
188	Crow, House	*Corvus splendens*	C
189	Crow, Jungle	*Corvus macrorhychos*	U.C
	Campephagidae : Cuckoo-shrikes & Minivets		
190	Cuckoo-Shrike, Large	*Coracina novaehollandiae*	O
191	Minivet, Small	*Pericrocotus cinnamomeus*	U.C
	Irenidae : Ioras etc.		
192	Iora, Common	*Aegithina tiphia*	C
	Pycnonotidae : Bulbuls		
193	Bulbul, Redvented	*Pyconotus cafer*	C
194	Bulbul, White-eared	*Pynonotus leucogenys leucotis*	C
	Muscicapidae : Babblers, Warblers, Chats etc.		
195	Babbler, Yellow-eyed	*Chryromma sinense*	C
196	Babbler, Common	*Turdoides caudatus*	C
197	Babbler, Large Grey	*Turdoides malcolmi*	C
198	Babbler, Jungle	*Turdoides striatus*	C
199	Flycatcher, Redbreasted	*Muscicapa parva*	O
200	Flycatcher, Tickell's Blue	*Muscicapa tickelliae*	U.C
201	Wren-Warbler, Freanklin's	*Prinia hodgsonii hodsonii*	C
202	Wren-Warbler, Streaked	*Prinia graciles*	U.C
203	Wren-Warbler, Plain	*Prinia subflava*	C
204	Wren-Warbler, Ashy	*Prinia socialis*	C
205	Tailor Bird	*Orthotomus sutorius*	C

206	Blue throat	*Erithacus svecicus*	O
207	Magpie - Robin	*Copsychus saularis*	C
208	Redstart, Black	*Phoenicurus ochruros*	C
209	Chat, Brown Rock	*Cercomela fusca*	R
210	Chat, Collared Bush	*Saxicola torquata*	C
211	Chat, Pied Bush	*Saxicola caprata*	U.C
212	Wheatear, Desert	*Oenanthe deserti*	U.C
213	Chat, Pied	*Oenanthe picata*	O
214	Robin, Indian	*Saxicoloides fulicata*	C
	Motacillidae : Pipits and Wagtails		
215	Pipit, sp.	*Anthus sp.*	O
216	Wagtail, Greyheaded Yellow	*Motacilla flava*	C
217	Wagtail, White	*Motacilla alba*	C
218	Wagtail, Large Pied	*Motacilla maderaspatensis*	O
219	Sunbird, Purple	*Nectarinia asiatica*	C
	Ploceidae : Sparrows, Weaver Birds, Munias		
220	Sparrow, House	*Passer domesticus*	C
221	Sparrow, Yellowthroated	*Petronia xanthocollis*	U.C
222	Baya	*Ploceus philippinus*	C
223	Weaver Bird, Blackthroated	*Ploceus berighalensis*	U.C
224	Weaver Bird, Streaked	*Ploceus manyar*	C
225	Munia Whitethroated	*Lonchura malabarica*	C
226	Munia, Spotted	*Lonchura punctulata*	O

C : Common
U.C : Uncommon
O : Occasional
R : Rare

*** = Not recorded during study period and/or reported occurrence needs to be varified**

++ = Possibility of more than one species in the genera/ -/group. Needs further verification.

Annexure - 3
Mammals and reptiles recorded at Nalsarovar

Sr. No.	Scientific Name	Common Name	Local Name
	Mammals		
1	*Antilope cervicapra*	Blackbuck	Kaliyar, Reda
2	*Boselaphus tragocamelus*	Bluebull	Rojh, Nilgai
3	*Canis aureus*	Jackal	Shiyal
4	*Equas hemionous khur*	Indian wild ass	Jungli Gadheda
5	*Felis chaus*	Jungle cat	Jungli bilado
6	*Funambulus pennanae*	Five striped palm squirrel	Khiskoli
7	*Herpestes edwardsi*	Common mongoose	Noliyo
8	*Lepus nigricollis ruficaudatus*	Rufoustailed hare	Sasalo
9	*Meriones hurricanae*	Desert gerbille	Ghus
10	*Sas scrofa*	Indian wild boar	Suar, Bhund
11	*Suncus murinus*	Grey musk shrew	Chachundar
12	*Tetera indica*	Indian gerbille	Ghus
13	*Vulpes bengalensis*	Indian fox	Lonkadi
	Reptiles		
1	*Bangarus calruleus*	Common krait	Kalotro
2	*Calotes versicolor*	Common garden lizard	Kachindo
3	*Echis carinatus*	Saw scaled viper	Padaku
4	*Hemidactyles alaviviridis*	House gecko	Garoli
5	*Lissemys punctata*	Indian mud turtle	Kachabo
6	*Mabuya carinata*	Common skink	Nagni mashi
7	*Naja naja*	Cobra	Nag
8	*Ptyas mucosus*	Common rat snake	Dhaman
9	*Varanus benglensis*	Common Indian monitor lizard	Patlagho
10	*Xenochrophis piscator*	Checkered keelback	Dendu
11	*Eryx johni*	Jon's earth boa	Andhali chakan

Annexure - 4

Occurrence of micro and macro-zooplanktons in various zones of Nalsarovar

Sr. No.	Zooplankton species	Vekaria tourist centre	Dharabla	Limsi, Surbet, Panvad	Lassa, Ranagadh	Brahmni river side	Remarks
	Invertebrates :						
1	*Amoeba sp.*	++	+	-	-	-	In detritus soil
2	*Spironema sp.*	+	+	-	-	+	Soil saprozoic
3	*Oikimonas sp.*	+	+	-	-	+	Soil saprozoic
4	*Trinema sp.*	+	+	-	-	+	Soil saprozoic
5	*Nebela sp.*	+	+	-	-	+	Soil saprozoic
6	*Euglypha sp.*	+	+	-	-	+	Fresh water saprozoic
7	*Balantidium*						
8	*Nyctotherus*	Parasites in frog gut					Present in the gut of frog
9	*Opalina*						
		+++					
10	*Euglena sp.*	Euglena sp.		+++	++	++	+++ Mixotrophic
11	*Paramoecium spp. (diff.species)*	+++	+++	++	++	+++	Holozoic, fresh water
12	*Chilomonas*	++	++	+	+	++	Saprozoic in mud
13	*Paranema*	+	+	-	-	+	Stagnant water
14	*Vorticella*	++	++	+	++	+	Holozoic, fresh water
15	*Stentor*	++	+	-	+	++	Carnivore, sewage water
16	*Spongilla sp. (sponge)*	-	+	-	-	++	Fresh water, stagnant water
17	*Hydra sp.*	+	+	-	+	-	Fresh water, carnivore
18	*Planaria sp., Dugasia sp.*	-	+	-	+	+	Fresh water, carnivorous
19	*Philodina sp.*	+++	+++	++	++	++	Free living, fresh water cosmopolitan
20	*Epiphanes senta (Hydatina)*	++	++	+	+	++	Large fresh water rotifer
21	*Branchionus*	+	+	-	+	+	Common, fresh water rotifer
22	*Asplanchna*	?	?	-	-	+	Pelagic, rare
23	*Chaetonotus (Gastrootricha)*	++	++	-	++	++	Devoure bacteria, diatoms & protozoa
24	*Earth worn*	++	+++	+	++	+++	Moist organic soil
25	*Hirudinia (Leech)*	-	+	+	-	-	Fresh stagnant water ectoparasite
26	*Eubranchipus*	++	++	+	++	++	Detritus, fresh water pool
27	*Triops sp.*	+	+	+	+	+	Detritus, fresh water pool
28	*Daphnia sp.*	+++	+++	++	++	+++	Detritus, fresh water pool

29	*Cypris sp.*	+++	+++	++	++	+++	Detritus, fresh omnivorous
30	*Cyclops sp.*	+++	+++	++	++	+++	Fresh water holozoic
31	*Carcinus*	++	+++	++	+	+	Detritus, semi-terrestrial
32	*Mysis*	++	++	+	++	++	Free living
33	*Palamnaeus sp.*	+	++	-	-	+	Scorpious, terrestrial
34	*Buthus sp.*	+	+	-	-	+	Carnivorous
35	*Salticus sp.*	++	+++	-	+	+	Spiders, terrestrial carnivonous
36	*Lycosa sp.*						
37	*Argipoe sp.*						
38	*Latrodectus sp.*						
39	*Phalangium sp.*						
40	*Lemnaea acuminata*	++	+++	++	++	+++	Aquatic, detritus
41	*Planorbis exustus*	++	+++	++	++	+++	Aquatic, omnivorous
42	*Vaginulus sp.*	++	-	-	-	++	Terrestrial, detritus
43	*Pila globosa*	++	++	+++	+++	++	Aquatic, herbivorous
44	*Lamellidens marginalis*	++	++	++	++	++	Aquatic, detritus
45	*Unio caerulens*	+	+	+	+	++	Aquatic, planktonic feeder
46	*Pomacea (apple sanil)*	++	++	++	++	++	Aquatic, gastropod
47	*Campeloma sp.*	+	+	+	+	+	Aquatic, gastropod
48	*Terebia sp.*	+	+	+	+	+	Aquatic, gastropod
49	*Pleurocera sp. (River Snail)*	-	-	-	+	++	Aquatic, gastropod
50	*Littorina sp. (Periwinkle)*	+++	+++	++	+++	+++	Aquatic, gastropod
51	*Helisoma*	++	++	+	++	++	Aquatic, gastropod aquatic shell
52	*Ferrissia (Limpet)*	+++	+++	++	+++	+++	Marine/brackish water, aquatic
53	*Nassa (Mud snail)*	+	+	+	+	++	
54	*Physa (Pauck snail)*	+	+	+	+	+	River bank
55	*Sphaerium sp. (Finger nail clam)*	+	+	+	+	+	Nymph auatic, adult winged
56	*Dragon fly & Nymph 3-4 Species*	+++	+++	+++	+++	++	Nymph auatic, adult winged
57	*Damsel fly & Nymph*	++	++	++	++	++	Nymph auatic, adult winged
58	*Caddis fly & Nymph*	++	++	++	++	++	Nymph auatic, adult winged
59	*Stone fly & Nymph*	++	++	++	++	++	Nymph auatic, adult winged
60	*May fly & Nymph*	+++	+++	++	++	++	Aquatic
61	*Chironomus (Larva midge)*	++	+++	++	++	+++	Winged
62	*Adult midge*	+++	+++	+++	+++	+++	Winged
63	*Masquitoes, Aedes sp.*	+++	+++	+++	+++	+++	On dung
64	*Tabanus larva*	++	+	+	+	++	Terrestrial
65	*Stenelmis (Riffle beetle)*	++	++	+	+	++	

66	*Dineutus (Whirling beetle)*	++	++	++	++	++	Aquatic beetle
67	*Hydrophilus*	++	++	++	++	++	Scavenger beetle
68	*Dytiscus (Diving beetle)*	+++	+++	++	++	+++	Predaceous, aquatic
69	*Lethodeecerus (Belostonma bug)*	++	++	-	-	+	Predaceous, aquatic
70	*Notonecta (Back swimmer)*	++	++	++	++	+++	Predaceous, aquatic
71	*Sigara (Water boatman)*	++	++	++	++	++	Predaceous, aquatic
72	*Hydrometra (Water trader)*	+++	+++	++	++	+++	Predaceous, aquatic
73	*Gerris (Water strider)*	+++	+++	++	++	+++	Predaceous, aquatic
74	*Periplaneta americana*	++	+	-	-	++	Terrestrial, near human habitats
75	*Blatta orientalis (Orient cockroach)*	++	++	++	-	++	Terrestrial, also on islands
76	*Ranatra (water scorpion)*	++	++	-	-	++	More in stagnant water

Note : This sampling is done on osbservations made and the collections made from various points in Nalsarovar during the year 1995-96.

Symbols : + = Rare occurence sample wise

Symbols : ++ = Common occurence sample wise

Symbols : +++ = Abundant occurence sample wise

Symbols : - = Absent/not noted.

Annexure - 5

Food items consumed by various species of waterfowl

Sr. No.	Name of species	Fish	Frog	Aquatic insects	Worms, snails, molluscs, crustaceans	Insects	Reptiles and lizards	Rodents or small birds	Algae, Aqu.plant seed etc..	Shoots, crops,terr.veg. Matter	Total no. of food items
A	**Grebes**										
1	Grebe, Little	*	*	*	*	-	-	-	-	-	4
2	Grebe, Great Crested	*	*	*	-	-	-	-	*	-	4
B	**Pelicans**										
1	Pelican, Rosy or White	*	-	-	-	-	-	-	-	-	1
2	Pelican, Spottedbilled	*	-	-	-	-	-	-	-	-	1
3	Pelican, Dalmatian	*	-	-	-	-	-	-	-	-	1
C	**Ducks & Geese**										
1	Goose, Barheaded	-	-	-	-	-	-	-	*	*	2
2	Goose, Greylag	-	-	-	-	-	-	-	*	*	2
3	Teal, Large Whistling	-	-	-	-	-	-	-	-	*	1
4	Teal, Lesser Whistling	*	*	-	*	-	-	-	*	*	5
5	Teal, Common	-	-	-	-	-	-	-	*	*	2
6	Teal, Cotton	-	-	*	*	-	-	-	*	*	4
7	Teal, Falcated	-	-	-	-	-	-	-	*	*	2
8	Shelduck, Common	-	-	-	*	*	-	-	*	-	3
9	Shelduck, Ruddy	-	-	*	*	-	*	-	-	*	4
10	Duck, Comb or Nakta	*	*	*	-	-	-	-	*	*	5
11	Duck, Spotbill	-	-	*	*	-	-	-	*	-	3
12	Duck, Tufted	*	*	*	*	-	-	-	*	-	5
13	Duck, Scaup	*	*	*	*	-	-	-	*	-	5
14	Pochard, Common	*	*	*	*	-	-	-	*	-	5
15	Pochard, White-eyed	*	*	*	*	-	-	-	*	-	5
16	Pochard, Redcrested	*	-	*	-	-	-	-	*	-	3
17	Mallard	*	*	*	-	-	-	-	*	*	5
18	Gadwall	-	-	*	*	-	-	-	*	*	4
19	Wigeon	-	-	*	*	-	-	-	*	*	4
20	Garganey	-	-	*	*	-	-	-	*	*	4
21	Shoveller	*	-	*	*	-	-	-	*	-	4

22	Pintail	-	-	*	*	-	-	-	*	*	4	
D	**Rails, Coots, Crakes, etc.**											
1	Rail, Water	-	-	-	*	*	-	-	*	*	4	
2	Rail, Bluebreasted	-	-	-	*	*	-	-	*	*	4	
3	Crake, Brown	-	-	*	*	-	-	-	-	*	3	
4	Crake, Spotted	-	-	*	*	-	-	-	-	*	3	
5	Crake, Ruddy	-	-	*	*	-	-	-	-	*	3	
6	Crake, Banded	-	-	-	*	*	-	-	*	*	4	
7	Moorhen, Purple	-	-	-	*	*	-	-	*	*	4	
8	Moorhen, Indian	*	*	*	*	-	-	-	*	-	5	
9	Waterhen, Whitebreasted	-	-	*	*	*	-	-	-	*	4	
10	Watercock	-	-	*	*	-	-	-	*	*	4	
11	Coot	-	-	-	-	-	-	-	*	*	2	
E	**Jacanas**											
1	Jacana, Pheasant-tailed	-	*	-	*	-	-	-	-	*	4	
2	Jacana, Bronzewinged	-	*	-	*	-	-	-	*	*	4	
F	**Cormorants & Darter**											
1	Cormorant	*	-	-	-	-	-	-	-	-	1	
2	Cormorant, Little	*	-	*	-	-	-	-	-	-	2	
3	Indian Shag	*	-	-	-	-	-	-	-	-	1	
4	Darter or Snakebird	*	-	-	-	-	-	-	-	-	1	
G	**Herons, Egrets & Bitterns**											
1	Heron, Grey	*	*	*	*	-	-	*	-	-	5	
2	Heron, Purple	*	*	*	*	-	-	*	-	-	5	
3	Heron, Night	*	*	*	*	-	-	-	-	-	4	
4	Heron, Little Green	*	*	*	*	-	-	-	-	-	4	
5	Heron, Pond	*	*	*	*	-	-	-	-	-	4	
6	Heron, Indian Reef	*	*	-	*	3						
7	Egret, Large	*	*	*	*	-	-	-	-	-	4	
8	Egret, Smaller	*	*	*	*	-	-	-	-	-	4	
9	Egret, Little	*	*	*	*	-	-	-	-	-	4	
10	Egret, Cattle	-	*	-	*	*	*	-	-	-	4	

11	Bittern	*	*	-	*	*	-	*	-	-	5
12	Bittern, Black	*	*	-	*	*	-	-	-	-	4
13	Bittern, Chestnut	*	*	*	*	-	-	-	-	-	4
14	Bittern, Yellow	*	*	*	*	-	-	-	-	-	4
H	**Storks,**										
1	Stork, Adjutant	*	*	-	*	-	*	*	-	-	5
2	Stork, Black	*	*	-	*	*	-	*	-	-	5
3	Stork, Blacknecked	*	*	-	-	-	*	*	-	-	4
4	Stork, Openbilled	-	*	-	*	-	-	-	-	-	2
5	Stork, Painted	*	*	-	*	-	-	-	-	-	3
6	Stork, White	*	*	-	*	-	*	*	-	-	5
7	Stork, Whitenecked	*	*	*	*	*	*	-	-	-	6
I	**Ibis & Spoon bill**										
1	Ibis, White	*	*	-	*	*	-	-	*	-	5
2	Ibis, Black	*	*	-	*	*	*	-	-	*	6
3	Ibis, Glossy	-	*	-	*	*	-	-	-	-	3
4	Spoonbill	*	*	*	*	-	-	-	*	-	5
J	**Flamingos**										
1	Flamingo /	*	-	-	*	-	-	-	*	-	3
2	Flamingo, Lesser	-	-	-	*	-	-	-	*	-	2
K	**Cranes**										
1	Crane, Common	-	-	-	-	*	*	-	-	*	3
2	Crane, Demoiselle	-	-	-	-	*	*	-	-	*	3
3	Crane, Sarus	*	*	*	*	*	*	-	*	*	8
L	**Waders/Shore birds**										
1	Lapwing, Redwattled	-	-	-	*	*	-	-	-	*	3
2	Lapwing, Yellow-wattled	-	-	-	-	*	-	-	-	-	- 1
3	Lapwing, Whitetailed	-	-	*	*	-	-	-	-	-	2
4	Plover, Golden	-	-	-	*	*	-	-	-	*	3
5	Plover, Grey	-	-	-	*	*	-	-	-	*	3

6	Plover, Kentish	-	-	-	*	*	-	-	-	-	2	
7	Plover, Lesser Sand	-	-	-	*	*	-	-	-	-	2	
8	Plover, Large Sand	-	-	-	*	*	-	-	-	*	3	
9	Plover, Little Ringed	-	-	-	*	*	-	-	-	-	2	
10	Plover, Ringed	-	-	-	*	*	-	-	-	*	3	
11	Godwit, Blacktailed	-	-	*	*	-	-	-	*	*	4	
12	Godwit, Bartailed	-	-	-	*	*	-	-	-	-	2	
13	Snipe, Common	-	-	-	*	*	-	-	-	-	2	
14	Snipe, Jack	-	-	-	*	*	-	-	*	-	3	
15	Snipe, Painted	-	-	-	*	*	-	-	*	-	3	
16	Curlew	-	-	-	*	*	-	-	-	-	2	
17	Curlew, Great Stone	-	*	-	*	*	-	*	-	-	4	
18	Curlew, Indian Stone	-	-	-	*	*	*	-	-	-	3	
19	Sandpiper, Common	-	-	-	*	*	-	-	-	-	2	
20	Sandpiper, Green	-	-	*	*	-	-	-	-	-	2	
21	Sandpiper, Marsh	-	-	*	*	-	-	-	-	-	2	
22	Sandpiper, Terek	-	-	-	*	*	-	-	-	-	2	
23	Shank, Red	-	-	*	*	-	-	-	-	-	2	
24	Shank, Green	-	*	*	*	*	-	-	-	-	4	
25	Stint, Little	-	-	-	*	*	-	-	*	-	3	
26	Stint, Temminck's	-	-	-	*	*	-	-	*	-	3	
27	Sanderling	-	-	-	*	-	-	*	-	-	2	
28	Stilt, Blackwinged	-	-	*	*	-	-	-	*	-	3	
29	Avocet	-	-	-	*	*	-	-	-	-	2	
30	Pratincole, Indian Small	-	-	-	-	*	-	-	-	-	-	1
31	Pratincole, Collared	-	-	-	-	*	-	-	-	-	1	
32	Ruff	-	-	-	*	*	-	-	-	*	3	
M	**Gulls**											
1	Gull, Blackheaded	*	-	-	*	-	-	-	-	-	2	
2	Gull, Brownheaded	*	-	-	-	-	-	-	-	-	1	
N	**Terns**											
1	Tern, Indian River	*	-	*	*	-	-	-	-	-	3	
2	Tern, Little	*	-	*	*	-	-	-	-	-	3	

3	Tern, Gullbilled	*	*	*	*	*	-	-	-	-	5	
5	Tern, Whiskered	*	*	*	*	*	-	-	-	-	5	
6	Tern, Common	*	-	*	*	-	-	-	-	*	3	
7	Tern, Caspian	*	-	-	-	-	-	-	-	-	2	
8	Tern, Whitewinged Black		*	*	*	*	*	-	-	-	-	5
O	**Kingfishers**											
1	Kingfisher, Common	*	-	-	-	-	-	-	-	-	1	
2	Kingfisher, Indian pied	*	-	-	-	-	-	-	-	-	1	
3	Kingfisher, Whitebreasted		*					*	*	-	-	3
P	**Some other spp. (Other than waterfowl)**											
1	Kite, Blackwinged	-	*	-	-	*	*	*	-	-	4	
2	Kite, Pariah	-	*	-	-	-	*	*	-	-	3	
3	Kite, Brahminy	*	*	-	-	*	*	*	-	-	5	
4	Osprey	*	-	-	-	-	-	-	-	-	1	
5	Harrier, Marsh	*	*	-	-	*	*	*	-	-	5	

Annexure - 6

Habitat preference of waterfowl for various habitat types at Nalsarovar

Sr No.	Name of species	Nesting probability	Status	Open Water		Emergent aquatic vegetation	Muddy area	Shore land	Surrounding		Wooded areas
				Deep	Shallow				Crop land	Fallow land	
A	**Grebes**										
1	Grebe, Little	P	R/LM	***	**	*	-	-	-	-	-
2	Grebe, Blacknecked	-	M	***	**	*	-	-	-	-	-
3	Grebe, Great Crested	-	M	***	*	*	-	-	-	-	-
B	**Pelicans**										
1	Pelican, Rosy or White	-	R/LM/M	***	-	-	-	-	-	-	-
2	Pelican, Spottedbilled	-	R/LM/M	***	-	-	-	-	-	-	-
3	Pelican, Dalmatian	-	R/LM/M	***	-	-	-	-	-	-	-
C.	**Ducks & Geese**										
1	Goose, Barheaded	-	R/LM/M	-	**	-	*	**	***	***	-
2	Gosse, Greylag	-	M	-	**	-	*	**	***	***	-
3	Teal, Large Whistling	-	R/L/M	*	***	**	*	*	-	-	*
4	Teal, Lesser Whistling	-	R/L/M	*	***	**	*	*	*	*	*
5	Teal, Common	-	M	-	***	**	**	-	-	-	-
6	Teal, Cotton	-	R/L/M	*	***	**	-	-	-	-	-
7	Teal, Baikal	-	M	-	***	*	*	-	-	-	-
8	Teal, Falcated	-	M	*	*	*	*	-	-	-	-
9	Shelduck, Common	-	M	*	*	**	*	*	-	-	-
10	Shelduck, Ruddy	-	R/LM/M	*	**	-	*	-	-	-	-
11	Duck, Comb	P	R/LM	*	***	**	-	-	-	-	-
12	Duck, Spotbill	P	R/LM	*	***	*	*	-	-	-	-
13	Duck, Tufted	-	M	***	**	*	-	-	-	-	-
14	Duck, Scaup	-	M	*	***	*	-	-	-	-	-
15	Pochard, Common	-	M	***	**	*	-	-	-	-	-
16	Pochard, White-eyed	-	M	***	**	*	-	-	-	-	-
17	Pochard, Redcrested	-	M	***	**	*	-	-	-	-	-

18	Mallard	-	M	*	***	-	*	-	-	-	-
19	Gadwall	-	M	*	***	*	*	-	-	-	-
20	Wigeon	-	M	*	***	*	-	-	-	-	-
21	Garganey	-	M	*	***	*	-	-	-	-	-
22	Shoveller	-	M	*	***	*	-	-	-	-	-
23	Pintail	-	M	-	***	**	**	-	-	-	-
D	**Rails, Coot, Crakes.**										
1	Rail, Bluebreasted	-	R	-	-	*	***	***	**	*	-
2	Crake, Brown	P	R/L/M	-	-	***	*	*	-	-	-
3	Crake, Spotted	-	M	-	-	***	*	*	-	-	-
4	Crake, Baillon's	-	LM/M	-	-	***	**	*	-	-	-
5	Crake, Ruddy	-	R	-	-	***	*	*	-	-	-
6	Crake, Banded	-	R/L/M	-	-	***	*	-	-	-	-
7	Moorhen, Purple	P	R	-	-	***	**	*	-	-	-
8	Moorhen, Indian	P	R	-	-	***	**	*	-	-	-
9	Waterhen, Whitebreasted		P	R/L/M	-	-	***	**	*	*	-
10	Watercock	P	R/LM	-	-	***	**	-	**	*	-
11	Coot	-	R/LM/M	***	**	*	-	-	-	-	-
E	**Jacanas**										
1	Jacana, Pheasant-tailed	P	R/L/M	-	**	***	*	*	*	-	-
2	Jacana, Bronzewinged	P	R/LM	-	**	***	*	*	-	-	-
F	**Cormorants & Darter**										
1	Cormorant	P	R/LM	***	**	*	-	-	-	-	-
2	Cormorant, Little	P	R/LM	***	**	-	-	-	-	-	-
3	Indian Shag	-	R/LM	***	**	-	-	-	-	-	-
4	Darter	-	LM	***	**	-	-	-	-	-	-
G	**Herons, Egrets & Bitterns**										
1	Heron, Grey	P	R/LM	-	-	*	***	**	-	-	-
2	Heron, Purple	-	R/LM	-	-	***	**	*	-	-	-

3	Heron, Night	P	R/LM	-	-	**	**	*	*	*	-
4	Heron, Little Green	P	R/LM	-	-	***	**	*	-	-	***
5	Heron, Pond	P	R	-	-	*	***	**	-	-	-
6	Heron, Indian Reef	P	R/LM	-	**	*	***	*	*	*	**
7	Egret, Large	P	R/LM	-	***	**	**	*	*	*	**
8	Egret, Smaller	P	R/LM	-	***	**	**	*	*	*	**
9	Egret, Little	P	R	-	**	**	***	**	**	*	**
10	Egret, Cattle	P	R	-	-	*	**	***	***	***	***
11	Bittern	-	M	-	-	***	*	-	-	-	-
13	Bittern, Chestnut	-	R/LM	-	-	***	***	*	*	-	-
14	Bittern, Yellow	-	R/LM	-	-	***	***	*	*	-	-
H	**Storks**										
1	Stork, Adjutant	-	LM	-	***	*	**	*	-	-	-
2	Stork, Black	-	M	-	***	*	**	*	*	*	-
3	Stork, Blacknecked	-	R/LM/M	-	***	-	**	*	*	*	-
4	Stork, Openbill	P	R/LM	-	***	*	*	-	**	**	**
5	Stork, Painted	P	R/LM	-	***	***	**	-	-	-	-
6	Stork, White	-	M	-	***	*	**	-	**	**	-
7	Stork, Whitenecked	-	R/LM	-	***	*	**	-	*	*	*
I	**Ibis & Spoonbill**										
1	Ibis, White	P	R/LM	-	*	*	***	*	*	*	***
2	Ibis, Black	P	R/LM	-	-	-	**	***	**	**	***
3	Ibis, Glossy	-	R/LM	-	-	**	***	**	*	*	***
4	Spoonbill	P	LM/M	-	***	*	**	*	-	-	**
J	**Flamingos**										
1	Flamingo	-	LM/M	-	***	-	*	-	-	-	-
2	Flamingo, Lesser	-	LM/M	-	***	-	*	-	-	-	-

K	**Cranes**											
1	Crane, Common	-		M	-	-	-	*	**	***	***	-
2	Crane, Demoiselle	-		M	-	-	-	*	**	***	***	-
3	Crane, Sarus	P		R	-	-	-	**	*	***	***	-
L	**Waders/Shorebirds**											
1	Lapwing, Redwattled	P		R	-	-	-	*	***	**	**	-
2	Lapwing, Yellow-wattled	P		R/LM	-	-	-	*	***	**	**	-
3	Lapwing, Whitetailed	-		M	-	-	-	*	***	**	**	-
4	Lapwing, Sociable	-		M	-	-	-	*	***	**	**	-
5	Plover, Golden	-		M	-	-	-	***	**	-	-	-
6	Plover, Grey	-		M	-	-	-	***	**	-	-	-
7	Plover, Kentish	P		R/LM	-	-	*	***	-	-	-	-
8	Plover, Lesser Sand	-		M	-	-	*	***	-	-	-	-
9	Plover, Little Ringed (Eur)			-	R/LM	-	-	-	***	**	-	-
10	Plover, Little Ringed (Jor)			-	R/LM	-	-	-	***	*	*	* -
11	Godwit, Blacktailed	-		M	-	**	*	***	*	-	-	-
12	Godwit, Bartailed	-		M	-	**	*	***	*	-	-	-
13	Snipe, Common	-		LM/M	-	-	*	***	*	-	-	-
14	Snipe, Jack	-		M	-	-	*	***	*	-	-	-
15	Snipe, Painted	P		R/LM	-	-	*	***	*	-	-	-
16	Curlew	-		M	-	-	**	***	*	-	-	-
17	Curlew, Eastern	-		M	-	-	**	***	*	-	-	-
18	Curlew, Great Stone	P		R/LM	-	-	-	*	***	*	***	-
19	Curlew, Indian Stone		P	R/LM	-	-	-	-	***	*	***	-
20	Whimbrel		-	M	-	-	*	***	***	-	-	-
21	Sandpiper, Common		-	M	-	-	*	***	*	-	-	-
22	Sandpiper, Broadbilled		-	M	-	-	*	***	*	-	-	-
23	Sandpiper, Green		-	M	-	-	*	***	*	-	-	-
24	Sandpiper, Terek		-	M	-	-	*	***	*	-	-	-
25	Sandpiper, Wood		-	M	-	-	*	***	*	-	-	-

26	Sandpiper,Curlew	-	M	-	-	*	***	*	-	-	-	
27	Snank, Red	-	M	-	*	*	***	*	-	-	-	
28	Shank, Green	-	M	-	*	*	***	*	-	-	-	
29	Shank, Dusky Red	-	M	-	*	*	***	*	-	-	-	
30	Stint, Little	-	M	-	-	*	***	*	-	-	-	
31	Stint, Temminck's	-	M	-	-	*	***	*	-	-	-	
32	Sanderling	-	M	-	-	*	***	*	-	-	-	
33	Dunlin	-	M	-	-	*	***	*	-	-	-	
34	Stilt, Blackwinged	P	R	-	**	**	***	**	-	-	-	
35	Avocet	P	RL/M/M	-	**	*	***	-	-	-	-	
36	Pratincole, Indian Small	P	R/LM	-	-	-	*	***	*	**	-	
37	Pratincole, Collared	-	M	-	-	-	*	***	*	**	-	
M	**Gulls**											
1	Gull, Blackheaded	-	M	***	***	-	*	**	-	-	-	
2	Gull, Brownheaded	-	M	***	***	-	*	**	-	-	-	
3	Gull, Herring	-	M	***	***	-	*	**	-	-	-	
N	**Terns**											
1	Tern, Indian River	P	R/LM	***	***	-	*	**	-	-	-	
2	Tern, Little	P	R/LM	***	***	-	*	**	-	-	-	
3	Tern, Gullbilled	-	R/LM	***	***	-	*	**	-	-	-	
4	Tern, Whiskered	-	R/LM	***	***	-	*	**	-	-	-	
5	Tern, Common	P	R/LM	***	***	-	*	**	-	-	-	
6	Tern, Caspian	-	R/LM	***	***	-	*	**	-	-	-	
7	Tern, Whitewinged Black	-	R/LM	***	***	-	*	**	-	-	-	

O	**Kingfishers**											
1	Kingfisher, Common	P	R/LM	*	**	***	*	**	-	*	-
2	Kingfisher, Pied	P	R/LM	**	***	*	-	*	-	*	-
3	Kingfisher, Whitebreasted	P	R/LM	**	***	*	*	*	*	*	**

Notes : *** Most preferred/ extensively used habitat
** Moderately preferred/ Moderatelly used habitat
* Less preferred/ Less used habiatat
P Potentiality of breeding in the area
R Resident species
M Migratory species
LM Locally migratory species

Annexure - 7

Waterfowl census - Nalsarovar bird sanctuary, January 1992

Sr. No.	Species	Total	Group of birds	Estimated % within group
A.	**Grebes**	738		
1.	Grebe, Little		738	100.00
2.	Grebe, Rednecked		0	0.00
3.	Grebe, Blacknecked		0	0.00
4.	Grebe, Great Crested		0	0.00
5.	Unidentified Grebes		0	0.00
B.	**Pelicans**	42877		
1.	Pelicans, Rosy or White		37533	87.60
2.	Pelicans, Spotbilled		634	1.50
3.	Pelicans, Dalmatian		4364	10.18
4.	Unidentified Pelicans		287	0.67
C.	**Ducks & Geese**	25074		
1.	Geese, Barheaded		7	0.03
2.	Geese, Greylag		58	0.23
3.	Unidentified Geese		54	0.22
4.	Teal, Large-Whistling		21	0.08
5.	Teal, Lesser-Whistling		190	0.75
6.	Teal, Comman		1384	5.52
7.	Teal, Cotton		14	0.06
8.	Teal, Marbled		0	0.00
9.	Teal, Baikal		0	0.00
10.	Teal, Falcated		0	0.00
11.	Shelduck, Common		0	0.00
12.	Shelduck, Ruddy		625	2.49
13.	Duck, Comb		115	0.46
14.	Duck, Spotbill		327	1.30
15.	Duck, Brahminy		0	0.00
16.	Duck, Tufted		85	0.34
17.	Duck, Scuap		38	0.15
18.	Pochard, Common		169	0.67
19.	Pochard, White-eyed		20	0.08
20.	Pochard, Redcrested		17	0.07
21.	Mallard		51	0.20
22.	Gadwall		131	0.52
23.	Wigeon		108	0.43
24.	Gargany		139	0.55
25.	Shoveller		6028	24.04
26.	Pintail		1406	5.61
27.	Unidentified Ducks		14087	56.18

D.	**Rails, Coots, Crakes**	19292		
1.	Rail, Water		0	0.00
2.	Rail, Bluebreasted Bar		0	0.00
3.	Crake, Brown		0	0.00
4.	Crake, Spotted		0	0.00
5.	Crake, Baillon's		0	0.00
6.	Crake, Ruddy		0	0.00
7.	Crake, Banded		0	0.00
8.	Moorhen, Purple		38	0.20
9.	Moorhen		14	0.07
10.	Waterhen, Whitebreasted		28	0.15
11.	Water cock		7	0.04
12.	Coot		19198	99.51
13.	Unidentified Rails, Coots & Crakes		7	0.04
E.	**Jacanas**	144		
1.	Jacana, Pheasant-tailed		62	43.06
2.	Jacana, Bronzewinged		0	0.00
3.	Unidentified Jacanas		82	56.94
F.	**Cormorants & Darter**	785		
1.	Cormorant		404	51.46
2.	Cormorant, Little		250	31.85
3.	Indian Shag		0	0.00
4.	Unidentified Cormorants		0	0.00
5.	Darter or Snakebird		131	16.69
G.	**Herons, Egrets & Bitterns**	8010		
1.	Heron, Grey		552	6.89
2.	Heron, Purple		213	2.66
3.	Heron, Night		136	1.70
4.	Heron, Little Green		0	0.00
5.	Heron, Pond		265	3.31
6.	Heron, Indian Reef		64	0.80
7.	Egret, Large		1381	17.24
8.	Egret, Smaller		3528	44.04
9.	Egret, Little		864	10.79
10.	Egret, Cattle		702	8.76
11.	Bittern		0	0.00
12.	Bittern, Black		0	0.00
13.	Bittern, Chestnut		4	0.05
14.	Bittern, Yellow		0	0.00
15.	Unidentified Herons		301	3.76

H.	**Storks**	590		
1.	Stork, Adjutant		0	0.00
2.	Stork, Black		85	14.41
3.	Stork, Blacknecked		31	5.25
4.	Stork, Open-Billed		0	0.00
5.	Stork, Painted		125	21.19
6.	Stork, White		209	35.42
7.	Stork, Whitenecked		140	23.73
8.	Unidentified Stork		0	0.00
I	**Ibis & Spoonbill**	12062		
1.	Ibis, White		89	0.74
2.	Ibis, Black		1933	16.03
3.	Ibis, Glossy		2742	22.73
4.	Spoonbill		6244	31.77
5.	Unidentified Ibises		1054	8.74
J.	**Flamingos**	10413		
1.	Flamingo,		1165	83.69
2.	Flamingo, Lesser		1624	15.00
3.	Unidentified Flamingo		74	0.71
K.	**Cranes**	32548		
1.	Crane, Common		1165	3.58
2.	Crane, Demoiselle		16362	50.27
3.	Crane, Sarus		21	0.06
4.	Unidentified Cranes		15000	46.09
L.	**Waders-Shorebirds**	63836		
1.	Lapwing, Redwattled		78	0.12
2.	Lapwing, Yellow-wattled		99	0.16
3.	Lapwing, Whitetailed		150	0.23
4.	Lapwing, Sociable		0	0.00
5.	Plover, Golden		0	0.00
6.	Plover, Grey		65	0.10
7.	Plover, Kentish		13	0.10
8.	Plover, Lesser Sand		0	0.00
9.	Plover, Large Sand		0	0.00
10.	Plover, Little Ringed E		41	0.06
11.	Plover, Little Ringed J		0	0.00
12.	Unidentified Plovers & Lapwings		1183	1.00
13.	Godwit, Blacktailed		13996	21.92
14.	Godwit, Bartailed		207	0.32
15.	Unidentified Godwits		1014	1.59
16.	Snipe, Common		637	1.00

17.	Snipe, Jack		0	0.00
18.	Snipe, Painted		195	0.31
19.	Snipe, Pintailed		110	0.17
20.	Unidentified Snipes		294	0.46
21.	Curlew		69	0.11
22.	Curlew, Eastern		0	0.00
23.	Curlew, Great Stone		0	0.00
24.	Curlew, Indian Stone		14	0.02
25.	Whimbrel		140	0.22
26.	Sandpiper, Common		8028	12.58
27.	Sandpiper, Broadbilled		7	0.01
28.	Sandpiper, Green		195	0.31
29.	Sandpiper, Marsh		55	0.09
30.	Sandpiper, Terek		17	0.03
31.	Sandpiper, Wood		212	0.33
32.	Sandpiper, Curlew		4	0.01
33.	Unidentified Sandpipers		7257	11.37
34.	Shank, Red		855	1.34
35.	Shank, Green		133	0.21
36.	Shank, Dusky Red		4	0.01
37.	Stint, Little		2800	4.39
38.	Stint, Temmink's		4	0.01
39.	Sanderling		164	0.26
40.	Turnstone		82	0.13
41.	Dunlin		253	0.40
42.	Stilt, Blackwinged		7499	11.75
43.	Avocet		485	0.76
44.	Pratincole, Indian Small		444	0.70
45.	Pratincole, Collored		680	1.07
46.	Phalarope, Rednecked		0	0.00
47.	Ruff		1658	2.60
48.	Unidentified Waders		14695	23.02
M.	**Gulls**	2575		
1.	Gull, Blackheaded		1067	41.42
2.	Gull, Brownheaded		346	13.42
3.	Gull, Blackbacked		47	1.82
4.	Gull, Great Blackbacked		7	0.27
5.	Gull, Slenderbilled		0	0.00
6.	Gull, Yellowlegged Herring		260	10.09
7.	Unidentified Gulls		849	32.96
N.	**Terns**	1983		
1.	Tern, Indian River		367	19.52
2.	Tern, Little		491	24.76
3.	Tern, Gullbilled		198	9.98
4.	Tern, Blackbellied		0	0.00

5.	Tern, Whiskered		149	7.50
6.	Tern, Common		161	8.12
7.	Tern, Caspian		128	6.45
8.	Tern, Whitewinged Black		0	0.00
9.	Unidentified Terns		462	23.30
10.	Skimmer		7	0.35
O.	**Kingfishers**	65		
1.	Kingfisher, Blackcapped		0	0.00
2.	Kingfisher, Storkbilled		0	0.00
3.	Kingfisher, Common		31	47.29
4.	Kingfisher, Indian Pied		0	0.00
5.	Kingfisher, Whitebreasted		34	52.71
6.	Unidentified Kingfisher		0	0.00
P.	**Additional Species**	3252		
1.	Not listed above (Others)		3252	100.00
	Total		**224245**	**224245**

Annexure - 8

Estimated population of various waterfowl based on waterfowl census during January 23-24, 1996

Sr. No.	Name of Species	Open water strata			Shoreland strata			Grand total and proportion				
		Group total	Estimated population	% within group	Group total	Estimated population	% within group	Group total	Estimated population	% within group	% in open water to total	% in shoreland to total
A	Grebes	20	-	-	120	-	-	140	-	-	14.29	85.71
1.	Grebe, little	-	20	100	-	115	95.83	-	135	96.43	14.29	85.71
2.	Grebe, Rednecked	-	-	-	-	-	-	-	-	-	-	-
3.	Grebe, Blacknecked	-	-	-	-	5	4.17	-	5	3.57	-	100
4.	Grebe, Great Crested	-	-	-	-	-	-	-	-	-	-	-
5.	Unidentified Grebes	-	-	-	-	-	-	-	-	-	-	-
B.	Pelicans	-	-	-	-	-	-	1813*	-	-	-	-
1.	Pelican, Rosy or White	-	-	-	-	-	-	-	1785*	-	-	-
2.	Pelican, Spottedbilled	-	-	-	-	-	-	-	-	-	-	-
3.	Pelican, Dalmatian	-	-	-	-	-	-	-	28*	-	-	-
4.	Unidentified Pelicans	-	-	-	-	-	-	-	-	-	-	-
C.	Ducks & Geese	25159	-	-	21062	-	-	46221	-	-	54.43	45.57
1.	Geese, Barheaded	-	-	-	-	-	-	-	-	-	-	-
2.	Geese, Greylag	-	-	-	-	-	-	-	-	-	-	-
3.	Unidentified Geese	-	-	-	-	-	-	-	-	-	-	-
4.	Teal, Large-Whistling	-	-	-	-	-	-	-	-	-	-	-
5.	Teal, Lesser-Whistling	-	-	-	-	-	-	-	-	-	-	-
6.	Teal, Comman	-	6185	24.58	-	3226	15.31	-	9411	20.36	65.72	34.28
7.	Teal, Cotton	-	394	1.57	-	-	-	-	394	0.85	100	-
8.	Teal, Marbled	-	-	-	-	-	-	-	-	-	-	-
9.	Teal, Baikal	-	-	-	-	-	-	-	-	-	-	-
10.	Teal, Falcated	-	-	-	-	-	-	-	-	-	-	-
11.	Shelduck Common	-	20	0.08	-	-	-	-	20	0.04	100	-
12.	Shelduck Ruddy	-	69	0.27	-	830	3.94	-	899	1.94	7.67	92.32
13.	Duck Comb	-	-	-	-	-	-	-	-	-	-	-
14.	Duck, Spotbill	-	74	0.29	-	38	0.18	-	112	0.24	66.07	33.92
15.	Duck, Tufted	-	-	-	-	10	0.05	-	10	0.02	-	100
16.	Duck, Scuap	-	-	-	-	-	-	-	-	-	-	-
17.	Pochard, Common	-	10	0.04	-	77	0.37	-	87	0.19	11.49	88.50
18.	Pochard, White-eyed	-	-	-	-	-	-	-	-	-	-	-
19.	Pochard, Redcrested	-	-	-	-	-	-	-	-	-	-	-
20.	Mallard	-	-	-	-	-	-	-	-	-	-	-
21.	Gadwall	-	187	0.74	-	-	-	-	187	0.40	100	-

22.	Wigeon	-	-	-	-	163	0.77	-	163	0.35	-	100
23.	Gargany	-	39	0.16	-	413	1.96	-	452	0.95	8.62	91.37
24.	Shoveller	-	13440	53.42	-	3374	16.02	-	16814	36.37	79.93	20.06
25.	Pintail	-	1212	5.17	-	3245	15.41	-	4457	9.64	27.19	72.80
26.	Unidentified Ducks	-	3529	14.03	-	9686	45.99	-	13215	28.59	26.70	73.29
D.	**Rails, Coots, Crakes**	2060	-	-	12283	-	-	14343	-	-	14.36	85.64
1.	Rail, Water	-	-	-	-	-	-	-	-	-	-	-
2.	Rail, Bluebreasted	-	-	-	-	-	-	-	-	-	-	-
3.	Crake, Brown	-	-	-	-	-	-	-	-	-	-	-
4.	Crake, Spotted	-	-	-	-	19	0.15	-	19	0.13	-	100
5.	Crake, Baillon's	-	-	-	-	-	-	-	-	-	-	-
6.	Crake, Ruddy	-	-	-	-	-	-	-	-	-	-	-
7.	Crake, Banded	-	-	-	-	-	-	-	-	-	-	-
8.	Moorhen, Purple	-	-	-	-	5	0.04	-	5	0.03	-	100
9.	Moorhen	-	-	-	-	-	-	-	-	-	-	-
10.	Waterhen, Whitebreasted	-	-	-	-	-	-	-	-	-	-	-
11.	Water Cock	-	-	-	-	-	-	-	-	-	-	-
12.	Coot	-	2060	100	-	12259	99.80	-	14319	99.83	14.38	85.61
13.	Unidentified Rails, Coots & Crakes	-	-	-	-	-	-	-	-	-	-	-
E.	**Jacanas**	-	-	-	-	-	-	-	-	-	-	-
1.	Jacana, Pheasant-tailed	-	-	-	-	-	-	-	-	-	-	-
2.	Jacana, Bronzewinged	-	-	-	-	-	-	-	-	-	-	-
3.	Unidentified Jacanas	-	-	-	-	-	-	-	-	-	-	-
F.	**Cormorants & Darter**	-	-	-	101	-	-	101	-	-	-	100
1.	Cormorant	-	-	-	-	19	18.81	-	19	18.81	-	100
2.	Cormorant, Little	-	-	-	-	72	71.29	-	72	71.29	-	100
3.	Indian Shag	-	-	-	-	10	9.90	-	10	9.90	-	100
4.	Unidentified Cormorants	-	-	-	-	-	-	-	-	-	-	-
5.	Darter or Snakebird	-	-	-	-	-	-	-	-	-	-	-
G.	**Herons, Egrets & Bitterns**	5421	-	-	3960	-	-	9381	-	-	57.79	42.21
1.	Heron, Grey	-	261	4.82	-	821	20.72	-	1082	11.53	24.12	75.87
2.	Heron, Purple	-	-	-	-	43	1.09	-	43	0.46	-	100
3.	Heron, Night	-	-	-	-	-	-	-	-	-	-	-
4.	Heron, Little Green	-	-	-	-	67	1.69	-	67	0.71	-	100
5.	Heron, Pond	-	148	2.73	-	322	8.13	-	470	5.01	31.48	68.51

6.	Heron, Indian Reef	-	-	-	-	24	0.61	-	24	0.25	-	100
7.	Egret, Large	-	2957	54.54	-	672	16.97	-	3629	38.68	81.48	18.51
8.	Egret, Smaller	-	310	5.73	-	566	14.29	-	876	9.34	35.39	54.61
9.	Egret, Little	-	1740	32.09	-	1402	35.40	-	3142	33.49	55.37	44.62
10.	Egret, Cattle	-	5	0.09	-	43	1.09	-	48	0.51	10.42	89.58
11.	Bittern	-	-	-	-	-	-	-	-	-	-	-
12.	Bittern, Black	-	-	-	-	-	-	-	-	-	-	-
13.	Bittern, Chestnut	-	-	-	-	-	-	-	-	-	-	-
14.	Bittern, Yellow	-	-	-	-	-	-	-	-	-	-	-
15.	Unidentified Heron	-	-	-	-	-	-	-	-	-	-	-
H.	**Storks**	34	-	-	72	-	-	106	-	-	32.07	67.93
1.	Stork, Adjutant	-	-	-	-	-	-	-	-	-	-	-
2.	Stork, Black	-	-	-	-	-	-	-	-	-	-	-
3.	Stork, Blacknecked	-	-	-	-	-	-	-	-	-	-	-
4.	Stork, Openbilled	-	-	-	-	10	13.88	-	10	9.43	-	100
5.	Stork, Painted	-	34	100	-	38	52.78	-	72	67.92	47.22	52.77
6.	Stork, White	-	-	-	-	-	-	-	-	-	-	-
7.	Stork, Whitenecked	-	-	-	24	33.33	-	-	24	22.64	-	100
8.	Unidentified Stork	-	-	-	-	-	-	-	-	-	-	-
I.	**Ibis & Spoonbill**	6526	-	-	15018	-	-	21544	-	-	30.29	69.71
1.	Ibis, White	-	-	-	-	28	0.19	-	28	0.13	-	100
2.	Ibis, Black	-	5	0.07	-	29	0.19	-	34	0.16	14.70	85.29
3.	Ibis, Glossy	-	1681	25.75	-	134	0.89	-	1815	8.42	92.61	7.38
4.	Spoonbill	-	4840	74.17	-	14827	98.73	-	19667	91.28	24.61	75.39
5.	Unidentified Ibises	-	-	-	-	-	-	-	-	-	-	-
J.	**Flamingos**	4159	-	-	-	-	-	4159	-	-	100	-
1.	Flamingo	-	1434	34.48	-	-	-	-	1434	34.48	100	-
2.	Flamingo, Lesser	-	2725	65.52	-	-	-	-	2725	65.52	100	-
3.	Unidentified Flamingo	-	-	-	-	-	-	-	-	-	-	-
K.	**Cranes**	-	-	-	-	-	-	22012	-	-	-	-
1.	Crane, Common	-	-	-	-	-	-	22000	-	-	-	-
2.	Crane, Demoiselle	-	-	-	-	-	-	-	-	-	-	-
3.	Crane, Sarus	-	-	-	-	-	-	12	-	-	-	-
4.	Unidentified Cranes	-	-	-	-	-	-	-	-	-	-	-
L.	**Waders-Shorebirds**	5573	-	-	10238	-	-	15811	-	-	35.25	64.75
1.	Lapwing, Redwattled	-	10	0.18	-	182	1.78	-	192	1.21	5.21	94.79
2.	Lapwing, Yellow-wattled	-	-	-	-	101	0.99	-	101	0.64	-	100

3.	Lapwing, White-tailed	-	-	-	-	48	0.47	-	48	0.30	-	100
4.	Lapwing, Sociable	-	-	-	-	-	-	-	-	-	-	-
5.	Plover, Golden	-	-	-	-	-	-	-	-	-	-	-
6.	Plover, Grey	-	-	-	-	-	-	-	-	-	-	-
7.	Plover, Kentish	-	591	10.60	-	34	0.33	-	625	3.95	94.56	5.44
8.	Plover, Lesser Sand	-	-	-	-	-	-	-	-	-	-	-
9.	Plover, Large Sand	-	-	-	-	48	0.47	-	48	0.30	-	100
10.	Plover, Little Ringed E	-	325	5.83	-	14	0.14	-	339	2.14	95.87	4.13
11.	Plover, Little Ringed J	-	-	-	-	24	0.23	-	24	0.15	-	100
12.	Unidentified Plovers & Lapwings	-	-	-	-	72	0.70	-	72	0.45	-	100
13.	Godwit, Blacktailed	-	-	-	-	984	9.61	-	984	6.22	-	100
14.	Godwit, Bartailed	-	-	-	-	10	0.10	-	10	0.06	-	100
15.	Unidentified Godwits	-	-	-	-	-	-	-	-	-	-	-
16.	Snipe, Common	-	-	-	-	336	3.28	-	336	2.12	-	100
17.	Snipe, Jack	-	-	-	-	-	-	-	-	-	-	-
18.	Snipe, Painted	-	-	-	-	-	-	-	-	-	-	-
19.	Snipe, Pintailed	-	-	-	-	38	0.37	-	38	0.24	-	100
20.	Unidentified Snipes	-	-	-	-	-	-	-	-	-	-	-
21.	Curlew	-	69	1.24	-	120	1.17	-	189	1.19	36.50	63.50
22.	Curlew, Eastern	-	-	-	-	-	-	-	-	-	-	-
23.	Curlew, Great Stone	-	-	-	-	-	-	-	-	-	-	-
24.	Curlew, Indian stone	-	-	-	-	-	-	-	-	-	-	-
25.	Whimbrel	-	-	-	-	53	0.52	-	53	0.33	-	100
26.	Sandpiper, Common	-	158	2.83	-	202	1.97	-	360	2.28	43.89	56.11
27.	Sandpiper, Broadbilled	-	-	-	-	-	-	-	-	-	-	-
28.	Sandpiper, Green	-	-	-	-	34	0.33	-	34	0.21	-	100
29.	Sandpiper, Marsh	-	5	0.09	-	34	0.33	-	39	0.25	12.82	87.18
30.	Sandpiper, Terek	-	-	-	-	19	0.18	-	19	0.12	-	100
31.	Sandpiper, Wood	-	5	0.09	-	5	0.05	-	10	0.06	50	50
32.	Sandpiper, Curlew	-	-	-	-	-	-	-	-	-	-	-
33.	Unidentified Sandpipers	-	-	-	-	-	-	-	-	-	-	-
34.	Shank, Red	-	-	-	-	566	5.53	-	566	3.57	-	100
35.	Shank, Green	-	-	-	-	-	-	-	-	-	-	-
36.	Shank, Dusky Red	-	-	-	-	-	-	-	-	-	-	-
37.	Stint, Little	-	24	0.43	-	240	2.34	-	264	1.67	9.11	90.90
38.	Stint, Temminkls	-	-	-	-	-	-	-	-	-	-	-
39.	Sanderling	-	-	-	-	-	-	-	-	-	-	-
40.	Turnstone	-	-	-	-	-	-	-	-	-	-	-
41.	Dunlin	-	-	-	-	-	-	-	-	-	-	-
42.	Stilt, Blackwinged	-	4386	78.70	-	4939	48.24	-	9325	58.98	47.03	52.97
43.	Avocet	-	-	-	-	62	0.60	-	62	0.39	-	100

44.	Pratincole, Indian Small	-	-	-	-	-	-	-	-	-	-	-
45.	Pratincole, Collared	-	-	-	-	38	0.37	-	38	0.24	-	100
46.	Phalarope, Rednecked	-	-	-	-	-	-	-	-	-	-	-
47.	Ruff	-	-	-	-	1526	14.90	-	1526	9.65	-	100
48.	Unidentified Waders	-	-	-	-	510	4.98	-	510	3.22	-	100
M.	**Gulls**	217	-	-	5127	-	-	5344	-	-	4.06	95.94
1.	Gull, Blackheaded	-	163	75	-	130	2.53	-	293	5.48	55.63	44.36
2.	Gull, Brownheaded	-	-	-	-	4848	94.55	-	48.48	90.71	-	100
3.	Gull, Blackbacked	-	-	-	-	-	-	-	-	-	-	-
4.	Gull, Great Black -backed	-	-	-	-	-	-	-	-	-	-	-
5.	Gull, Slenderbilled	-	-	-	-	-	-	-	-	-	-	-
6.	Gull, Yellowlegged Herring	-	5	2.27	-	125	2.44	-	130	2.43	3.85	96.15
7.	Unidentified Gulls	-	49	22.73	-	24	0.47	-	73	1.36	67.12	32.87
N.	**Terns**	35	-	-	509	-	-	544	-	-	6.43	93.57
1.	Tern, Indian River	-	-	-	-	77	15.13	-	77	14.15	-	100
2.	Tern, Little	-	-	-	-	154	30.25	-	154	28.30	-	100
3.	Tern, Gullbellied	-	-	-	-	134	26.33	-	134	24.63	-	100
4.	Tern, Blackbellied	-	-	-	-	-	-	-	-	-	-	-
5.	Tern, Whiskered	-	-	-	-	29	5.69	-	29	5.33	-	100
6.	Tern, Common	-	-	-	-	-	-	-	-	-	-	-
7.	Tern, Caspian	-	10	28.57	-	48	9.43	-	58	10.66	17.24	82.36
8.	Tern, Whitewinged Black	-	-	-	-	-	-	-	-	-	-	-
9.	Unidentified Terns	-	25	71.42	-	67	13.16	-	92	16.91	27.17	72.83
10.	Skimmer	-	-	-	-	-	-	-	-	-	-	-
O.	**Kingfishers**	-	-	-	15	-	-	15	-	-	-	100
1.	Kingfisher, Blackcapped	-	-	-	-	-	-	-	-	-	-	-
2.	Kingfisher, Storkbilled	-	-	-	-	-	-	-	-	-	-	-
3.	Kingfisher, Common	-	-	-	-	-	-	-	-	-	-	-
4.	Kingfisher, Indian-Pide	-	-	-	-	10	66.66	-	10	66.66	-	100
5.	Kingfisher, Whitebreasted	-	-	-	-	5	33.33	-	5	33.33	-	100
6.	Unidentified Kingfisher	-	-	-	-	-	-	-	-	-	-	-

Notes :

☆ Indicates species not occurred during 0800 Hrs. count but occurred during other record timings within sample sites.

* Pelicans were counted separtely and the figures are for total count, counted earlier than the census days.

⁜ Figures for Sarus Crane are for actual undividuals sighted during census days. Common Crane and Demosille Crane were estimated separately by taking total counts one day before the census days.

Annexure - 9

Effect of the Nal on household by communities (Rs. per annum)

Sr No.	Community	Value of grass from the Nal	Fish	Mud taken	Item of Roofing	Boat* repair	Irrigation value effect (per acre)
1	Koli patel	85848.00	-	17280.00	400.00	-	89.47
		(26)		(16)	(3)		
		(46)@					
2	Ghanchi vora	29273.00	-	-	-	-	458.33
		(2)					
		(14)@					
3	Padhar	145635.00	292788.10	88560.00	5852.00	23900.00	122.97
		(30)	(38)	(82)	(37)	(10)	
		(69)@					
4	Shenva	584.00	-	1080.00	-	-	-
		(1)		(1)			
		(2)@					
5	Others	437087.50	-	3240.00	-	-	-
		(26)		(3)			
		(198)@					
	Total	**698427.50**	**292788.10**	**110160.00**	**6252.00**	**23900.00**	**233.59**
		(85)	(38)	(102)	(40)	(10)	
		(329)@					

() = No. of households ()@ = No. of Animals

* = Excluding residents of Vekaria, who earns through tourism.

Annexure - 10
Material taken from the Nal for building house

Sr. No.	Community	Total hh	Item Earth	%	Thatch	%	Not used any item	%
1	Koli Patel	58	21	36.21	16	27.59	21	36.21
2	Ghanchi vora	9	1	11.11	0	0.00	8	88.89
3	Padhar	155	70	45.16	83	53.55	2	1.29
4	Shenva	19	3	15.79	1	5.26	15	78.95
5	Other	59	11	18.64	3	5.08	45	76.27
	Total	**300**	**106**	**35.33**	**103**	**34.33**	**91**	**30.33**

hh = Households

Annexure - 11

Community-wise land holding and area under irrigation around Nalsarover

Sr No.	Community	Land owning		Per hh land (ha)	Per person land (ha)	Irrigated land		Per hh.irri land (ha)	% irr.area total land
		No.of hh	No.of person			no.of hh	ha		
1	Koli Patel	52	318	4.38	0.72	27	69.91	2.67	30.69
2	Ghanchi vora	5	37	3.68	0.50	4	8.80	2.20	47.83
3	Padhar	96	595	1.80	0.29	68	68.40	1.00	39.68
4	Shenva	17	96	2.66	0.46	2	2.40	1.20	5.48
5	Others	44	251	5.72	1.00	10	26.08	2.21	10.36