Conservation and Management of Lakes with Special Reference to Dal Lake

Sabah Ul Solim

J&K Lakes and Waterways Development Authority, Srinagar, J&K

15/04/2009 15:27

LAKE ANALYSIS

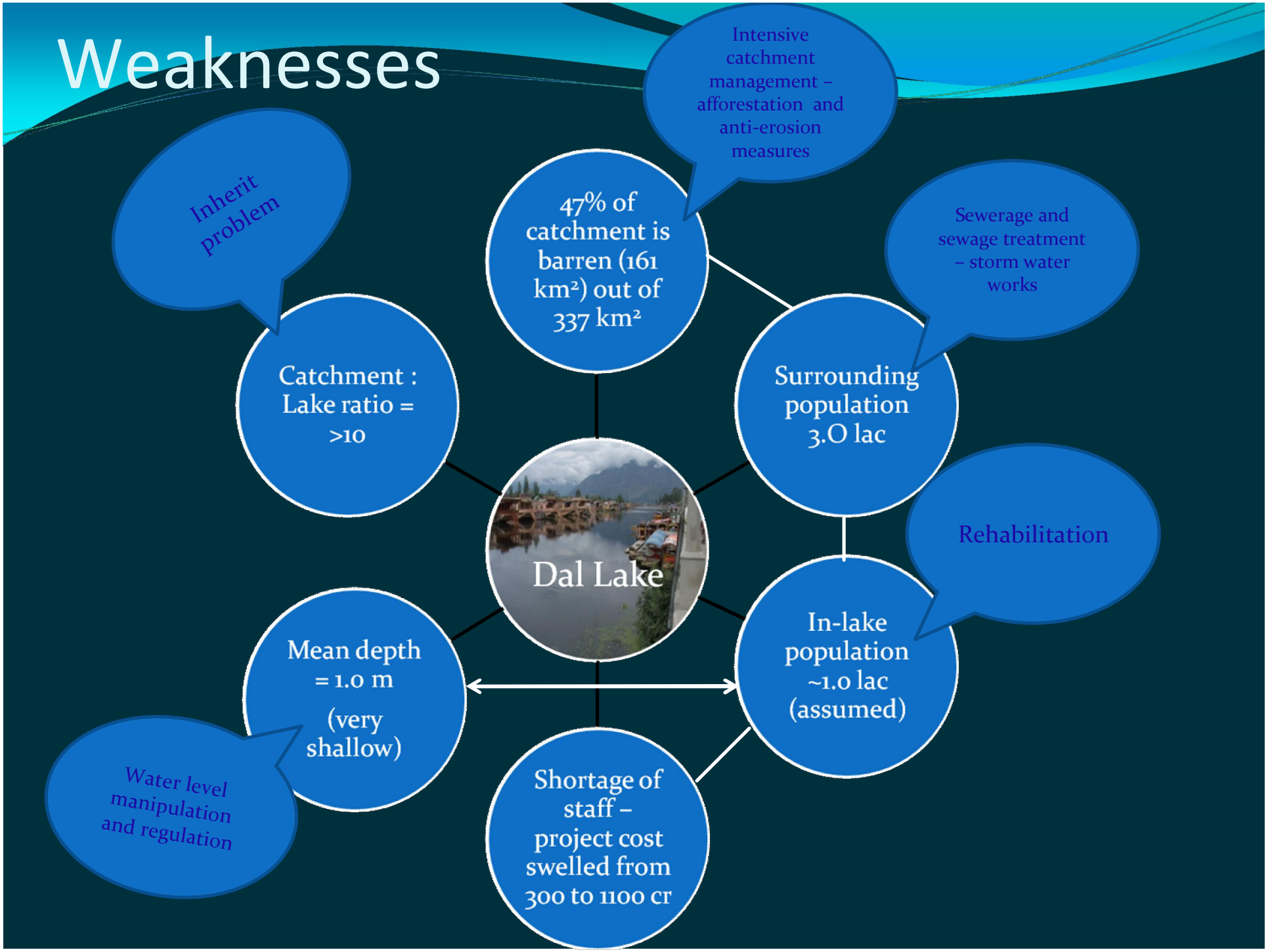
S (Strengths) → 1. Varied utilities, 2. High water flow, 3. flushing's thereof, 4. macrophyte dominated, 5. three outflow channels

W (Weaknesses) → 1. Urban locale, 2. shallow depth, 3. inlake population, 4. High catchment-lake ratio,

O (Opportunities) → 1.Water level manipulation and regulation, 2. additional water inputs (Sindh), 3. water sports (Jet skies) for circulation, 4. manure, 5. biogas and 6. electricity

T (Threats) → 1. Unplanned urbanization, 2. erratic rainfalls 3. extensive weeds – their recycling 4. Timely implementation of conservation measures

Weaknesses


Intensive catchment management – afforestation and anti-erosion measures
Inherit problem
47% of catchment is barren (161 km²) out of 337 km²
Sewerage and sewage treatment – storm water works
Catchment : Lake ratio = >10
Surrounding population 3.0 lac
Dal Lake
Rehabilitation
Mean depth = 1.0 m (very shallow)
In-lake population ~1.0 lac (assumed)
Water level manipulation and regulation
Shortage of staff – project cost swelled from 300 to 1100 cr

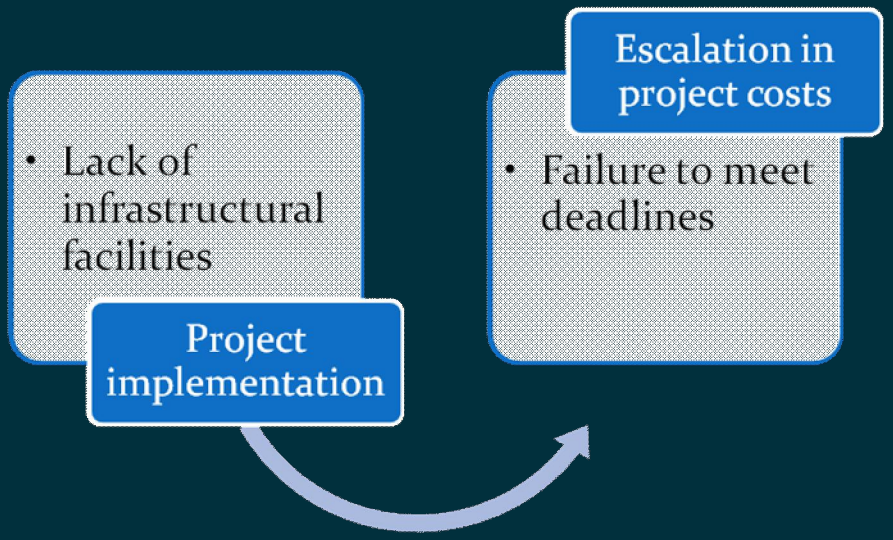
Urban Locale

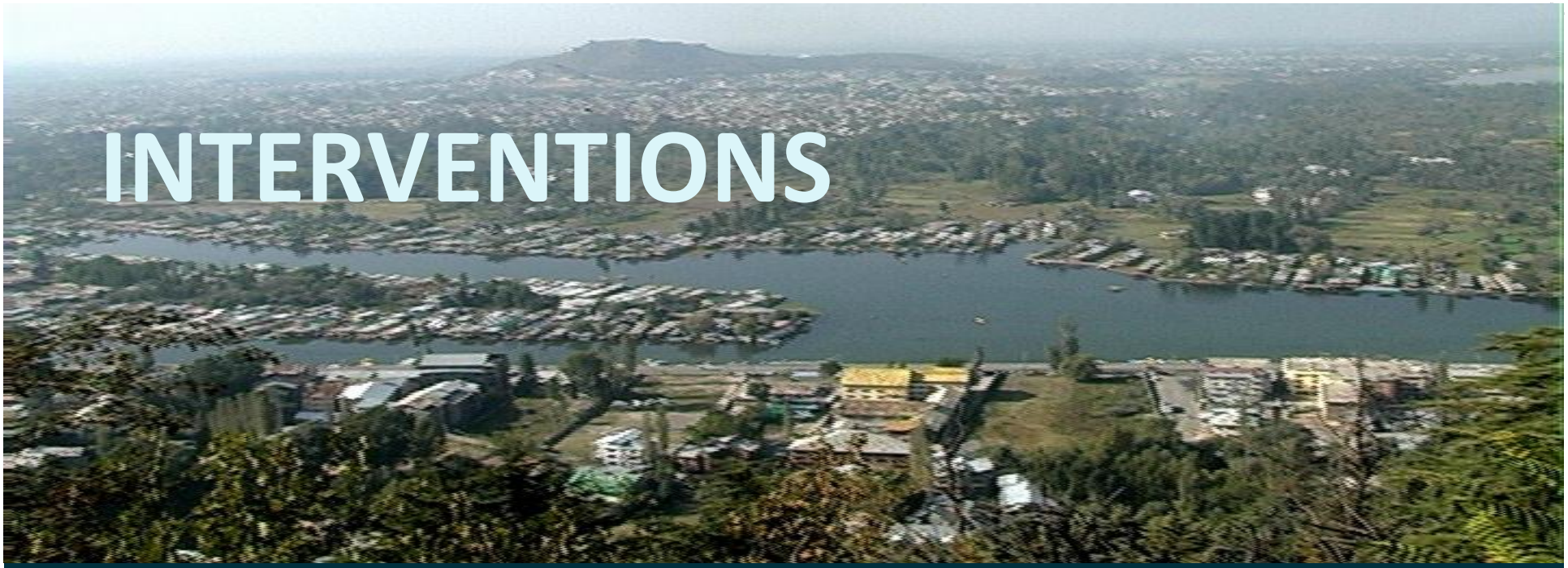
Threats

- Unplanned urbanization
- Erratic rainfalls
- Excessive weeds – their recycling and regeneration
- Population living inside the lake
- Timely completion of conservation measures – inadequate staff

Un-planned urbanization

- Inadequate infrastructural facilities has been observed to be the biggest impediment in implementing the projects and meeting the deadlines)
- Administrative bottle-necks





INTERVENTIONS

2004 onwards:	**Grants under National Lake Conservation Programme**
October 1999:	**MoEF engaged Alternate Hydro Energy centre (AHEC) of IIT Roorkee for preparation of Detailed Project Report.**
December, 2002	**DPR cleared by State Cabinet and submitted to Government of India.**
September, 2005:	**Sanctioned by GOI for Rs.298.76 Cr**

Reasons of Deterioration (DPR – AHEC- IIT Roorkee)

- Reduction in volume by silting caused mainly due to catchment area degradation.
- Increased pollution because of the increasing number of lake dwellers and floating gardens, entry of untreated sewage and solid waste from the peripheral areas and from the hamlets and house boats and agricultural return flow from catchment into the lake.
- Reduction and clogging of water channels within the lake because of encroachments leading to reduce circulation.
- Reduction of fresh water inflow into the lake.
- Nutrient enrichment of the lake-water and sediment resulting in excessive weed growth and change in the bio-diversity in the lake.
- Data deficiency
- Institutional deficiency

Interventions

Nutrient & Solid wastes	• Sewerage and Sewage treatment – Houseboat sanitation • Solid Waste management • Catchment area treatment
Hydrology	• Opening up of blocked channels, Brari-Numbal Cut and Conduit • Additional water from Padshahi Canal • Diversion works on Teilbal Nallah & Improvement to Nallah Amir Khan
Enrich--ment	• Deweeding (Manual and Mechanical) • Dredging • Additional water from streams to the lake
Encroach--hment	• Enforcement
Public awareness	• Public Awareness Programmes • Documentaries
Aesthetics	• Shoreline development

Conservation & Management Plan

(MoEF Approved Project)

Rupees in lacs

S.No.	Components	DPR Cost	Expenditure ending 12/2009
1.	Sewerage Treatment Works	9691.38	4726.99
2.	Solid Waste Management	75.59	87.99
3.	Hydraulic Works	1283.03	601.87
4.	Restoration & Dev. Works	4961.79	2670.70
5.	Catchment Management Works	2584.00	1005.21
6.	Infrastructure facilities	1592.33	216.26
7.	Public Awareness	541.08	44.10
8.	Unforeseen Miscellaneous	435.85	343.71
9.	Provision for land acquisition under conservation component	8710.00	4811.24
	Total	**29875.74**	**14507. 97**

Financial Implications (Amount in crore)

S.No.	Component	Cost	Source of funding
Part – I (Conservation)			
1.	Conservation and Mgt. Prog	**298.76**	MoEF, GOI under NLCP
2.	Conservation and Mgt. Prog (Acq. of land/Structures within lake and dredging/procurement of lake cleaning machines	**356.00***	PMPRP
3.	Laterals/House Connectivity	**55.00**	State Plan (not provided in the NLCP norms)
4.	Conservation of Brari-Numbal (incl. Aqc. of land)	**27.00**	State Plan
	Sub Total	**736.76**	
Part – II Rehabilitation & Resettlement a) Rakhi Arth		**402.00**	State Plan/JNNURM - HUPA, GOI
	G. Total	**1138.76**	

Physical Progress

Conservation Plan

Sewage Treatment Plants

Total *capacity to be installed* = 36.7 MLD
Plants = 5 Nos

Plants Commissioned = 3 Nos (15.2 MLD)

STP Hazratbal (7.5 MLD)

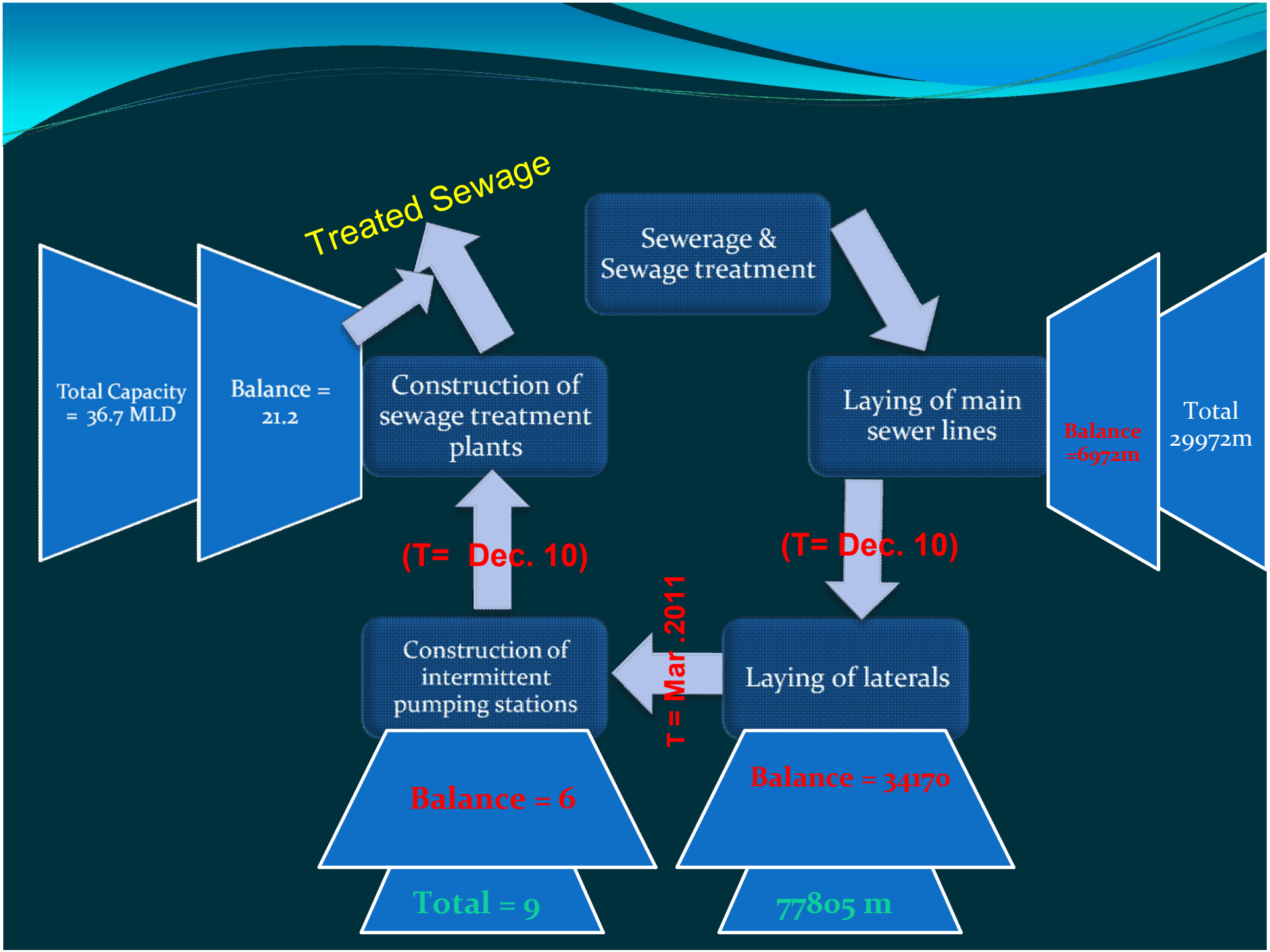
- Targeted Sewers lines = 7909 m
- Sewer lines completed = 7652.50 m (%)
- Targeted laterals = 20187 m
- Laterals = 12557 m (%)
- House Connectivity = 65%
- IPS = 2 (One commissioned and one to be Mar- 2010)

STP Habak (3.2 MLD)

- Targeted Sewers lines = 3057 m (100%)
- Sewer lines completed = 3057 m
- Targeted laterals = 8163 m
- Laterals = 7611 m (%)
- House Connectivity = 80%

STP Laam (4.5 MLD)

- Targeted Sewers lines = 4920 m (100%)
- Targeted laterals = 32620 m
- Laterals = 24843 m (%)
- House Connectivity = 90%
- IPS = 1 No. (Commissioned)


Treated Sewage
Sewerage & Sewage treatment
Total Capacity = 36.7 MLD
Balance = 21.2
Construction of sewage treatment plants
Laying of main sewer lines
Balance =6972m
Total 29972m
(T= Dec. 10)
(T= Dec. 10)
T = Mar .2011
Construction of intermittent pumping stations
Laying of laterals
Balance = 6
Balance = 34170
Total = 9
77805 m

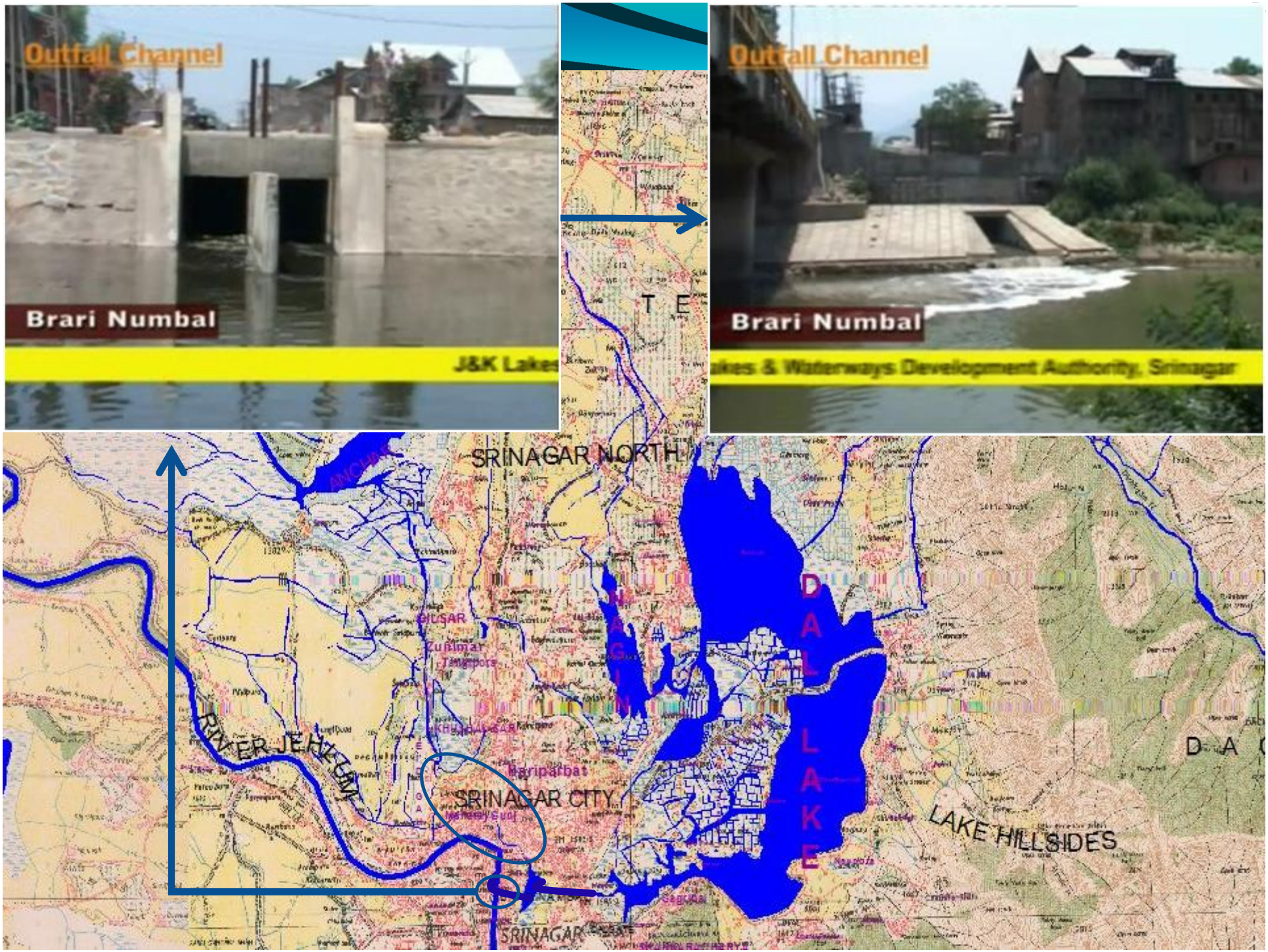
Low Cost Sanitation (LCS)

- 14 villages lack basic sanitation facilities around Dal Lake – Have constructed open latrines on inflowing Nallahs- like Telbal and Boutkul Nallahs
- DPR for LCS – Sulabh International (Appointed by IIT Roorkee)
- No. of households – 7150
- No. of community toilets – 14

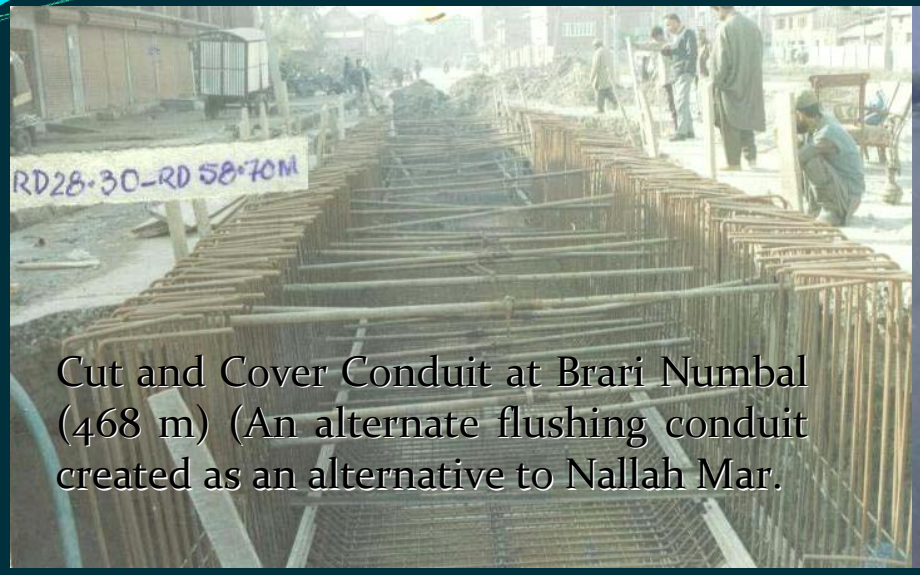
Map showing peripheral villages

Solid waste management

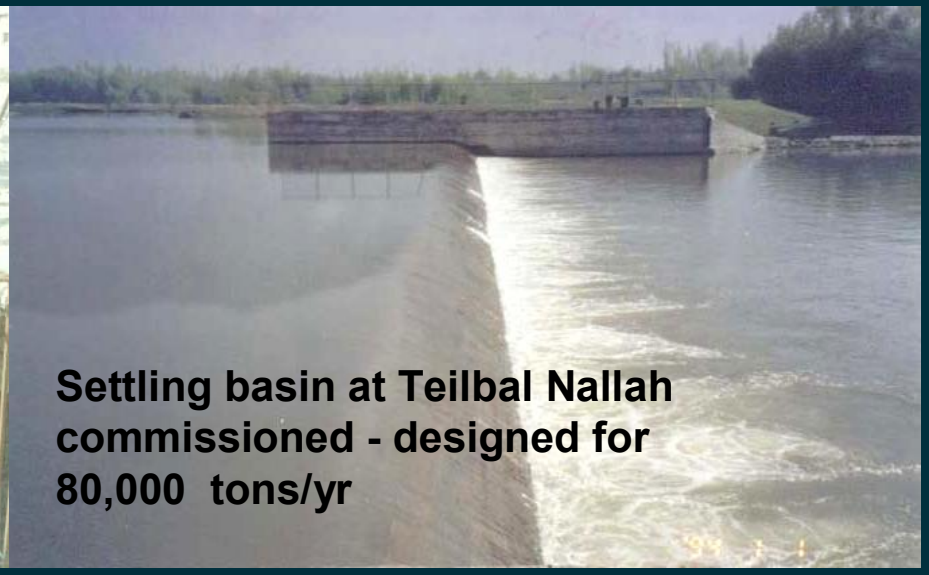
- Outsourced to NGOs
- Services provided to 7450 dwelling units including houseboats inside the lake.
- About 9000 Cubic Mtr. of solid waste collected annually and disposal through Srinagar Municipal Corporation.


Outfall Channel
Brari Numbal
J&K Lakes
Outfall Channel
Brari Numbal
Lakes & Waterways Development Authority, Srinagar
SRINAGAR NORTH
SRINAGAR CITY
SRINAGAR
RIVER JEHLUM
DAL LAKE
LAKE HILLSIDES
Hariparbat
Zadibal
Zuthmar
Tangpora

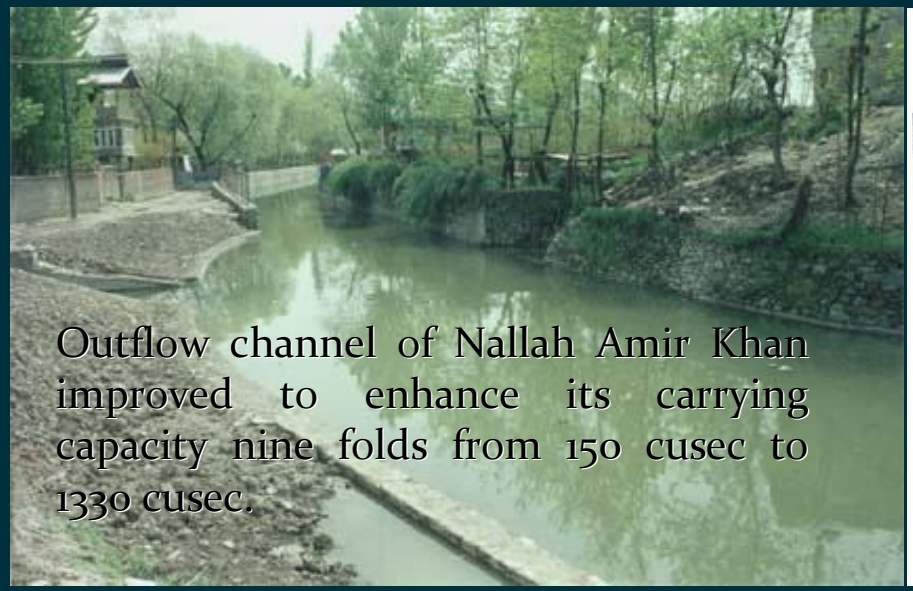
Hydraulic Works



Cut and Cover Conduit at Brari Numbal (468 m) (An alternate flushing conduit created as an alternative to Nallah Mar.



Settling basin at Teilbal Nallah commissioned - designed for 80,000 tons/yr



Outflow channel of Nallah Amir Khan improved to enhance its carrying capacity nine folds from 150 cusec to 1330 cusec.

Diversion Head Works on Teilbal Nallah with escape gates, fish ladder and navigational lock channel in final stages of completion (civil works already completed).

Additional water for dilution and flushing

- **Provision of additional water of 2 Cumecs for dilution and flushing purpose i.e. 5.27×10^6 m^3 per month**
- **Will bring 26.3% increase in flushing rate per month**
- **Will dilute the high concentration of nutrients in the lake.**

Catchment Management

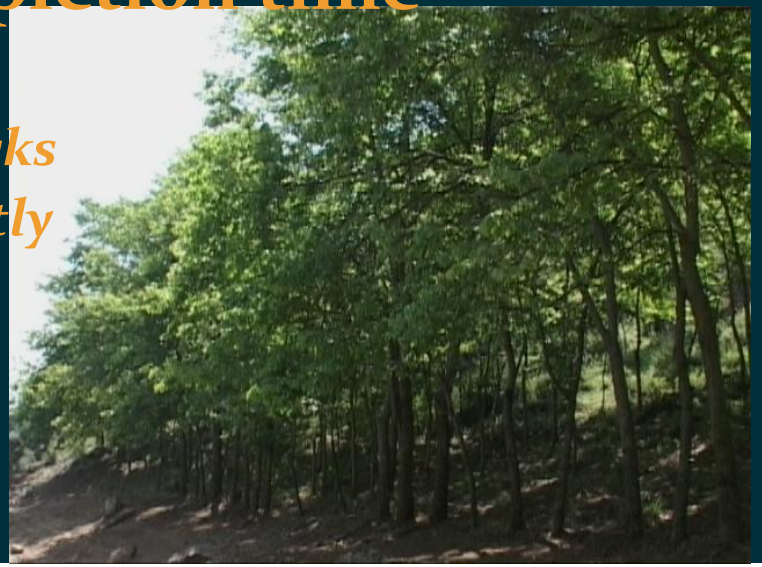
- **Main contributory Catchment**

  (6 water sheds with 12 micro water sheds 337 Sq. Km area in Dachigam , Dara – Danihama, lake body and peripherals draining towards lake).

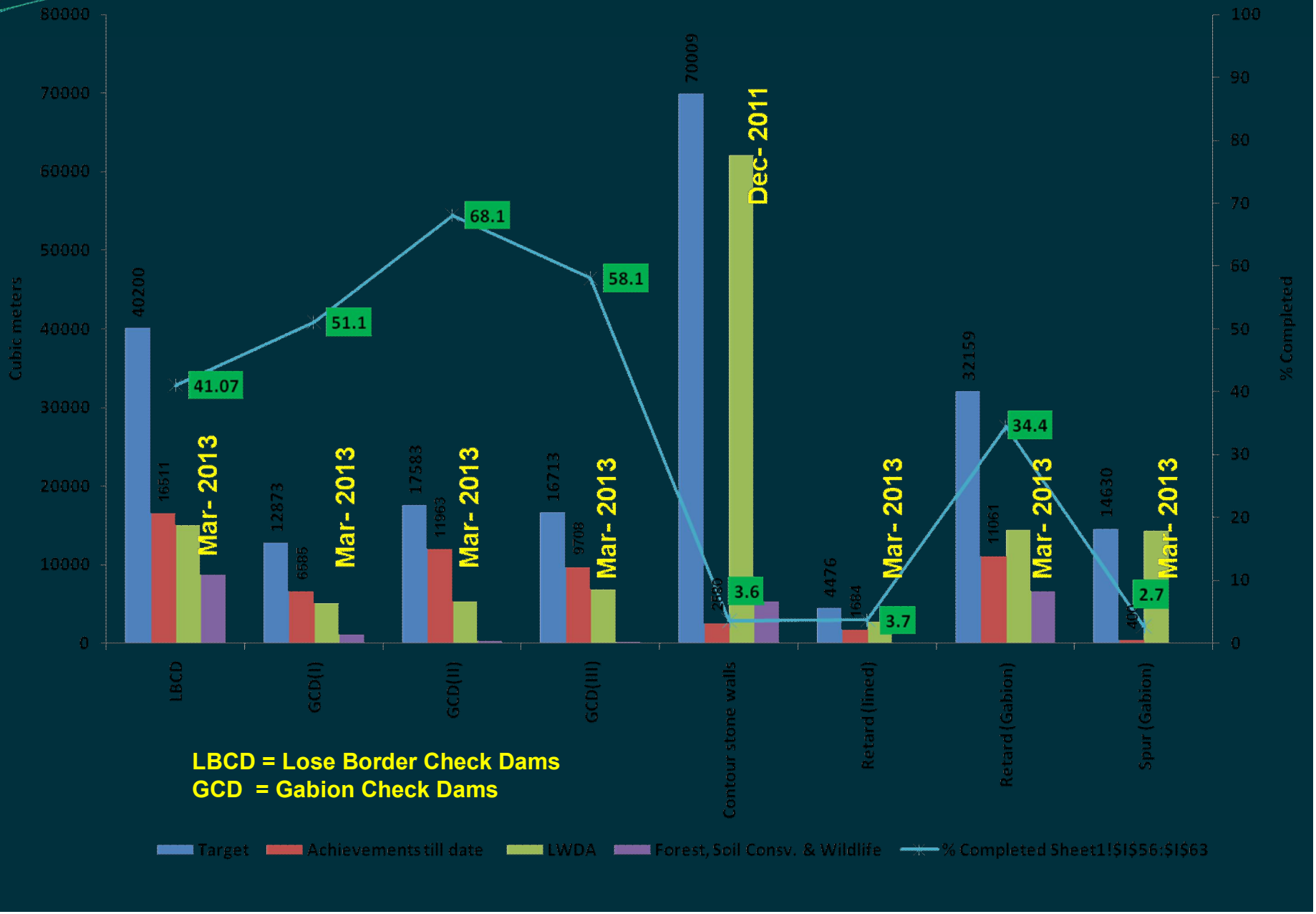
- **Interventions & achievements**

➢ *Gully plugging, anti-erosion, toe-crates and check dams in storm-water rivulets, trenching, pasture development, fencing, harvesting, etc to achieve:*

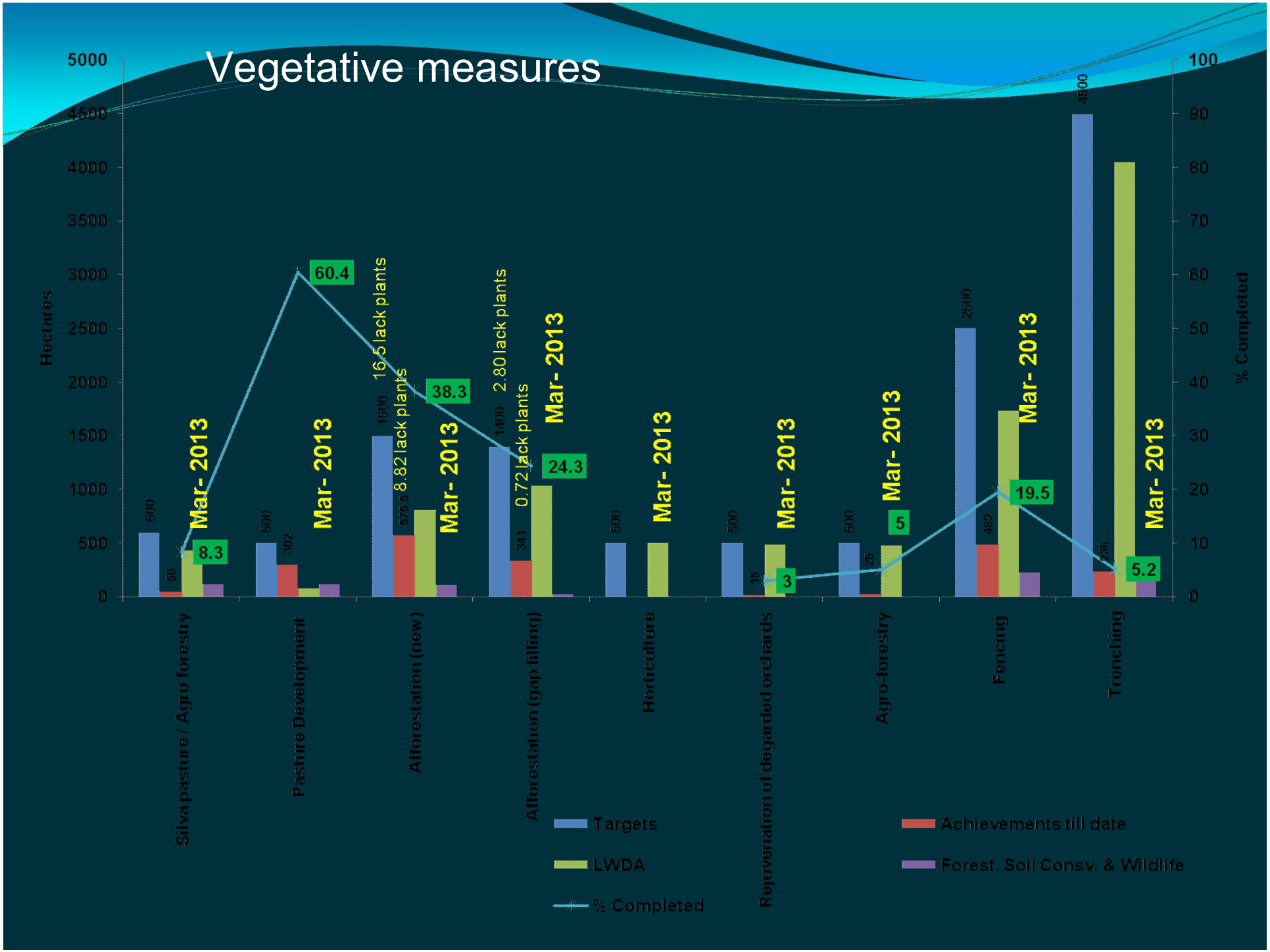
- **To meet the project completion time line:**
- *The afforestation and its allied works in the catchment area shall be jointly carried out by LWDA, forest, Soil Conservation and Wild Life Departments*



Structural measures



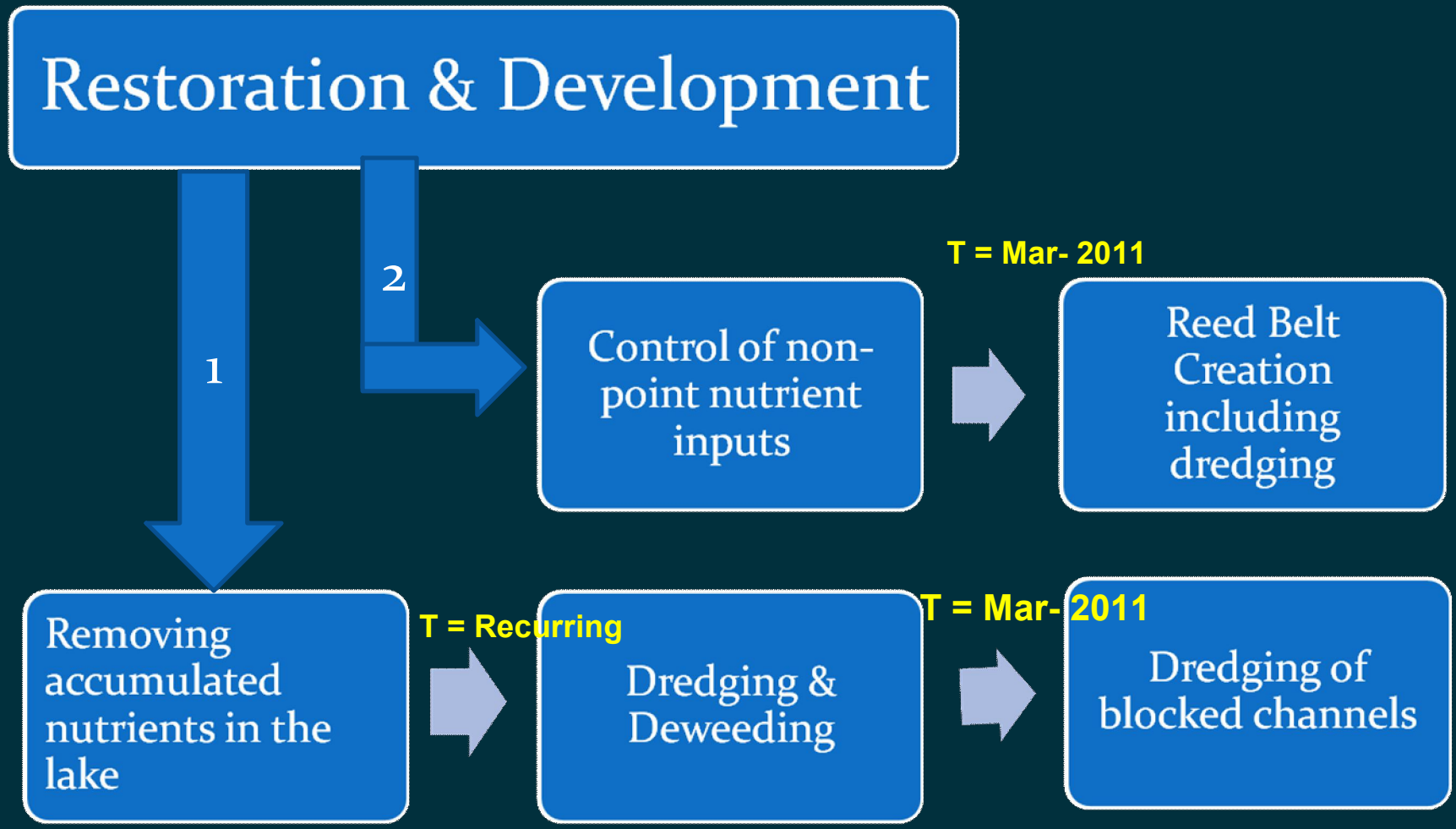
Vegetative measures



Watershed Development Committees

- For participatory approach LDA has constituted watershed development committees.
- Participatory approach in:
  - Developmental activities
  - Active participation in the micro-action plan formulation
  - Maintenance and upkeep of assets

Restoration & Development



Pre-dredging

Post-dredging

Before Dredging

After Dredging

Before Dredging

After Dredging

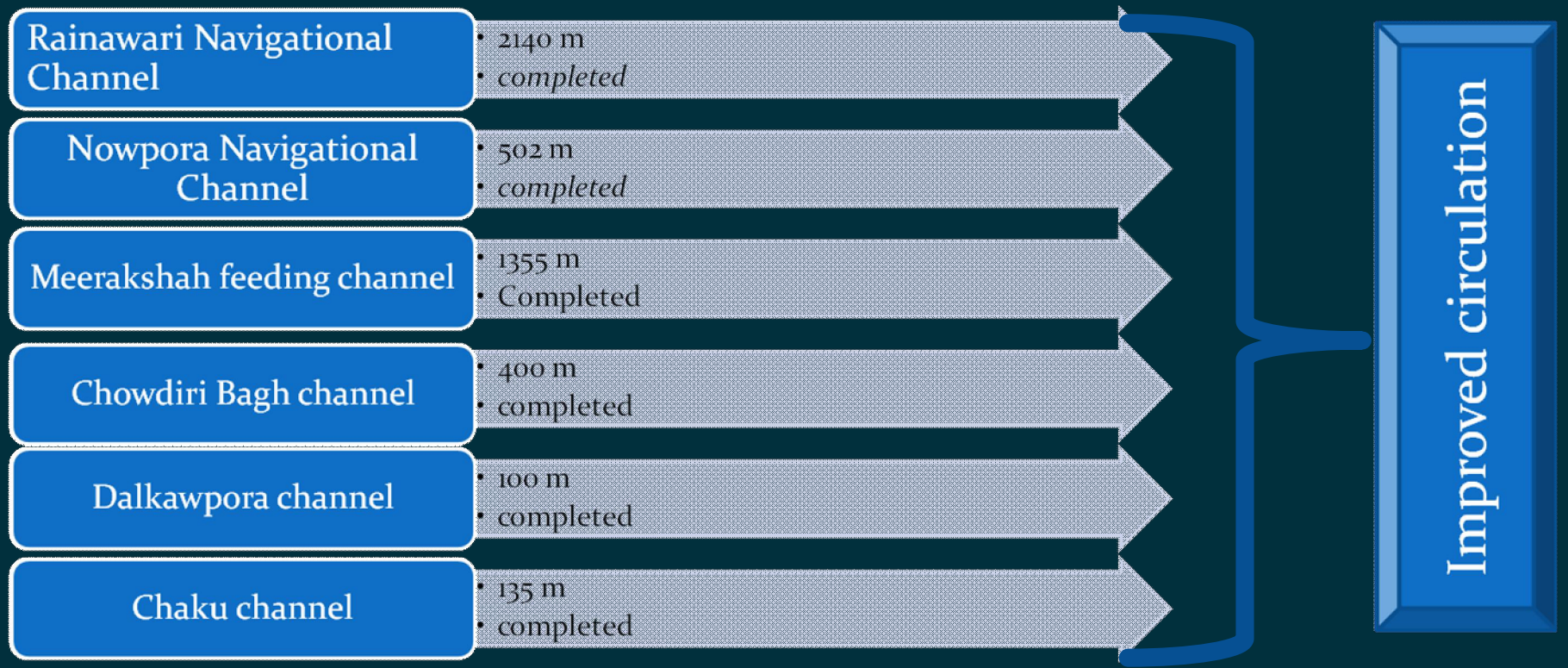
After

Before

Impact of dredging

- Removal of 2.53 x 10^6 m^3 of bottom sediments, thereby bringing and equivalent increase in volume of the lake
- 40% increase in water transparency in Hazratbal Basin
- 10% decrease in COD values in Hazratbal Basin.
- 295.11 tons of nitrogen and 73.74 tons of phosphorus removed from lake nutrient budget as a consequence.

Dredging of Blocked channels

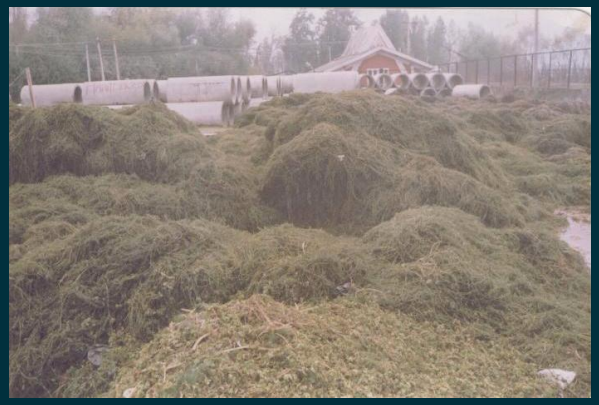


- Three more blocked channels to be dredged this year - process completed
- Total 38 blocked channels to be dredged by Mar- 2011

20,000 cum of wet weed on average is removed from Dal-Nagin lake area relieving the lake of nutrients trapped in weeds.

Before Dweeding

During Dweeding



After Dweeding

Removal of floating gardens at Nageen

Before

After

Public Awareness

- Public awareness program carried out regularly through electronic and print media, seminars, symposiums, debates and focused group discussions.
- Anti polythene campaign carried out with NGOs.

- Legislation passed by State Government banning use of non-biodegradable material like plastics, polythene etc.
- Road show & public awareness prog. was recently held on Dec-1st 2008 in association with a educational institutions and traffic police.
- Technical offers received from various NGOs and firms for carrying out of the awareness drives and programmes round the year- evaluation under process for final allotment

Infrastructure

- **Development of institutional infrastructure**
  Construction of 2 laboratories for monitoring lake-water quality and research work.

- **Equipment and machinery for the project**

Dredgers	2 Nos.
Harvesters	4 Nos.
Motor Boats	4 Nos.
Excavator	1 No.
JCB Excavator//Loader	1 No.
Tippers	2 Nos.

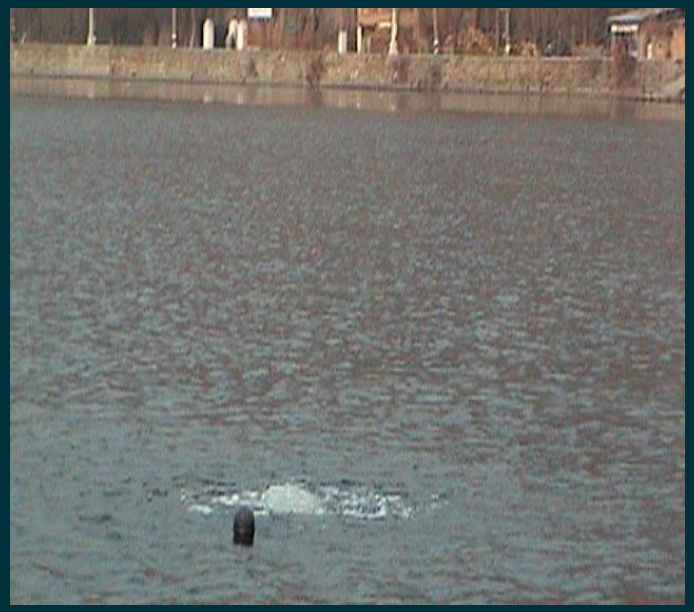
Aquarius Truxor DM 4700 B2

Watermaster Classic-III

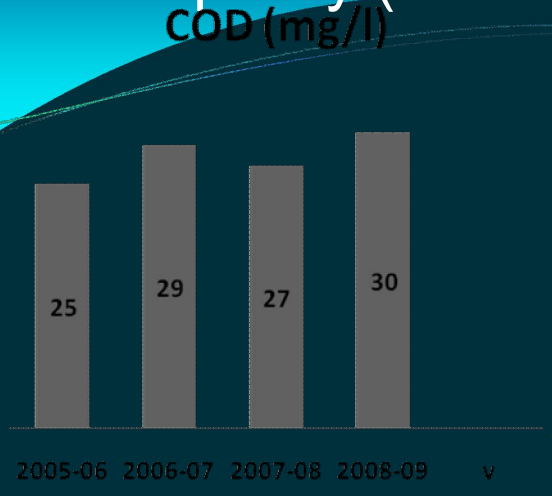
Research and Development

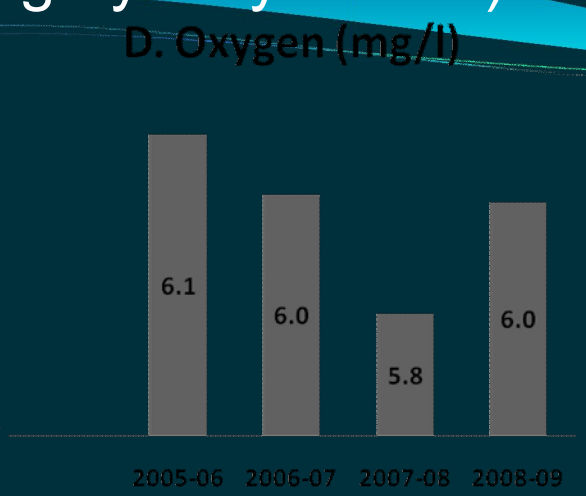
- Research and Monitoring Wing set up for regular monitoring of lake water quality and lake flora and fauna.

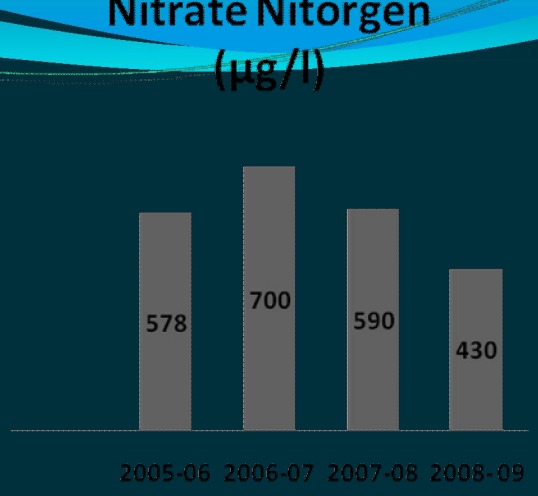
- Scientific Advisory Committee Meeting held in June 2009- valuable suggestions obtained – like Creation of artificial wetlands in upstream of Telbal Nallah, Augmentation of treatment process of existing STPs, incineration of Azolla, low cost sanitation etc.

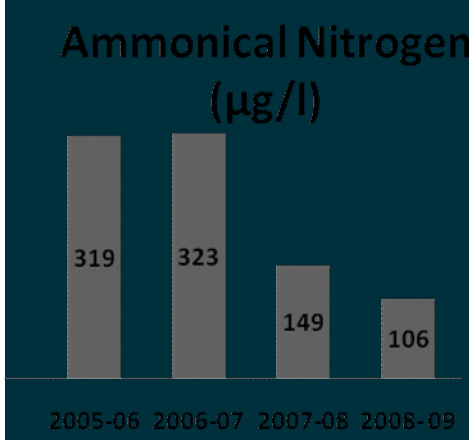


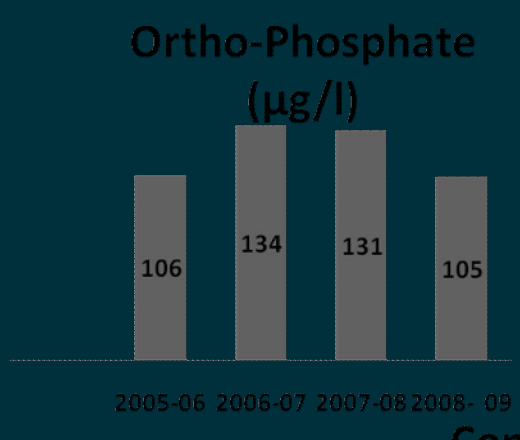
Water quality (Average yearly values)

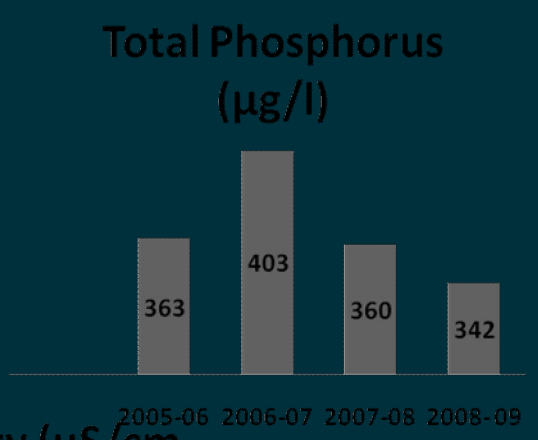


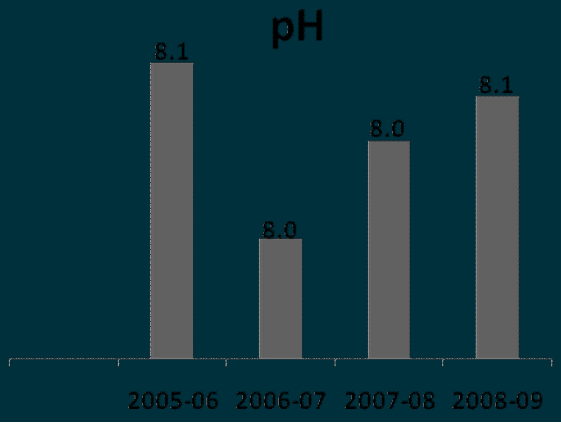


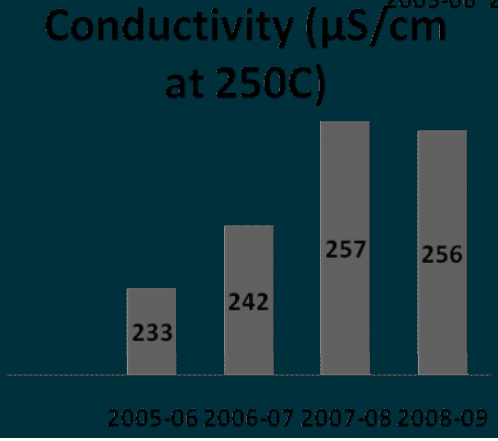




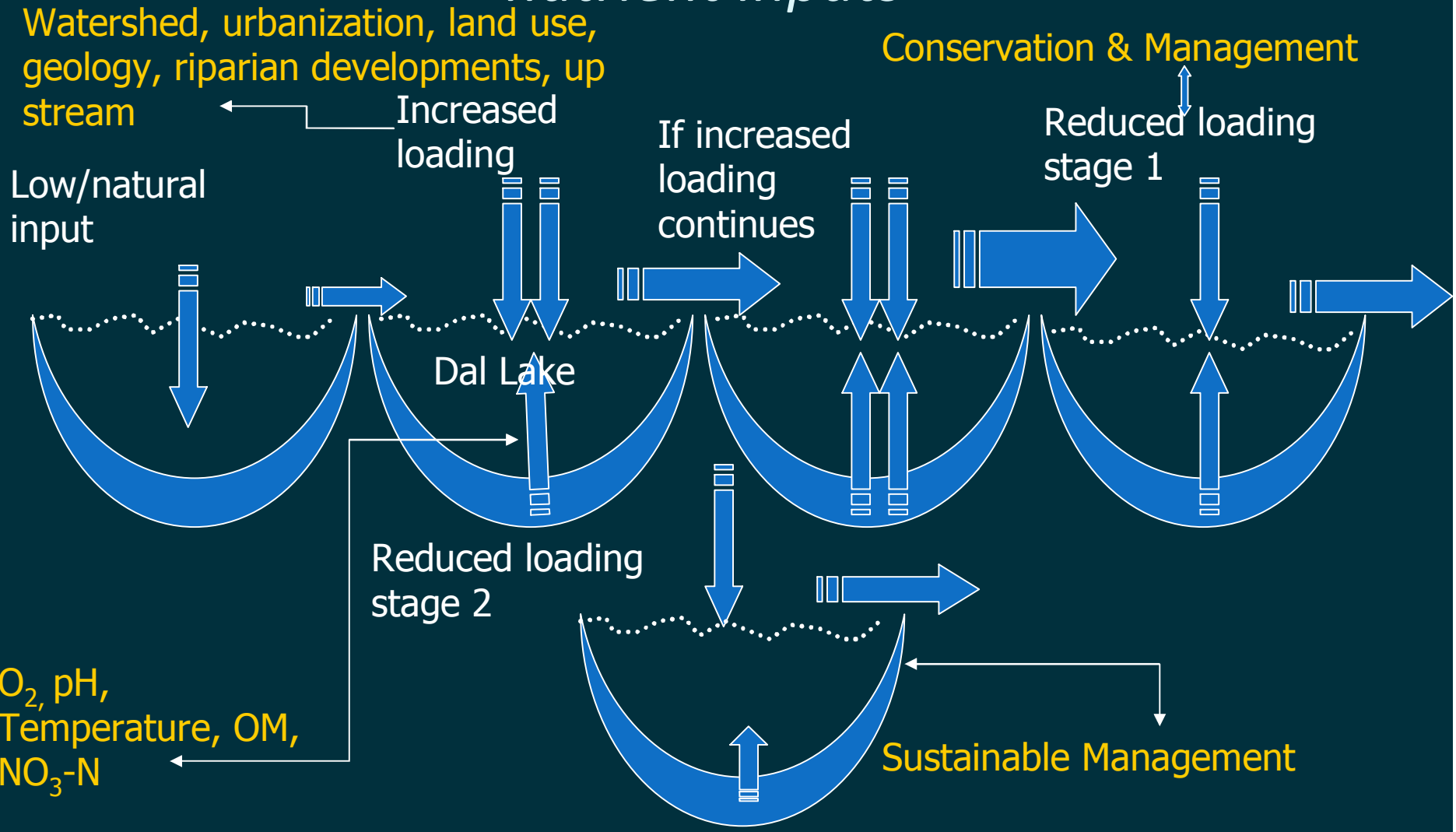




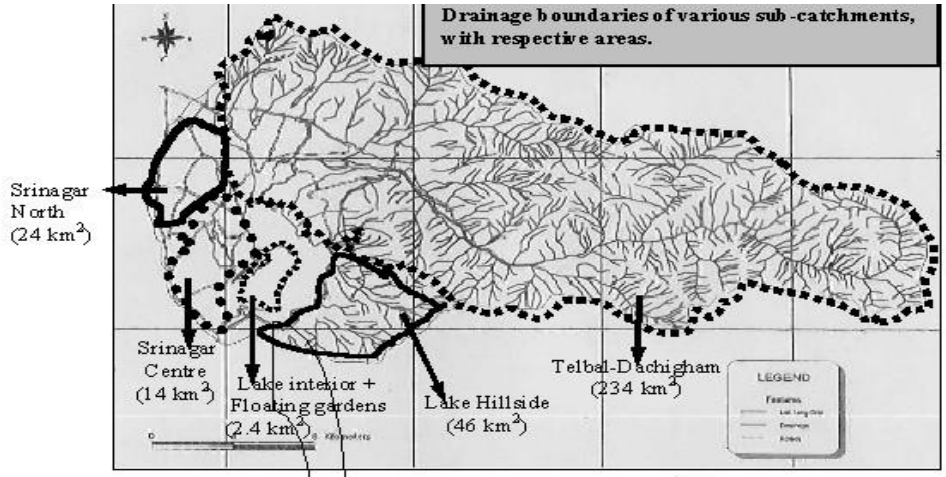




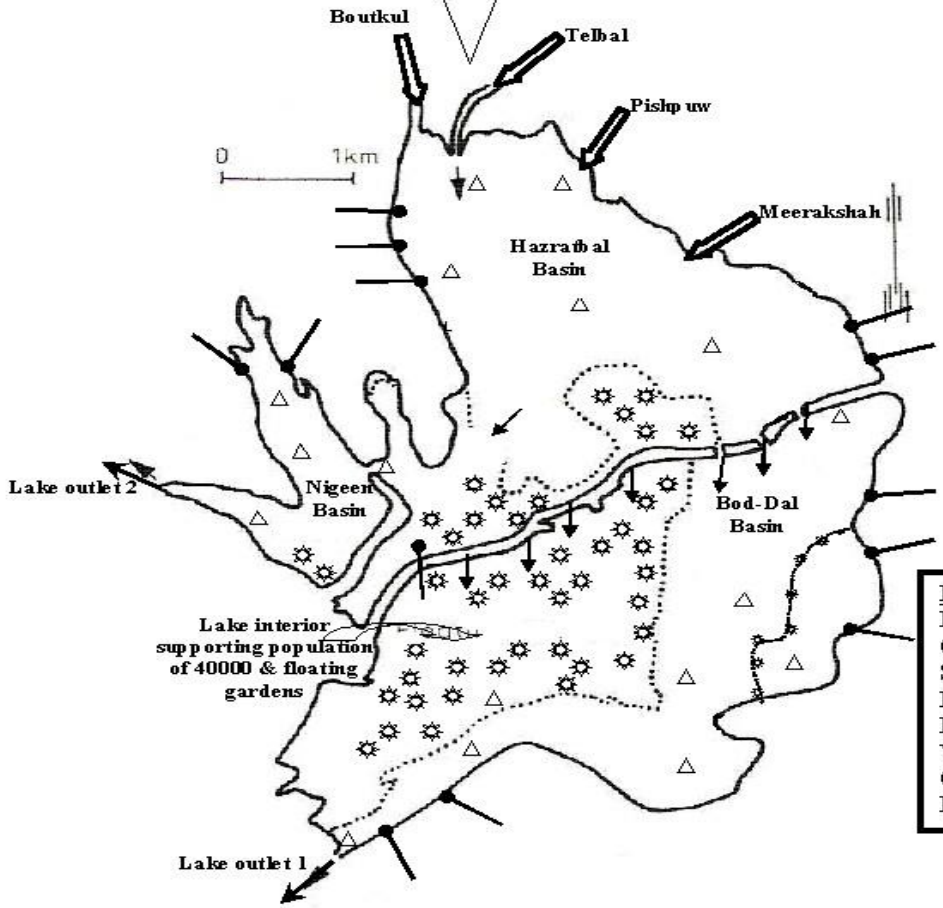
Eutrophication of the lakes in relation to Dal Lake *with emphasis on nutrient inputs*



Integrated drainage –Lake map



Drainage map source: (Survey of India) 1:50,000.



Legend

- Stream inputs
- Sewage inputs
- Water sampling sites
- Outlet sites
- Lake area under Cyanophyceae dominance
- Hydraulic connectivity between lake basins
- Floating garden areas

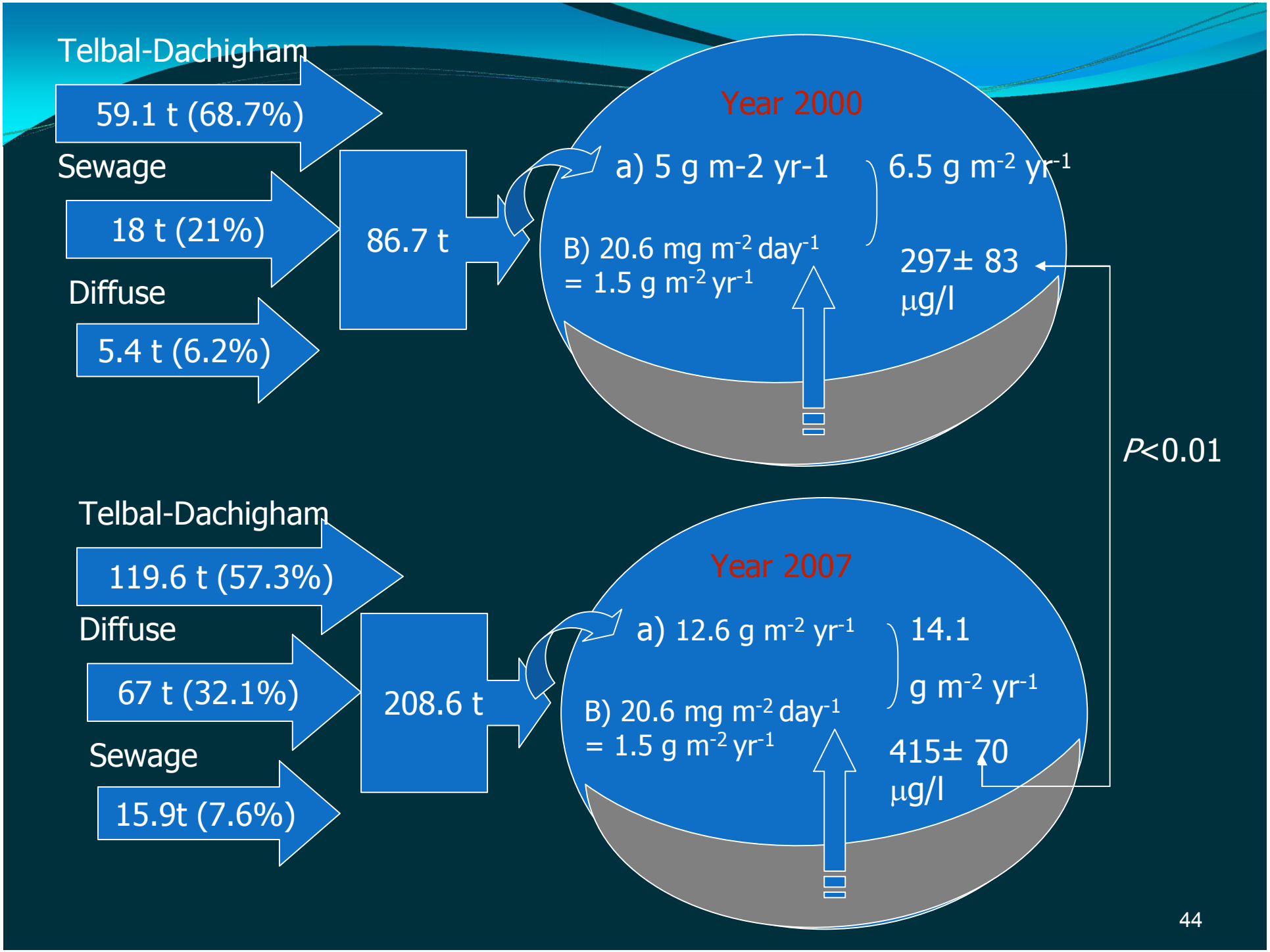
Morphometric features:

Elevation = 1581m
Coordinates = 34° 9" N74° 8" E
Surface area = 16.6 km^2
Maximum depth = 6.0m
Mean depth = 0.9m
Volume = 15.5 x 10^6 m^3
Catchment area = 337 km^2
Flushing rate = 10.8 volumes yr^{-1}

Areas of diffuse runoff

Water budget (annual)

- **Inflow** (x 10^6 m^3)
  - Streams = 248.3 (Telbal, Boutkul Meerakshah, and Pishpuw
  - Runoff = 43.8 (Lake Hill side, Srinagar Center, S. North)
  - Sewage = 6.6 (Mainly from old city areas)
  - Treated Sewage = 2.5 + 3.1* (STPs Hazratbal, Habak, and Laam. * Diverted after treatment at Brari-Numbal STP to River Jehlum)
  - Precipitation = 9.14 (Lake surface)
  - Ground water = 10.0 (Interpolated from inflows-outflows and storage change)
- **Outflow** (Mcm)
  - Exit gates = 274.5 *(Dal Exit, Nallah Amir Khan, and Brari Numbal)*
  - Evaporation = 14.8 *(Natural)*
  - Drinking water = 25.92 *(Nishat and Pokribal plants of PHE department)*
  - Irrigation = 0.54 *(Royal Springs Golf Course)*
- **Lake Volume** (Mcm)
  - Volume = 16.0
  - Volume added by dredging = 2.65 (16.5% of actual lake vol.)
  - Total volume = 18.6
- **Flushing rate and water loading**
  - Flushing rate = 14.5 (time per year)


Telbal-Dachigham
59.1 t (68.7%)
Sewage
18 t (21%)
Diffuse
5.4 t (6.2%)
86.7 t
Year 2000
a) 5 g m-2 yr-1
6.5 g m-2 yr-1
B) 20.6 mg m-2 day-1
= 1.5 g m-2 yr-1
297± 83
µg/l
P<0.01
Telbal-Dachigham
119.6 t (57.3%)
Diffuse
67 t (32.1%)
Sewage
15.9t (7.6%)
208.6 t
Year 2007
a) 12.6 g m-2 yr-1
14.1
g m-2 yr-1
B) 20.6 mg m-2 day-1
= 1.5 g m-2 yr-1
415± 70
µg/l

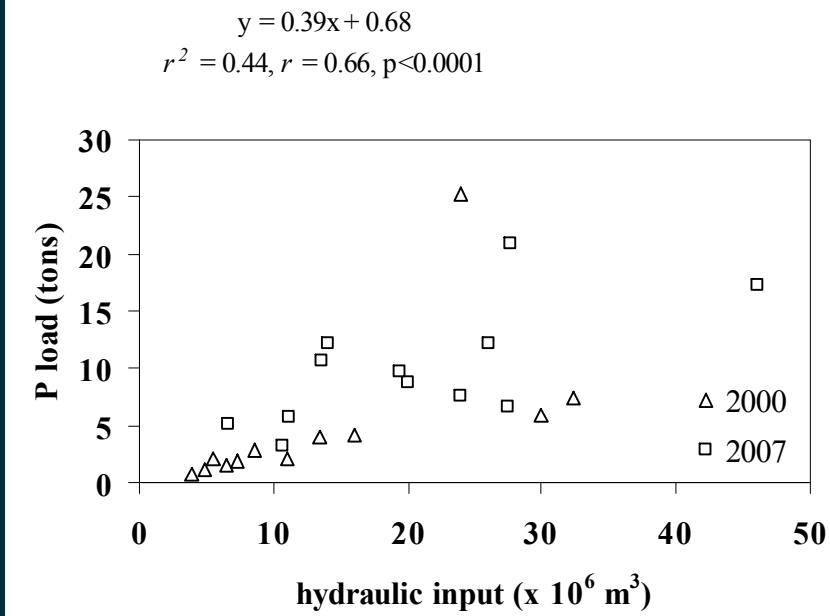
Watershed P loading

Telbal-Dachigham

- P conc. 2000 & 2007 (p>0.05), P conc. vs. discharge p>0.05
- P load 2000 = 59.1 tons
- P load 2007 = 119.6 tons

Two fold increase

P<0.05

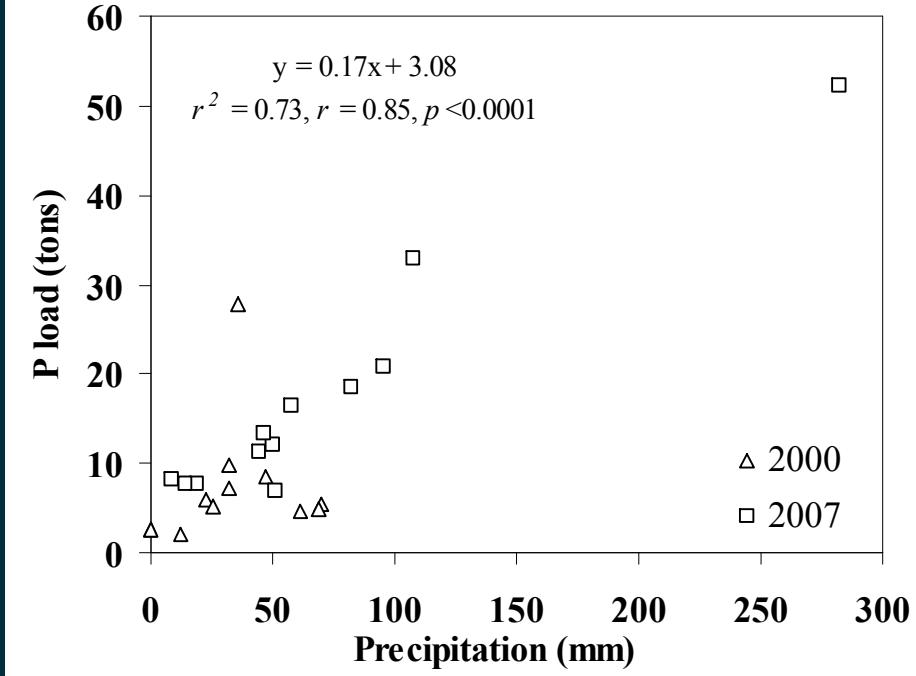


Urbanized catchments (S.C, S.N & LHS)

- P conc. 2000 & 2007 (p>0.05)
- P load 2000 = 5.4 tons
- P load 2007 = 67 tons

Manifold increase

P<0.05



Watershed Measures Adopted & Flaws

✓ Measures adopted

- Re-forestation
- Gully plugging, check dams, gabion check dams, and control of stream bank erosion by installing crate networks
- Urbanized catchments inhabiting a three lack people lack storm water runoff facilities and treatment- directly enters the lake

➢ Flaws

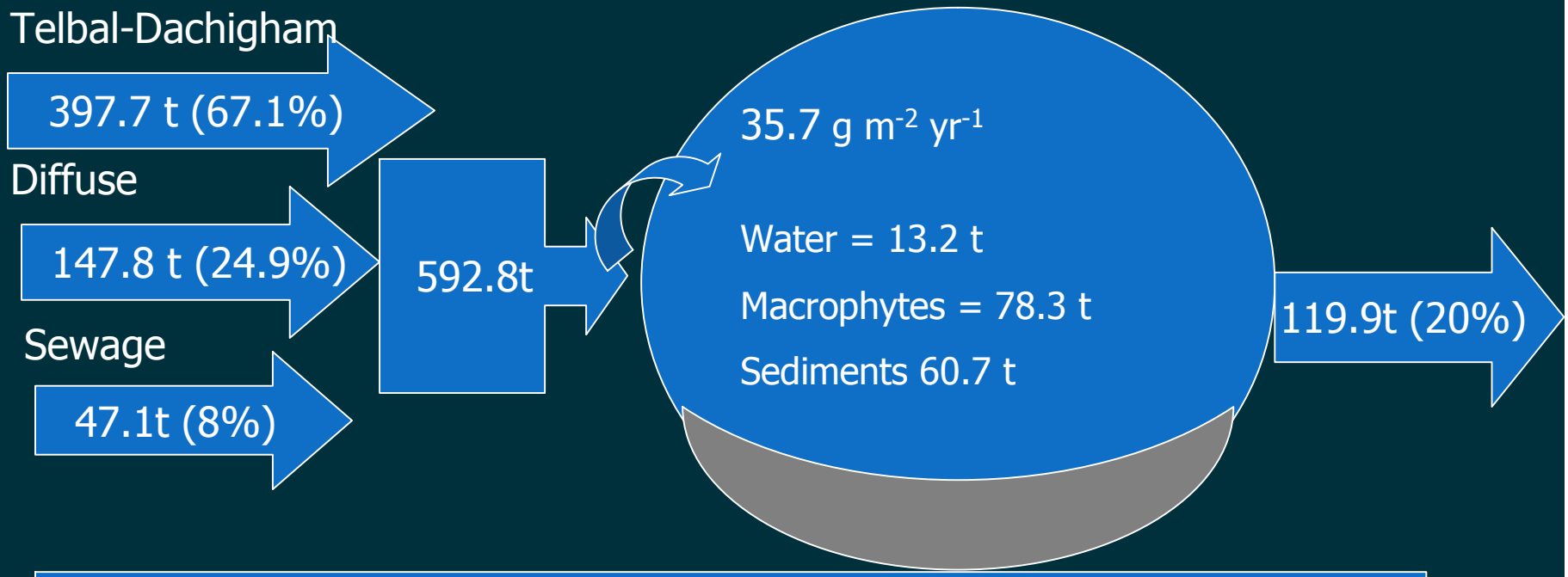
- 140 km² of Telbal-Dachigham catchment is barren landscape, which has not been touched
- Overgrazing continues
- Use of phosphate fertilizers continues
- Conversion of forested land for agriculture continues
- Pace of urbanization is quite rapid

- **Over the period of time the lake appears to be losing its capacity as a sink for P.**

✓ Phosphorus retention in 1981-82 = 33% (Ishaq & Kaul (1990)
✓ Phosphorus retention in 2000 = 27%
✓ Phosphorus retention in 2007 = 22%

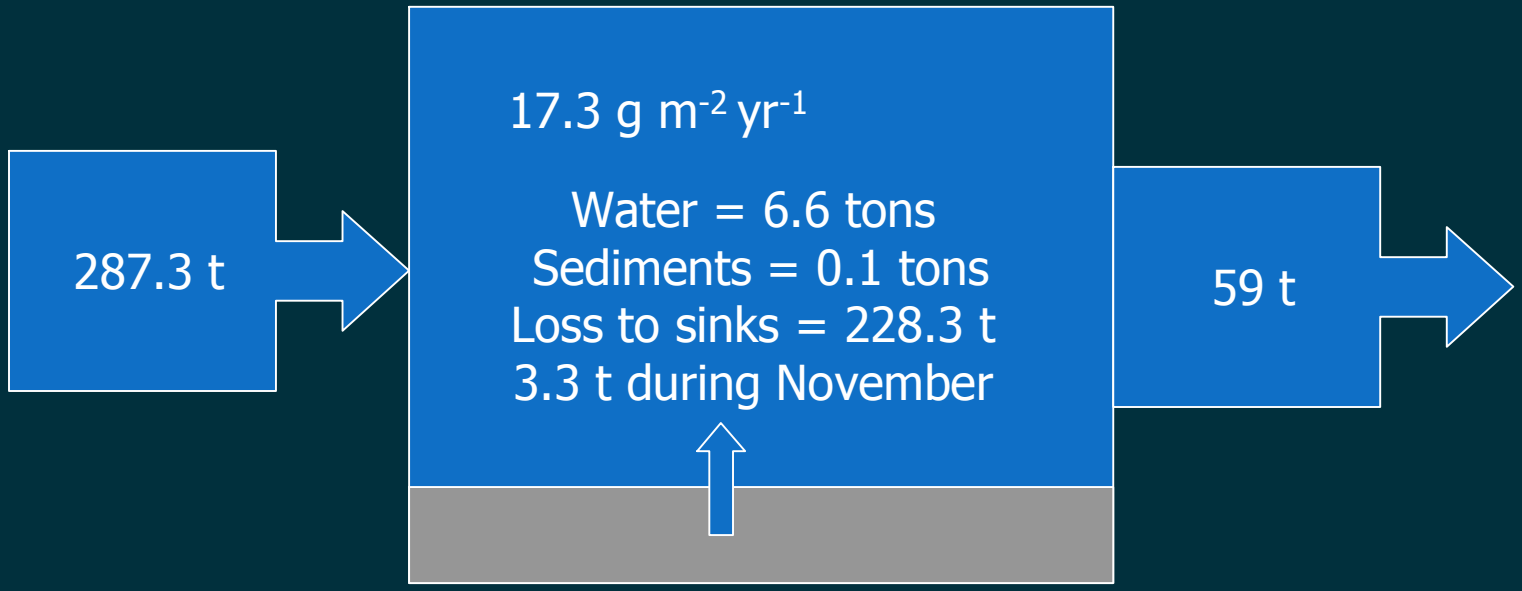
- P retention in the lake has decreased progressively.
- This clearly shows that the lake has by and largely lost the efficacy of P trapping.
- Historic anthropogenic pressures have left enough P reserves in the bottom sediments, which over time have started to get released, such that the lake is in the stage of transition from P-trapping to p-releasing.
- Gross internal P release rate are high = 20.6 mg m^{-2} day^{-1}

Nitrogen Budget



The nitrogen budget shows that a high percentage of the total nitrogen input is lost to sinks. The net sinks i.e. loss through uptake, atmospheric exchanges and also to some extent to sediments are a much more important elimination routes than outflow losses.

NO_3-N balance



During spring-summer period, 78 - 92% of NO_3-N load (9.1 g m-2 yr-1 i.e. 52.6% of total yearly loading) is either entrapped within the newly developing macrophyte tissues, or appears to get eliminated by virtue of temperature controlled microbial denitrification.

Influence of NO_3-N on internal P release

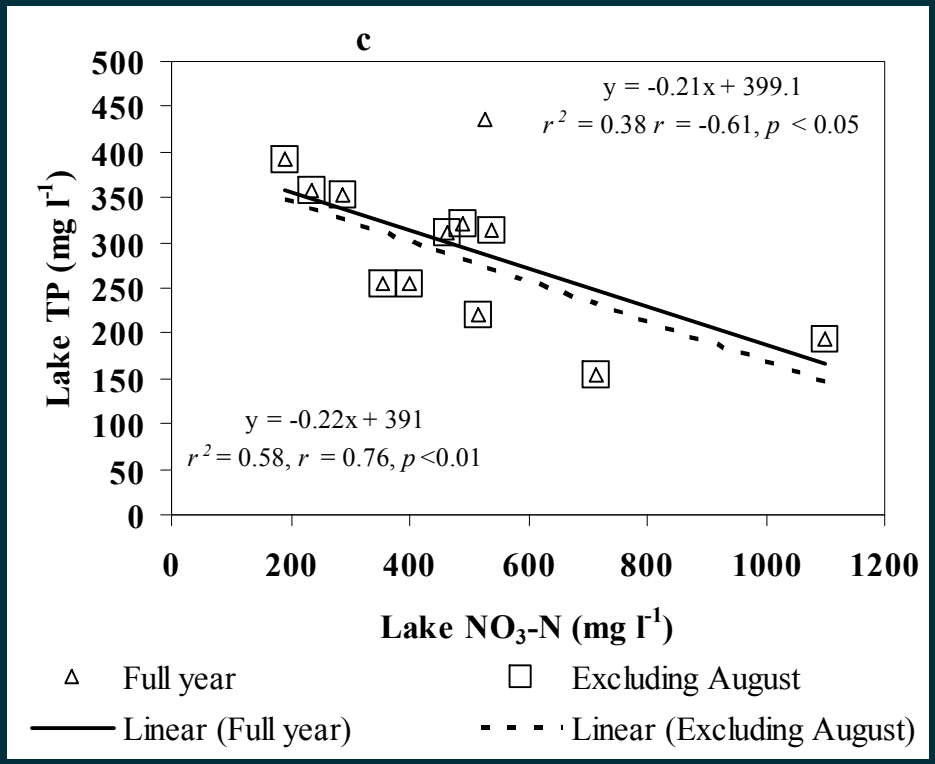
➢**Low levels of NO_3-N in the lake waters have been shown to influence the sediment P release (Ripl 1976; Andersen 1982; Boström *et al.* 1982; Jensen & Andersen 1992; Søndergaard *et al.* 2000). According to Boström *et al.* (1988) no P release seems to occur at a NO3-N supply of > 0.5 mg m^{-2} h^{-1}, while Andersen (1982) had reported P release in shallow polymictic Danish Lakes with NO_3-N < 500 µg l-1**

✓**NO_3-N supply in Dal Lake is much higher in magnitude of 0.5 mg m^{-2} h^{-1}**

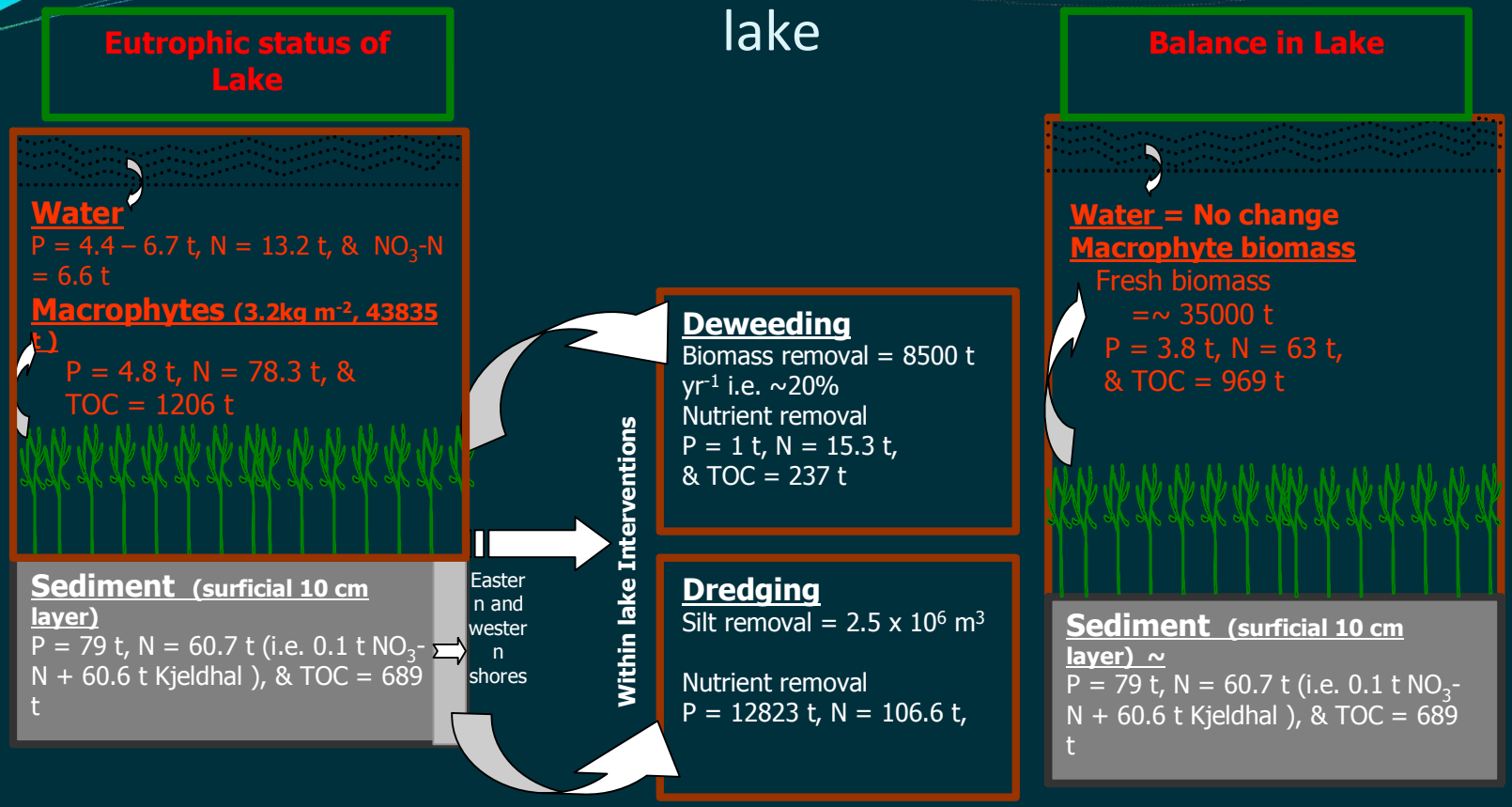
✓**Low NO_3-N of <500 µg l^{-1} during spring-summer periods result from denitrification and entrapment within macrophytes.**

✓**concurrent occurrence of NO_3-N minima and P maxima, and vice-versa observed in the lake.**

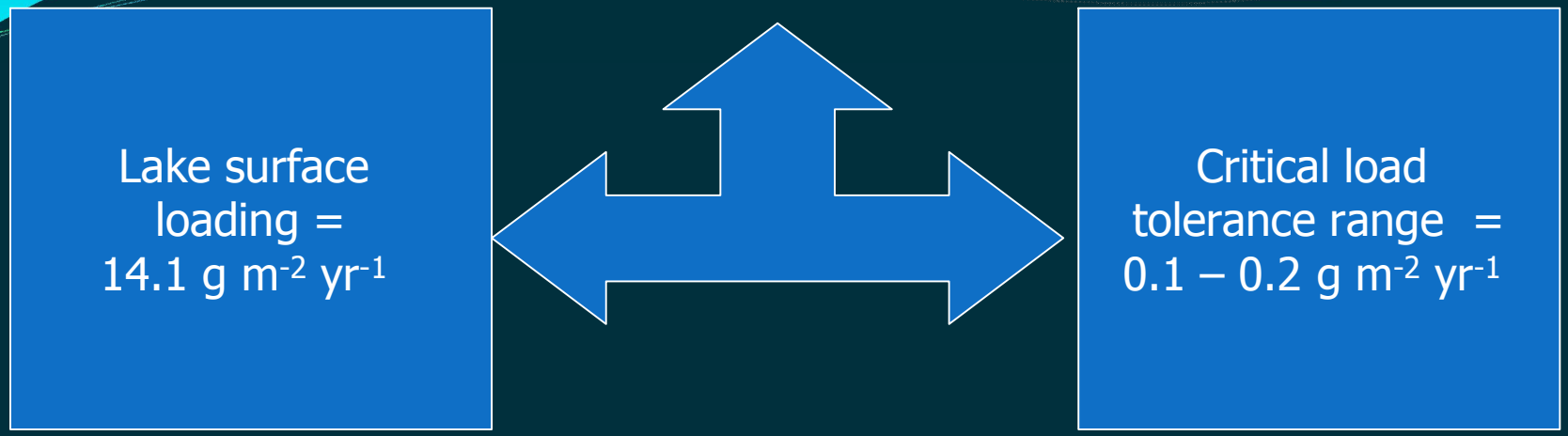
✓**In relation to NO_3-N minima, P maxima were observed during May, July, and September.**



Within lake interventions in relation to eutrophic status of the lake



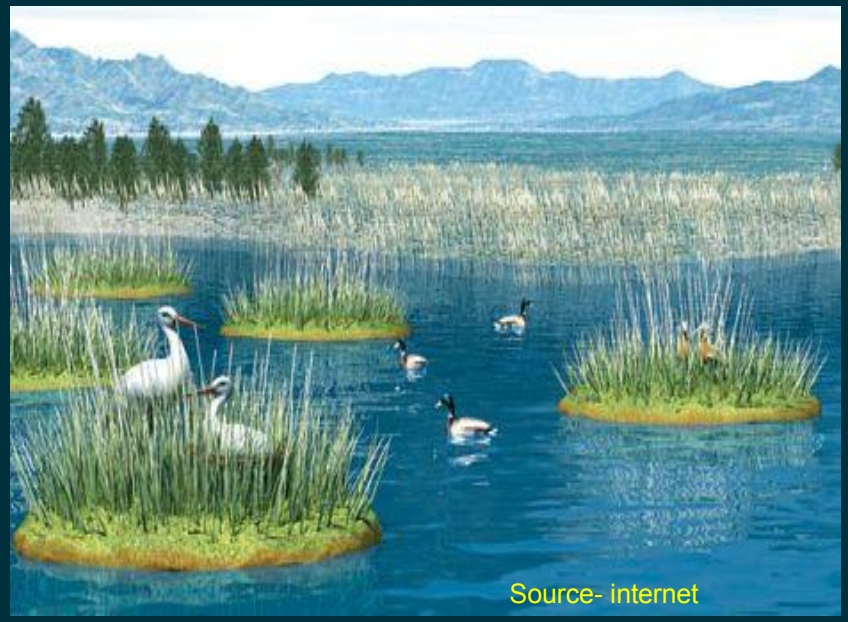
"FEED BACK" LOOP: Linking macrophyte nutrient and organic demands to nutrient and organic inputs from macrophyte decomposition and translocation, and dissolution from bottom sediments and translocation (*c.f.* Landers 1982; Engel 1988; Barko *et al.* 1991). Removal of ~ 20% of the standing macrophyte biomass from the lake still leaves a huge proportion in the lake to augment the enrichment of the bottom sediments with N, P and TOC, which in turn bring increase in biomass and regeneration potential through a feed back loop



- As the lake is gradually loosing the P trapping capacity, it is expected, that if significant reduction is not brought in external loadings, the internal loading with increase with time, which will further augment total P loading and the lake P concentrations.

Decisions of 2nd Scientific Advisory Committee

- Creation of artificial wetlands up-stream of the main feeding stream i.e. Telbal Nallah
- Creation of buffer zones along the eastern shores to sponge the diffuse runoff
- With this decision both point and non-point sources of pollution for the lake will be tackled



Regulatory standards and indices

- Lack of regulatory norms for discharge into the lakes – the present CPCB standards are for discharge of COD, BOD, TSS into the inland water bodies. - The definition of inland water bodies applies to wide range of water bodies including rivers and wetlands which have higher assimilative capacities as in comparison to lakes
- There are no standards for discharge of nitrogen and phosphorus into the lakes and rivers, which in addition to COD and BOD are the critical parameters of eutrophication
- Four categories A, B C and D type waters are classified primarily from drinking water point of view and not from eutrophication control.
- Lack of sanitary code or procedure
- Inspirations can be drawn from European water framework directive which encompasses both chemical and biological indices.

Thank You