Implementing Sewerage and Sewage Treatment Schemes in Developing Countries:
Lessons from Lake Nakuru, Kenya and the Bhoj Wetland, India

JICA
Integrated Basin Management for
Lake Environment Project

Outline

1. Introduction
2. Key Considerations
3. Bhoj Wetland Case Study
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5. Lessons Learned
6. Conclusion

1. Introduction: Why Sewerage Schemes?

- Pollution of lakes by sewage is a major problem
  - Pathogens cause waterborne diseases
  - Nutrients (N & P) cause eutrophication
  - Organic matter causes reduced DO
  - Industrial effluents contain toxic pollutants
- By implementing sewerage schemes the pollution problems can be addressed
- However, in general, sewerage schemes are implemented for public health protection rather than lake conservation *per se*

1. Introduction: Global Sanitation Situation

- More than 2.6 billion people (40% of global population) lack access to sanitation
- MDG target to halve, by 2010, the population without access to sanitation lags behind the target for access to safe water
  - High cost for sanitation provision
  - Low priority given to sanitation
- Low sanitation coverage in developing countries posses a big threat to lakes, especially small urban lakes

1. Introduction: Objective of this Paper

- To review the challenges of implementing sewerage systems in developing countries
- To draw lessons for the future

  - Based on case studies of two small urban lakes
    - Bhoj Wetland in India
    - Lake Nakuru in Kenya

2. Key Considerations: Wastewater Treatment Technology

- Four types of sewage treatment
  - On-site treatment
  - Conventional treatment
  - Advanced treatment (for N&P removal)
  - Treatment by natural systems
- Advanced treatment is very costly and therefore mainly applied in developed countries

2. Key Considerations: Cost of Wastewater Treatment

- Cost depends on treatment method and local circumstances
- Capital cost for conventional treatment in developing countries is prohibitively high and corresponds to a significant proportion of GNI
  - External financial assistance is needed
- While O&M costs for conventional treatment seem bearable, experience in many developing countries shows that allocation of funds for O&M is often a problem

2. Key Considerations: Cost Range for Wastewater Treatment Options

Economy (GNI/capita)[1]	Option	Capital Cost		Capital + O&M	
		US$/capita	%[4]	USD/capita/year	%[6]
Low-Income Economies (<USD765)	On-site sanitation	10 - 100	>7.2	3 - 10	>0.8
	Treatment plant[2]	20 - 80	>6.5	5 - 15	>1.3
	Sewer + treatment[2]	200 - 400	>39.2	10 - 40	>3.3
Middle-Income and Transitional Economies (USD765-9,385)	Treatment plant	60 – 80[2]	0.7 - 9.2	-	-
		30 – 50[3]	0.4 - 5.2	-	-
	Sewer + treatment	300 – 500[3]	4.3 - 52.3	30 – 60[5]	0.5 -5.9
Industrialized Countries (>USD9,385)	Treatment plant	150 – 300[2]	<2.4	-	-
		100 – 200[3]	<1.6	-	-
	Sewer + treatment	-	-	100 – 150[5]	<1.3

Notes

[1] GNI values based on World Bank (2006) data.

[2] For primary plus secondary treatment, for a capacity of 30,000 – 40,000 persons.

[3] For plant capacity for 100,000 – 250,000 persons.

[4] Capital cost in USD/capita as a percentage of GNI/capita.

[5] For industrialized countries, includes tertiary treatment and full sludge treatment; for other countries, includes basic secondary treatment.

[6] Total cost in USD/capita/year as a percentage of GNI/capita.

3. Bhoj Wetland: Introduction

- Located in Bhopal, the capital of Madhya Pradesh State of India
- Consists of Upper and Lower Lakes
- Both lakes are manmade (11th and 18th Cent.)
- Upper Lake provides 40% drinking water of Bhopal
- Designated Ramsar Site
- Problems and stresses
  - Inflow of sewage, solid waste, silt and nutrients, etc
  - Severe eutrophication, water hyacinth infestation, heavy metal pollution, sedimentation, water quality deterioration, etc

3. Bhoj Wetland: Outline of the Basin

Lake Sub-basin	Upper Lake	Lower Lake
Construction	11th Ce.	Late 18th Ce.
Surface Area	36 km^2	1.29 km^2
Drainage Basin Area	361 km^2	9.6 km^2
Volume	0.117 km^3	0.004 km^3
Maximum Depth	11.7 m	9.5 m
Average Depth	6 m	?
Population (Basin)	0.5 million	
Population (Bhopal City)	1.8 million	

3. Bhoj Wetland: Objectives of LBCMP

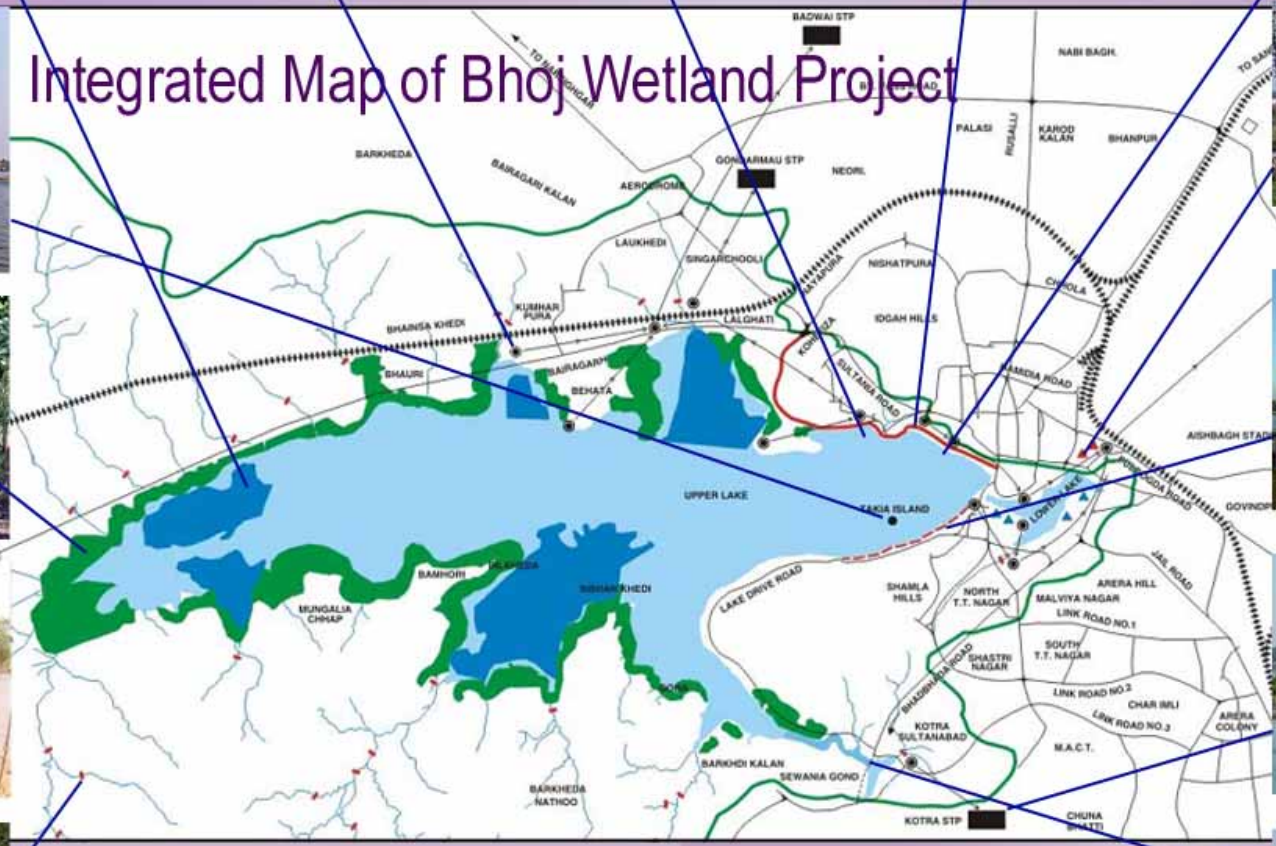
- Improvement of environmental conditions of Bhoj Wetland
- Improvement of water quality of the Upper and Lower Lakes

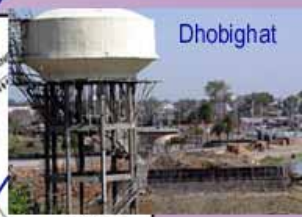
  - Conservation of the lakes
  - Improvement of overall health and living conditions

3. Bhoj Wetland: Outline of LBCMP

Item	Details
Total Cost	7,706 million Yen
Funding Agency	JBIC
Loan or Grant	Loan
Terms and Conditions	Interest rate: 2.6% Repayment period: 30 years (10 years grace period) General untied
Duration	February 1995 – June 2004
Major Components	1) Sewerage scheme (Largest component in terms of cost) 2) Desilting and dredging 3) Catchment area treatment (afforestation, gabions and silt traps) 4) Management of shoreline (construction of link road, solid waste management, relocation of washermen (dhobis) from lakeshore) 5) Management of water quality (deweeding, biological control of weeds, water quality monitoring and installation of aerators) 6) Public participation (awareness campaigns, Interpretation Center, organic farming)

3. Bhoj Wetland: Integrated Map of LBCMP





3. Bhoj Wetland: Sewerage Facilities of LBCMP


Interceptor sewerage


Open drain


SPH


STP

3. Bhoj Wetland: Status of LBCMP Sewerage Scheme

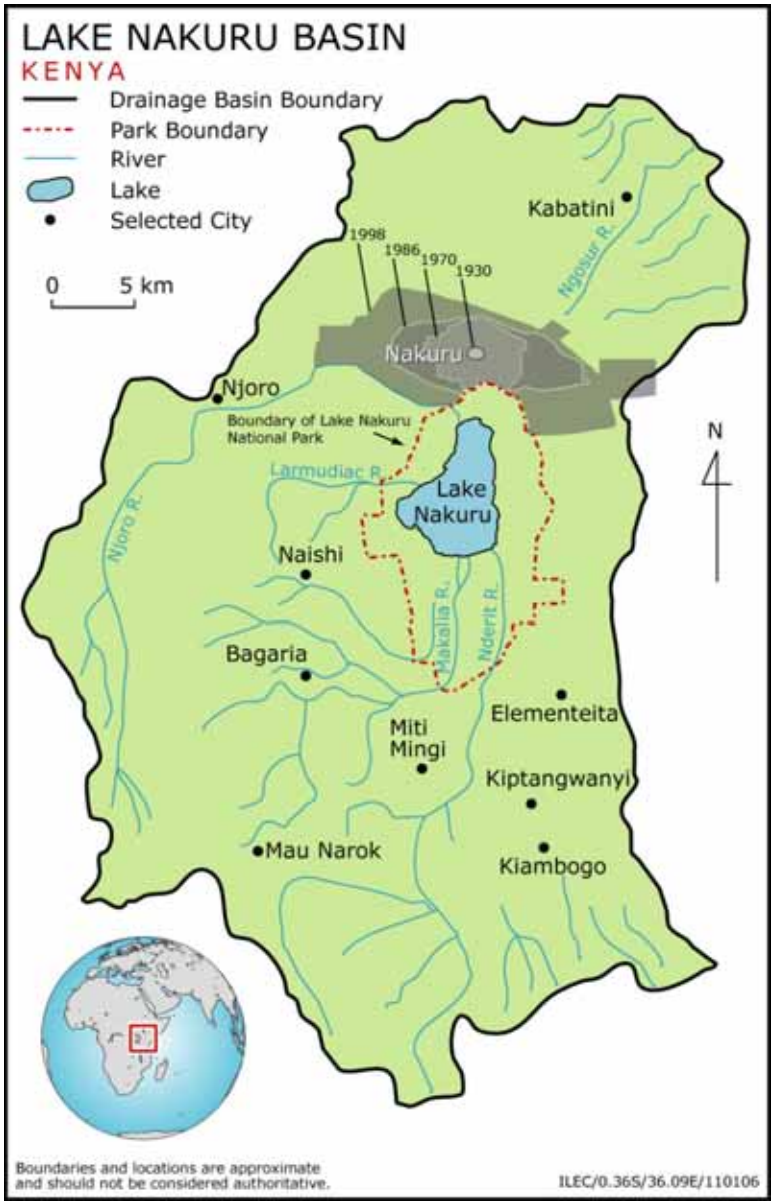
- Interceptor sewerage for 80 – 85% of the served population, piped sewer for the rest
- Sewage still flows to the lake especially in wet season
- STP capacity increased from 4,000 to 58,530 m^3/d
- However, only 25% of STP capacity is utilized
  - Low connectivity to piped sewer network
- Treated effluent quality meets STP design standard
- Sewage flow to STPs is projected to exceed available capacity in near future
- Inadequate budget allocation for O&M
  - Sewerage user fee is not charged

4. Lake Nakuru: Introduction

- Located in the Kenyan Rift Valley, with Nakuru Town lying in the basin
- Is a small shallow alkaline-saline lake
- Famous for lesser flamingos, a major tourist attraction
- Designated UNESCO World Heritage Site and Ramsar Site
- Problems
  - Water abstractions, deforestation, sewage, solid waste, agro-chemicals, heavy metals, sporadic flamingo deaths, etc

4. Lake Nakuru: Outline of the Basin

Surface Area	30 km^2
Drainage Basin Area	1,800 km^2
Volume	0.092 km^3
Maximum Depth	2.8 m
Average Depth	2.3 m
Population (Basin)	0.4 million
Population (Nakuru Municipality)	0.231 million



4. Lake Nakuru: Objectives of GNWSP & NSWREP

- Increase the water supply to Nakuru Municipality
- Prevent pollution of Lake Nakuru from increased sewage flow resulting from increased water supply

  - Improvement of overall health and living conditions
  - Conservation of Lake Nakuru, and important habitat for lesser flamingoes

4. Lake Nakuru: Outline of GNWSP & NSWREP

Item	Greater Nakuru Water Supply Project (GNWSP)	Nakuru Sewerage Works Rehabilitation and Expansion Project (NSWREP)
Total Cost	5,092 million Yen	2,804 million Yen
Funding Agency	JBIC	JICA
Loan or Grant	Loan	Grant
Terms and Conditions	Interest rate: 3.5% Repayment period: 30 years (10 years grace period) Partial untied	
Duration	October 1987 – October 1994	August 1994 - 1997
Major Components	1) Construction of new water intake, aqueduct, treatment, conveyance and distribution facilities 2) Rehabilitation of existing facilities (17,000 m^3/d additional capacity)	1) Refurbishment and expansion of existing STP (two locations with 9,200 m^3/d additional capacity) 2) Construction of a new rainwater detention pond 3) Refurbishment of pumping facilities 4) Construction and equipment of a water quality testing laboratory

4. Lake Nakuru: Flamingos & Sewerage Facilities

4. Lake Nakuru: Status of NSWREP Sewerage Scheme

- 45% of Municipality population is in service area
- 40% of population in service area is connected
- STP capacity increased from 7,000 to 16,200 m^3/d
- Only 56% of STP capacity is utilized
  - Low connectivity to piped sewer network
  - Low water usage due to water shortage
- Treated effluent quality meets STP design standard
- Sewage flow to STPs is projected to exceed available capacity in near future
- Inadequate budget allocation for O&M
  - Sewerage user fee unable to meet O&M cost

5. Lessons Learned (1/4)

- Prioritizing sewerage works
  - If long-term resource values of lakes are properly understood and taken into consideration in decision making, sewerage works for lake basin protection can receive high priority
  - While quantitative assessment of lake resource values is desirable for decision making, even qualitative assessment only may suffice

5. Lessons Learned (2/4)

- Financing capital costs
  - External financing for capital costs is critical to the implementation of sewerage projects
- Long-term planning
  - High costs of sewerage systems and rapid population growth call for a long-term approach in planning
- Connectivity to sewer network
  - Facilitation of individual connections to sewer network should be in-built in project design

5. Lessons Learned (3/4)

- Technology choice
  - Cost effective technologies are the most feasible in developing countries
- O&M
  - Budget allocation for O&M is often inadequate because of low priority accorded to sewerage
  - Sewerage user fee structures should aim at ensuring full cost recovery at least for O&M

5. Lessons Learned (4/4)

- Industrial wastewater and enforcement
  - Installation of industrial wastewater treatment facilities is necessary to meet the overall objective of pollution control of the lake environment
  - Strict enforcement of effluent discharge standards is necessary for industrial wastewater pollution control
- Monitoring and evaluation
  - Monitoring and evaluation should be included as important components of sewerage schemes
  - Assessment of total pollution load input to lakes is essential for evaluation of effectiveness of STPs

6. Conclusion

- Projected continuous population growth in developing countries implies that lack of sanitation will impact negatively on many lakes, especially urban lakes
- If long-term resource values of lakes are properly considered in the decision making process, installation of sewerage systems for lake conservation should receive high priority
- Continued external financial facilitation is essential to meet the sanitation challenge
- Financing mechanisms that ensure full cost recovery for O&M are needed for sustainability