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CHAPTER 4

WATER QUALITY CONTROL PLAN COMPONENT (1)

The Development Study on Environmental Conservation of Phewa Lake in Pokhara, Nepal

CHAPTER 4
WATER QUALITY MANAGEMENT PLAN COMPONENT (1)

4.1 BASIC POLICY

4.1.1 Issues Effects and Root Causes

Based on the current condition of water pollution in Phewa Lake, there are mainly four issues which need to be addressed in terms of deterioration of water quality. The justification of each issue in terms of impacts are assessed and presented in **Fig I-4.1** along with their root causes.

Spatial and temporal distribution of key pollutants (eg. TN, TP, Chl-a, Fecal coliform) over the Lake are the indicators, which explains deterioration of Lake water quality (refer **Fig I-4.2**).

For a particular location and period, the pollutant concentration in the lake is a function of runoff load from different generation sources. The algal bloom and the over growth of water hyacinth mat are mainly due to the increase in concentration of TN, TP, BOD and COD. The increasing trend of concentration of these pollutants indicate that growth rate of algal bloom & water hyacinth will be increased in future if countermeasures are not implemented.

4.1.2 Objectives of Water Quality Management Plan

The objectives of the water quality management plan are to (i) estimate runoff loads from pollution sources; (ii) formulate water quality management measure; (iii) assess impact of countermeasures in improving water quality of the Lake; and (iv) support & provide input to PLECC.

Photo 1: Growth of water hyacinth

Photo 2: Algal bloom in Lake

The impressions of local people indicate that people are fearful of swimming in the Lake as there are many complaints of itching soon after swimming. The excessive concentration of pathogenic bacteria and increase in TN, TP, and BOD could be the reason behind such phenomenon. The presence of bacteria causing such diseases are attributed through the concentration of fecal coliform.

The increasing trend of concentration of fecal coliform at different locations of Lake indicate the high susceptibility of Lake water to waterborne diseases in future if appropriate measures are not taken.

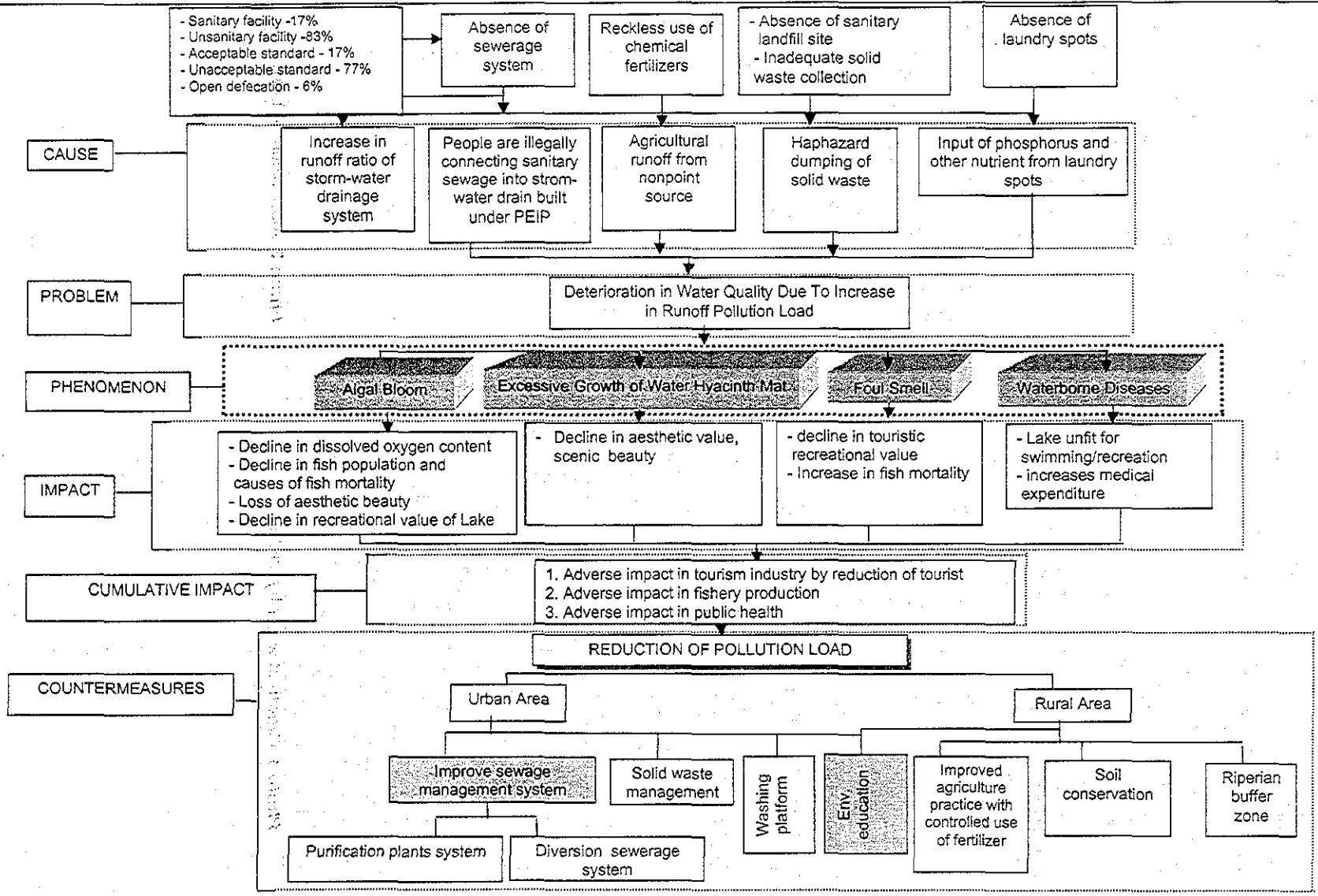
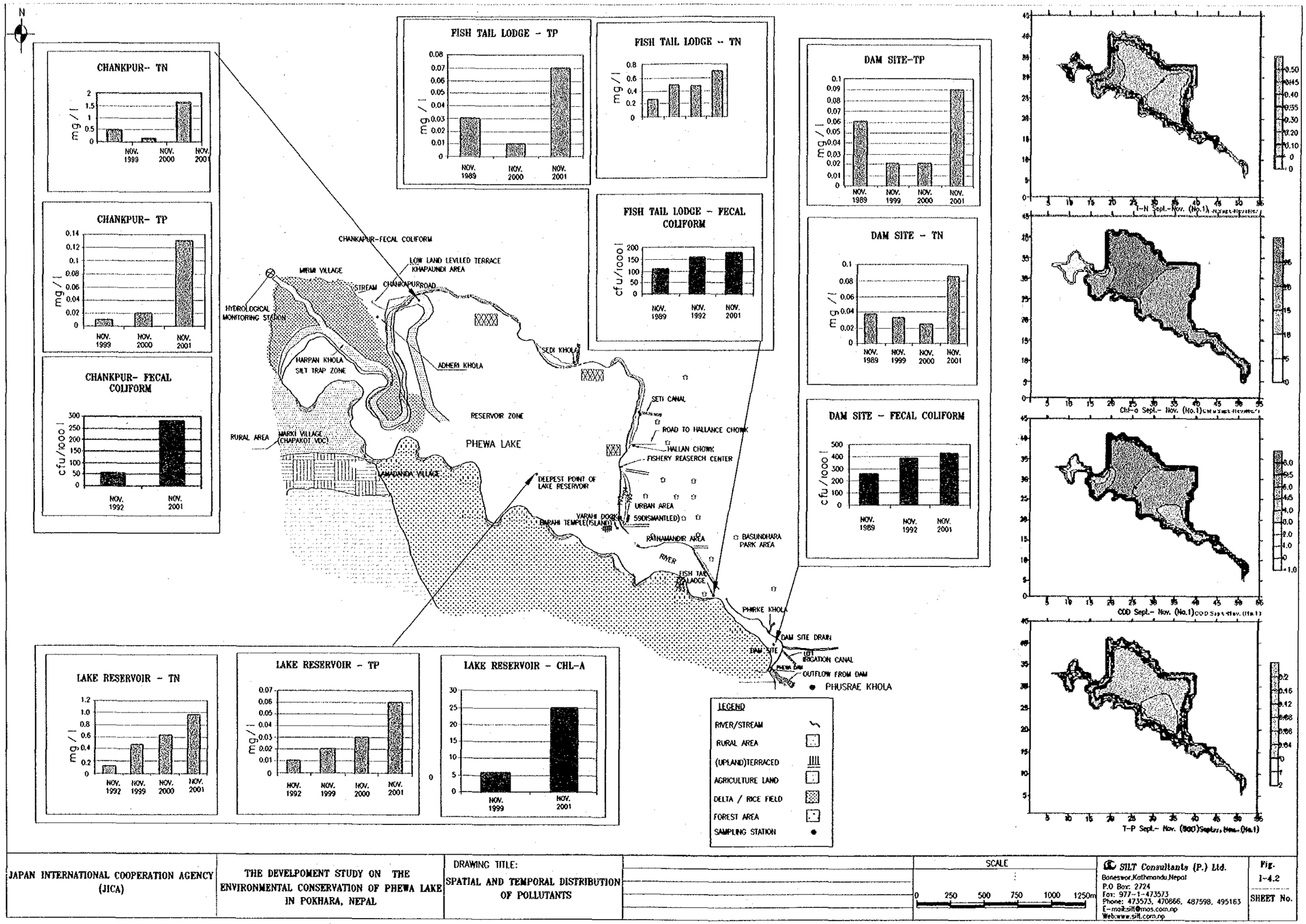


Fig I-4.1: Causes and Effects of Lake Water Quality Deterioration



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	THE DEVELPOMENT STUDY ON THE ENVIRONMENTAL CONSERVATION OF PHEWA LAKE IN POKHARA, NEPAL	DRAWING TITLE: SPATIAL AND TEMPORAL DISTRIBUTION OF POLLUTANTS		SCALE 0 250 500 750 1000 1250m	SILT Consultants (P.) Ltd. Baneswor,Kathmandu,Nepal P.O Box: 2724 Fax: 977-1-473573 Phone: 473573, 470866, 487598, 495163 E-mail:silt@mos.com.np Web:www.silt.com.np

Fig. 1-4.2

SHEET No.

Foul smelling in Lake is mainly due to the anaerobic decomposition generating Hydrogen Sulfide (H_2S) and Methane (CH_4) gases. Decline in Dissolved Oxygen (DO) and increase in BOD, COD are attributes for such processes.

4.1.3 Basic Policies of Water Quality Management

Based on the issues discussed above, basic policies for water quality management will be as following:

(a) Prevention of Pollution from Domestic Sewage

- As sewage contamination is especially high along the Damside and Lakeside areas, domestic wastewater from the service area within the Pokhara city that drain in the Lake must be treated before discharging in the Lake or disposed through sewerage system to safe location beyond the Lake.
- The method adopted to treat domestic wastewater must not only eliminate fecal and organic pollution but also significantly reduce nitrogen and phosphorous.
- Provision of washing platform of required numbers should be provided at Lakeshore area and effluent should be connected to sewer line ensuring that it does not enter the Lake.

(b) Prevention of Eutrophication

- Eutrophication is developing rapidly in the Eastern areas of the Lake. As this phenomenon spoils the merits of the Lake and is difficult and takes long time to remedy, its prevention must appear as an important issue in the water quality management plan.
- Countermeasures, which highly reduce the phosphorous level must be adopted, with an emphasis on countermeasures on domestic wastewater and nonpoint sources generating TN and TP.
- Countermeasures on nonpoint sources with high risks of phosphorous and sediment runoff must be implemented in priority.

(c) Establishment of Environmental Information System

- Environmental information are scattered between all the concerned institutions and not sufficiently shared. Moreover, the collected primary data are not used efficiently. To ensure that these information are properly shared, they should be organized into a database and distributed through a network to improve water quality management.
- In order to obtain the cooperation of related sectors, land owners and residents, information should be made available to the public through various events such as workshops advocating the importance of water quality conservation.

(d) Improvement of the Resident's Environmental Awareness

- Environmental education should be promoted in order to obtain the peoples participation in restoration and conservation activities for the water environment.

  As the people in the watershed are not very concerned about the water environment, environmental education should be promoted as a means to improve their awareness.

To accomplish the above mentioned objectives and basic policies for Water Quality Management, following steps are proposed to be taken:

(i) sort out the issues; (ii) examine main causes; (iii) decide the policies; (iv) assess the indicator; (v) assess likely impacts examine main causes; (vi) fit a simulation model; (vii) select the countermeasures; (viii) assess the impact of countermeasures (ix) examine the scope of countermeasures.

Fig. I-4.3 presents details flow chart of proposed water quality management plan.

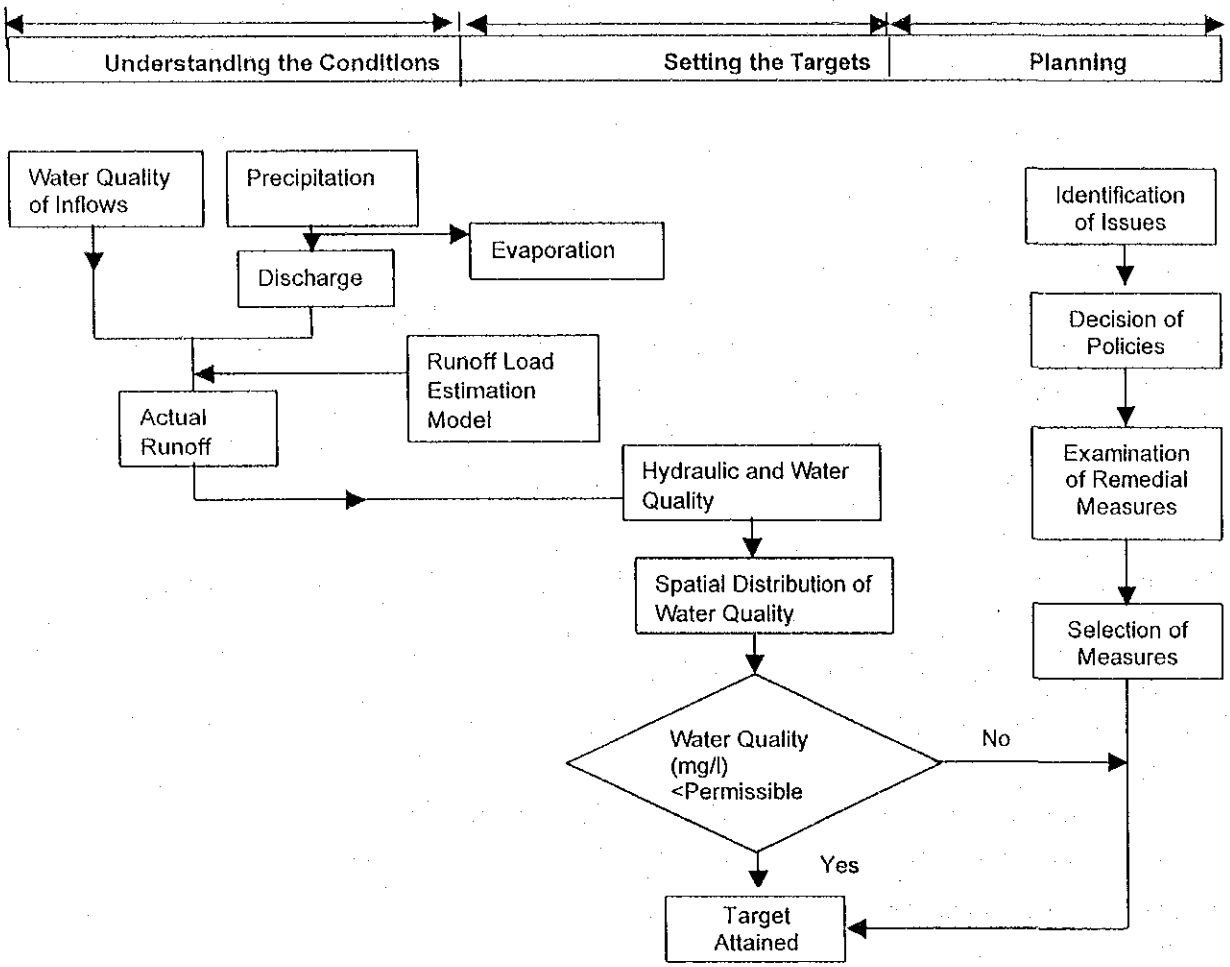


Fig I-4.3: Represent detail flow chart of proposed water quality management plan.

4.2 LOAD REDUCTION PLAN

4.2.1 Proposed Countermeasures

The annual run off loads (COD, TN & TP) from inflowing tributaries are shown in **Table I-4.1** and **Fig I-4.4**. The resulting spatial distribution of TN, TP, COD and Chl-a over the Lake during the months of September to November are presented in **Fig I-4.5** through **I-4.8**.

Table I-4.1: Inflow Loads of Various Tributaries of Phewa Lake

S. No	Inflow Points	Discharge m^3/s		COD		T-N (g/s)		T-P (g/s)	
		m^3/s	%	(g/s)	%	g/	%	(g/s)	%
1	Harpan Khola	6.15	73.3	10.8	61.1	4.45	52.1	0.97	43.9
2	Sedi Khola (1)	0.52	6.2	1.09	6.2	0.92	10.8	0.30	13.6
3	Sedi Khola (2)	0.52	6.2	1.09	6.2	0.92	10.8	0.30	13.6
4	Seti Canal	0.17	2	1.70	9.6	0.85	9.9	0.26	11.7
5	Phirke Khola	0.22	2.7	2.20	12.4	1.10	12.9	0.33	15
6	Forest Area (1)	0.40	4.8	0.40	2.3	0.15	1.75	0.024	1.1
7	Forest Area (2)	0.40	4.8	0.40	2.3	0.15	1.75	0.024	1.1
	Total	**8.38**	**100%**	**17.68**	**100**	**8.54**	**100**	**2.208**	100

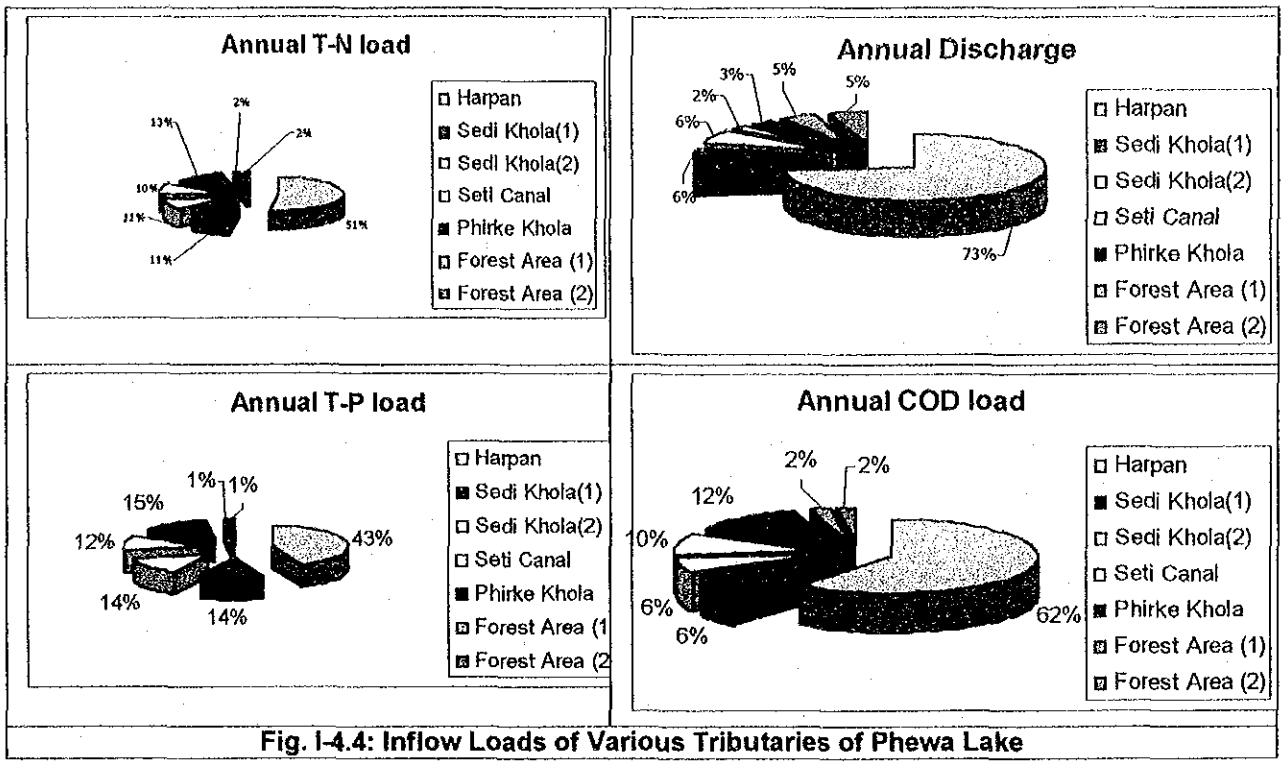


Fig. I-4.4: Inflow Loads of Various Tributaries of Phewa Lake

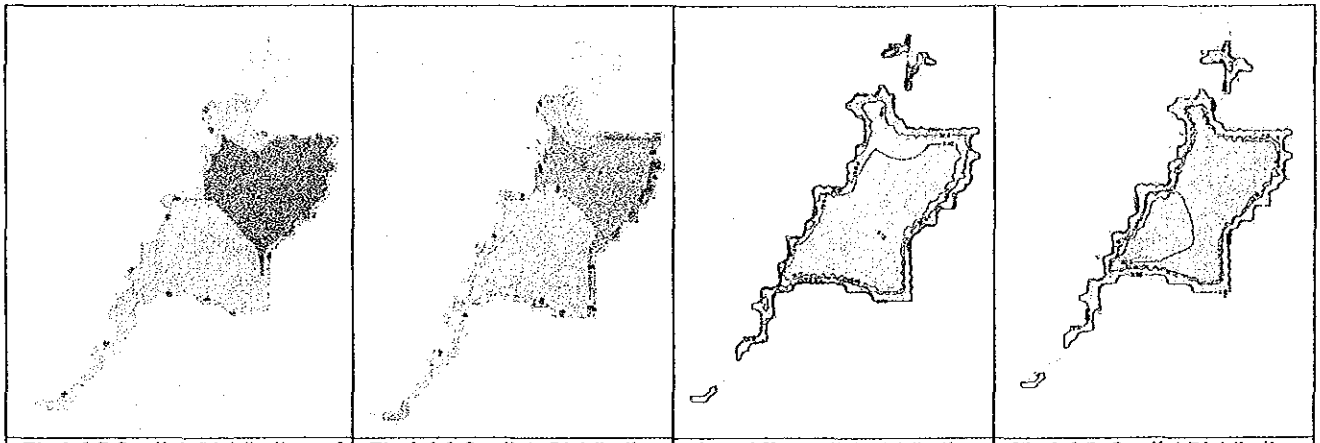


***Fig.I-4.5**:Spatial Distribution of Chl-a (Present Condition)*

***Fig.I-4.6**:Spatial Distribution of COD (Present Condition)*

***Fig.I-4.7**: Spatial Distribution of TN (Present Condition)*

***Fig.I-4.8**: Spatial Distribution of TP (Present Condition)*

The Present spatial distribution of pollutants clearly indicate that the water quality of the Lake is beyond the permissible standard in most part of the Lake resulting in algal bloom, excessive growth of water hyacinth, foul smell and outbreak of waterborne diseases. To tackle these issues, the outline of load reduction measures for water quality management plan of Phewa Lake has been developed and presented in **Fig. I-4.9**.

4.2.2 Examination of Load Reduction Measures

The system of load reduction measures for water quality management plan of Phewa Lake is presented in **Fig. I-4.10.**

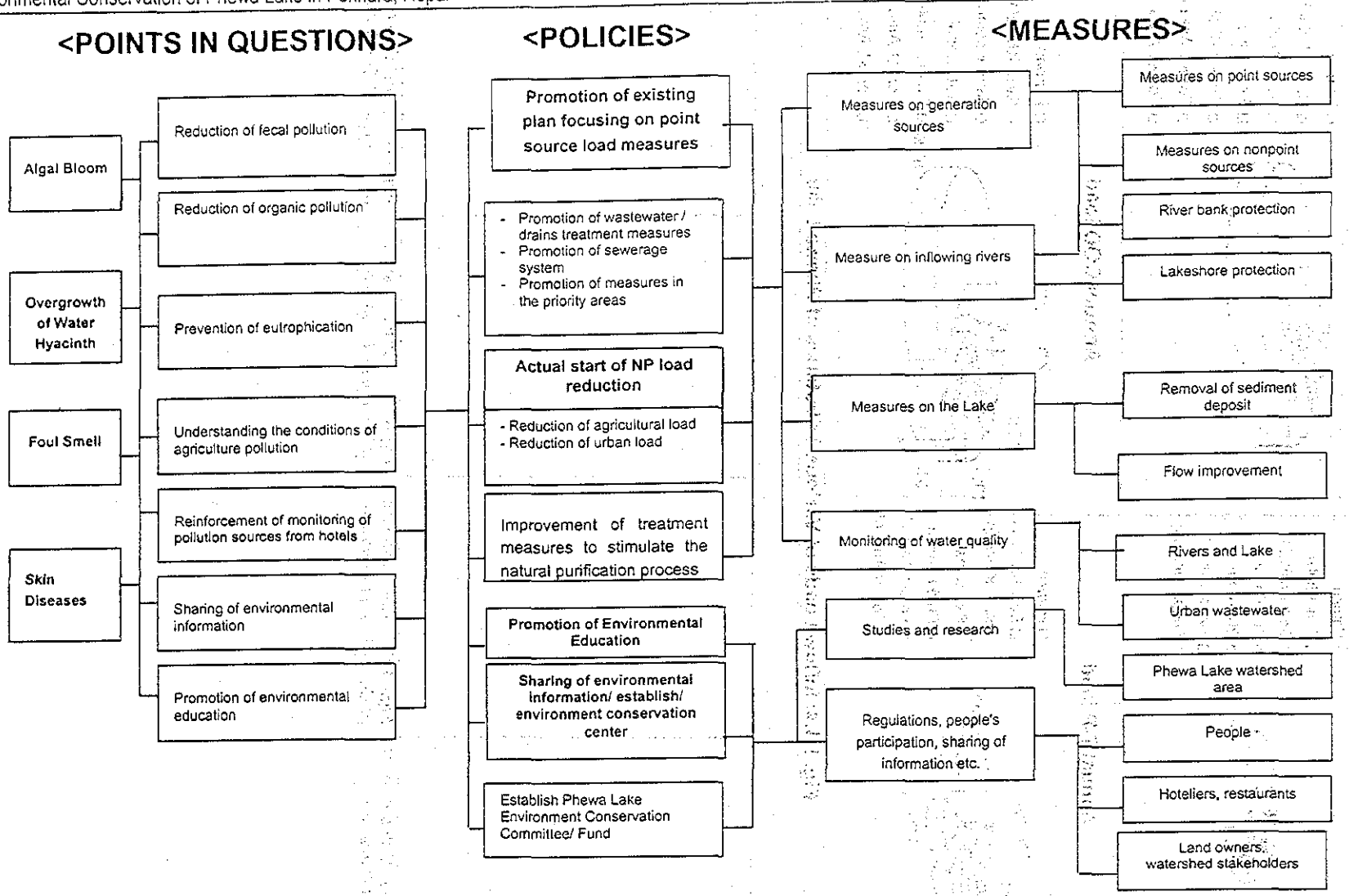


Fig. I-4.9: Outline of Load Reduction Measure for Phewa Lake

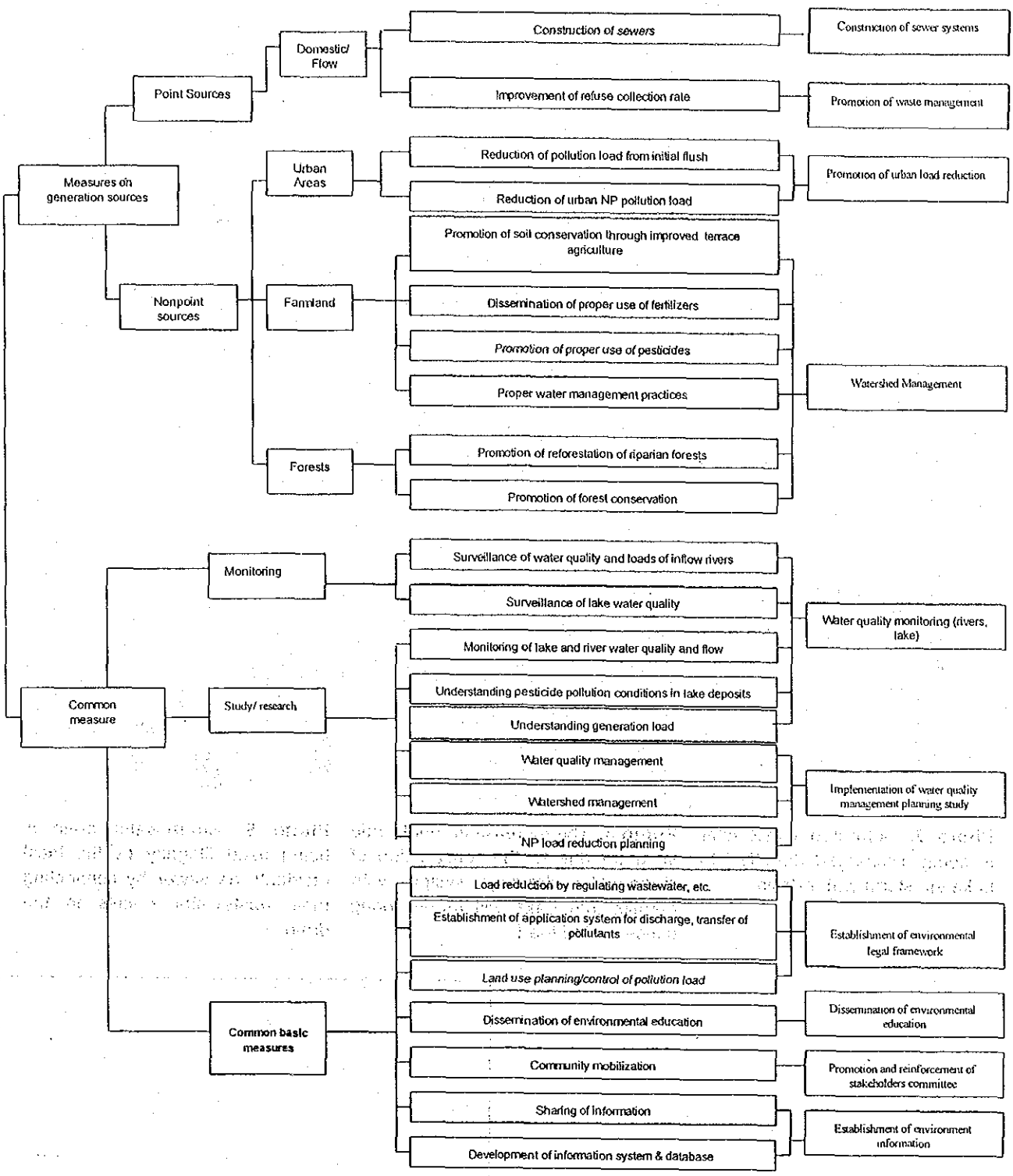


Fig. I-4.10: System of Load Reduction Measures

4.2.3 Load Reduction Measures Applicable to Phewa Lake

The countermeasures which are applicable for the reduction of loads in Phewa Lake in order to deal with issues mentioned in **Fig. I-4.9** are as follows:

(1) Load Reduction Measures for Point Sources

(a) Countermeasures for Domestic Load

- **Domestic Wastewater**

There is no domestic wastewater treatment facilities in the city. Most of this untreated wastewater is discharged directly into streams and canal, which finally discharge into the Lake. As a result, urban waterways and the Lakeshore are polluted by fecal coliform, which is unhygienic and prohibits recreational activities. Moreover, the construction of storm-water drain system which outfalls into the Lake has apparently increased the runoff ratio of the catchment. The residents and hoteliers have illegally connected their domestic wastewater outlets with high concentration of coliform and other organic substances into it. As a result, further deterioration of water quality near the urban side of the Lake has been observed leading to foul smell, algal bloom, excessive growth of water hyacinth and outbreak of waterborne diseases.

Thus, the main measure should be to prevent polluted water being discharged into the Lake. This can be achieved by either treating the stream/urban drain wastewater before discharging into the Lake, or divert their flow away and discharge it beyond the Lake through construction of a sewerage system.

In the former option of treatment system, the seepage flow from open-bottomed septic tanks into the Lake can not be avoided.

Photo 3: Untreated wastewater is being discharged directly into Lake via storm-water drain.

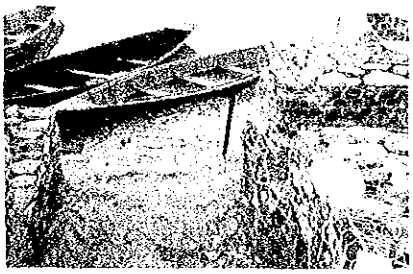


Photo 4: The increase in runoff ratio in future due to the construction of storm-water drainage system with outfalls into Lake will further bring concentrated load.

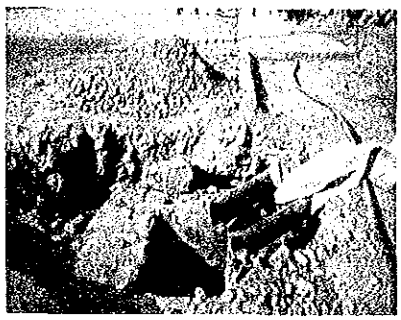


Photo 5: Storm-water drain is being used illegally by the local residents as sewer by connecting their wastewater outlets in the drain.

- **Domestic Solid Waste**

Refuse scattered in the city not only become part of the inflow load towards Lake but also hinder the flow of streams/canals and is detrimental to the sanitary urban environment. Moreover, when it rains, solid waste flows with rainwater into the Lake. It is therefore important to implement appropriate solid waste management system as part of the management of the Lake water quality.

Photo 6: Solid waste and sedimentation in Phewa Lake at the inlet point of Seti Canal

(2) Load Reduction Measures for Nonpoint Sources

As more than 80% of pollution loads flowing into Phewa Lake originate at nonpoint sources, measures to reduce these loads are crucial. The present nonpoint load countermeasures must be planned as per land

uses such as urban areas, farmlands and forests and will therefore be covered in water quality management plan.

(a) Countermeasures for Urban Nonpoint Loads

As loads discharged from urban areas account for a large portion, an efficient measure to control the runoff load from urban areas would be to treat initial surge containing large amount of pollutants. Therefore, the construction of partially combined type of sewerage system along with diversion of Phirke Khola discharge during such surge is one of the most appropriate solution. In addition, to reduce the pollution load from urban areas, improvement of collection/ disposal rate of urban solid waste also needs to be controlled.

(b) Countermeasure for Agricultural Nonpoint Loads

Since the loads discharged from cultivated land account for a large portion of nonpoint source runoff loads, countermeasures for agricultural loads are crucial. The introduction and dissemination of environmental protection oriented agriculture, which takes into account soil runoff prevention through terrace farming and related soil conservation activities like water source protection, conservation ponds construction, landslide & gullies treatments, trail improvement works, irrigation canal improvement works, riparian buffer strips, Lakeshore buffer strips etc. needs to be planned. Such measures reduces the loads of both N and P from upland crops. The plan also includes the provision of guidance on proper management of fertilizers and appropriate use of pesticides in order to reduce the amounts of pesticides and fertilizers used for cultivation. For areas highly susceptible to soil runoff, the plan will include the introduction of vegetative methods, and micro-watershed management plan to attain runoff peak-cut.

Photo 7: Phirke Khola draining into the Lake carrying wastewater, sewage and garbage from most part of Pokhara city.

(c) Countermeasures for Load from Forest Land

Woodlands often become sources of nonpoint runoff loads due to illegal felling of trees. The plan needs to include promotion of reforestation and appropriate forest management in order to reduce nonpoint runoff load from woodlands.

The plan for reduction of nonpoint source loads is also related to the "environmental conservation oriented sustainable agriculture promotion program", a sub-program of the watershed management plan described in **Chapter 7** of **Part I** of this Report.

These two plans should be formulated in close cooperation. Soil runoff not only incurs a drop in land productivity but also carries N, P and water pollutants and plays a role in raising riverbeds and filling Lake with sediment.

(d) Countermeasures for Inflowing Rivers

Regarding the polluted Phirke Khola and Seti Canal flowing through the urban area, the plan should include either treating their discharge before flowing into the Lake or diversion of their flow beyond the Lake through a sewerage system. Also, riverbank erosion treatment and construction of embankment needs to be planned for section of the waterways showing significant bank erosion and flooding.

(e) Countermeasures for the Lake Bottom Improvement

The Plan should look into feasibility of Lake sediment removal measures, such as dredging in the sediment trap zone and wetland paddy field area of the Lake.

Table I-4.2: Examination of Methods of Load Reduction Measures

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Watershed
Generation Sources	Point sources	Domestic	▪ Prefab type river/urban drain treatment system ▪ Construction of trunk sewer (with primary sewage treatment) and diversion system	- Reduction of load through oxidation - Diverting fecal pollution load from domestic wastewater and disposing it to safe location resulting in reduction of organic pollution, N&P	▪ High O/M cost, land acquisition is necessary, 100% reduction in load is not possible ▪ There should be enough space for the construction of primary treatment (grit chamber etc.) ▪ Many apurtenent structures are required for topography like Pokhara valley ▪ Availability of safe outfall & water bodies for natural dilution	Introduce in model site
	Nonpoint source (Best management practices)	Urban areas	Reduction of pollution load from initial surge in urban areas	Reduction of loads in urban areas by constructing partially combined sewerage system	▪ Strategic location of street inlets basins must be identified ▪ Appropriate numbers of catch pits are required	▪ Highly applicable
			Improvement of refuse collection rate	Reduction of load from scattered refuse in urban areas	▪ Environmental education for the residents must be improved ▪ Slow results	▪ applicable
		Farmland	Promotion of standard soil conservation activities already practiced in farmlands of Nepal	Reduction of runoff load through soil conservation measures in farmlands	▪ Introduction of measures for farmland on slopes over 10^0 ▪ Incentives must be created for farmers	▪ First, introduction in model areas
			Dissemination of appropriate use of fertilizers (reduction of doses, etc.)	Reduction of runoff load through promotion and dissemination of low quantities of chemical fertilizers	▪ Incentives for farmers and dissemination of environmental education are necessary	▪ Introduction in model areas
			Promotion of proper use of pesticides	Reduction of pesticide load by banning toxic agricultural chemicals and disseminating proper use of pesticides		
			Promotion and guidance on proper water management in paddy fields	Control of runoff load from excess water by proper water management in paddy field		
			Introduction of cash crop as substitute to paddy	Reduction in hazard due to subsurface water subsequently reducing runoff load		
		Forest	Promotion of reforestation along stream banks	Reduction of runoff load by promoting reforestation along stream banks	▪ This will be useful not only for runoff load reduction but also for habitat conservation	▪ Possible to introduce together with habitat conservation
			Promotion of forest conservation	Reduction of runoff load by protecting forests in the watershed	▪ This will contribute to stabilizing water sources	▪ Possible to introduce in combination with environmental education (reforestation)

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Watershed
Runoff	Runoff counter-measures	River banks, lakeshore	Reduction of nonpoint source loads from riverbanks and reservoirs	Reduction of runoff load by setting riparian buffer zones which prevent soil erosion	▪ Results are difficult to quantify	▪ Highly applicable
		Reservoir protection	Reduction of pollution load from reservoir protections	Reduction of runoff load by growing vegetation on bank/shore protections with severe soil erosion		
Lake	Lake counter-measures	Sediments	Reduction of elution load from the lake bottom by removing sediments	Reduction of N and P elution loads from the bottom mud through bottom dredging or removal of lake bottom sediments	▪ Reducing inflow load through water treatment and other measures is a precondition ▪ Large funds will be necessary for the removal of bottom sediments	Secondary priority
		Lake counter measures	Pollutants	Dilution of stagnated polluted zone of lake by diverting excess water from Harpan Khola	Reduction of concentration of pollutant by dilution	High implementation cost
Monitoring	Monitoring	Rivers	Observation of inflow water quality/load by monitoring inflowing rivers	Observation of water quality/load and toxic substances flowing into lake by monitoring inflowing rivers	▪ It will be necessary to set up a monitoring system, and to secure the necessary funds ▪ Load reductions are not directly linked	▪ The establishment of a monitoring system (standardization etc.) will allow the implementation or efficient load reduction measures
		Lakes	Observation of Lake water quality through monitoring	Observation of water quality conditions by monitoring the lake		
Studies and Research	Studies and research	Basic studies	Study on generation load per unit production	Understanding domestic and other generation loads per unit production	▪ Determination of values which are indispensable for rational planning ▪ Large funds and efforts are necessary for this study	▪ This is possible by cooperating with university research organs and securing study expenses, and if it is implemented according to a plan
			Study on pesticide pollution	Understanding the conditions of pesticide pollution	▪ Large funds are necessary for the analysis of pesticide pollution ▪ Although analysis need not be carried out often, many study items are necessary	

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Watershed
			Water quality monitoring of Phewa Lake and tributaries	Monitoring to understand the pollution conditions and mechanisms (loads) of Phewa Lake	▪ It will be necessary to analyze the monitoring results carried out in past and to sort out the required items ▪ Observation of flow and water quality of inflowing and outflowing rivers will be necessary	▪ This measure can be implemented by proposed PLECC in coordination with fisheries research centre which is already monitoring the water quality at Phewa Lake
Others	Social foundations (improvement of regulations, environmental education, peoples participation, information sharing, utilization of social capital)	Improvement of environmental laws and regulations	Regulations on effluents and loads, guidance	Reduction of effluent loads by regulating effluent loads and creating rules for hoteliers and residents	▪ Even when making regulations, the key is whether they are respected	▪ This is possible if a monitoring system is created and if penalties are imposed
		Land use planning	Formulation of a land use plan that would allow low runoff of pollution loads			
		Environmental education, staff trainings	Dissemination of environmental education	Reduction of pollution load through the dissemination of environmental education	▪ Though the effects will be slow, this will be effective in the long run ▪ Secondary effects can be expected	▪ This is possible by cooperating with environmental NGOs
		Sharing of environmental information	Reinforcement of the functions of the conservation committee	Conservation of lake water quality by reinforcing the functions of the committee	▪ The effects will be slow but this countermeasure will be indispensable for future water quality management of lake and for people's participation in water quality management	▪ There is already a conservation committee formed for Phewa Lake
			Sharing of information on lake conservation countermeasures	More efficient lake conservation countermeasures through making related study and research information available to people, researchers, etc	▪ This will contribute to the implementation of more effective and efficient environmental conservation countermeasures ▪ The cooperation of concerned institutions and necessary funds will have to be obtained ▪ The cooperation of residents, businesses and research institutions will be indispensable	▪ Phewa Lake Conservation Center with Phewa Lake Homepage will assist to attain it.

4.3 TARGET REDUCTION LOAD

4.3.1 Permissible Inflow Load and Target Reduction Load

The permissible inflow load is defined here as " inflow load which can be assimilated in the Lake while sustaining good water quality". It is considered that the permissible inflow load is equivalent to the permissible runoff load, and the excess of the current inflow load over the permissible inflow load is the target reduction load at this stage.

The target reduction load is therefore, the amount of load that must be reduced from the current load in order to reach the water quality standard for Phewa Lake as presented in **Table II-3.1** in **Chapter 3** of **Part II** of this Report.

Prediction of spatial distribution of pollutant concentration in the Lake is function of runoff loads from catchment. The mixing mechanism of inflow loads into Lake depends on many parameters and is complex in itself. A numerical simulation model is therefore most important for predicting permissible runoff load at various sensitive inflow points in the Lake.

With the help of simulation model developed for this purpose, the present (existing) distribution of pollutants are predicted using present runoff loads from various tributaries.

The spatial distribution of pollutants predicted by the model clearly indicate that the water quality of the Lake is beyond the permissible standard in most part of the Lake. Model runs with various combination of inflow loads resulting in the distribution of water quality to the required standard in the Lake is thus necessary. The optimum inflow loads estimated through this process is termed as permissible inflow load.

For the purpose of this Study, the simulation runs were, however, carried out only to examine the spatial distribution of pollutants during dry season for cases (i) after 20% reduction in inflowing load by means of a purification plant system and (ii) after 100% reduction in inflowing load by means of diversion sewerage system.

The simulation results show that the diversion canal system measure brings water quality of most part of Lake to permissible standard (refer **Fig I-4.11**).

The simulation results also shows that either of the countermeasures viz. purification plant system and diversion sewerage system could reduce the water quality at North-Western stagnant portion of the Lake (at around Sedi and Khapaundi area) to permissible level. There are two approaches to tackle this situation.

(1) Determine permissible inflow loads from Harpan Khola, Sedi Khola (1) & Sedi Khola (2) with the help of simulation model and implement appropriate watershed management measure to arrive at that load.

(2) Divert the excess flow of Harpan Khola during dry season to that zone in order to allow dilution of pollutants as well as generate some level of current in the portion of the Lake.

In this Study, emphasis has been given to approach 2, as the impact of such countermeasure is immediate.

4.3.2 Evaluation and Selection of Reduction Measures and Estimation of the Scope of the Countermeasures

The load reduction measures for point sources and nonpoint sources that are applicable and should be promoted in the watershed, were selected, compared and evaluated (as presented in **Table I-4.3**).

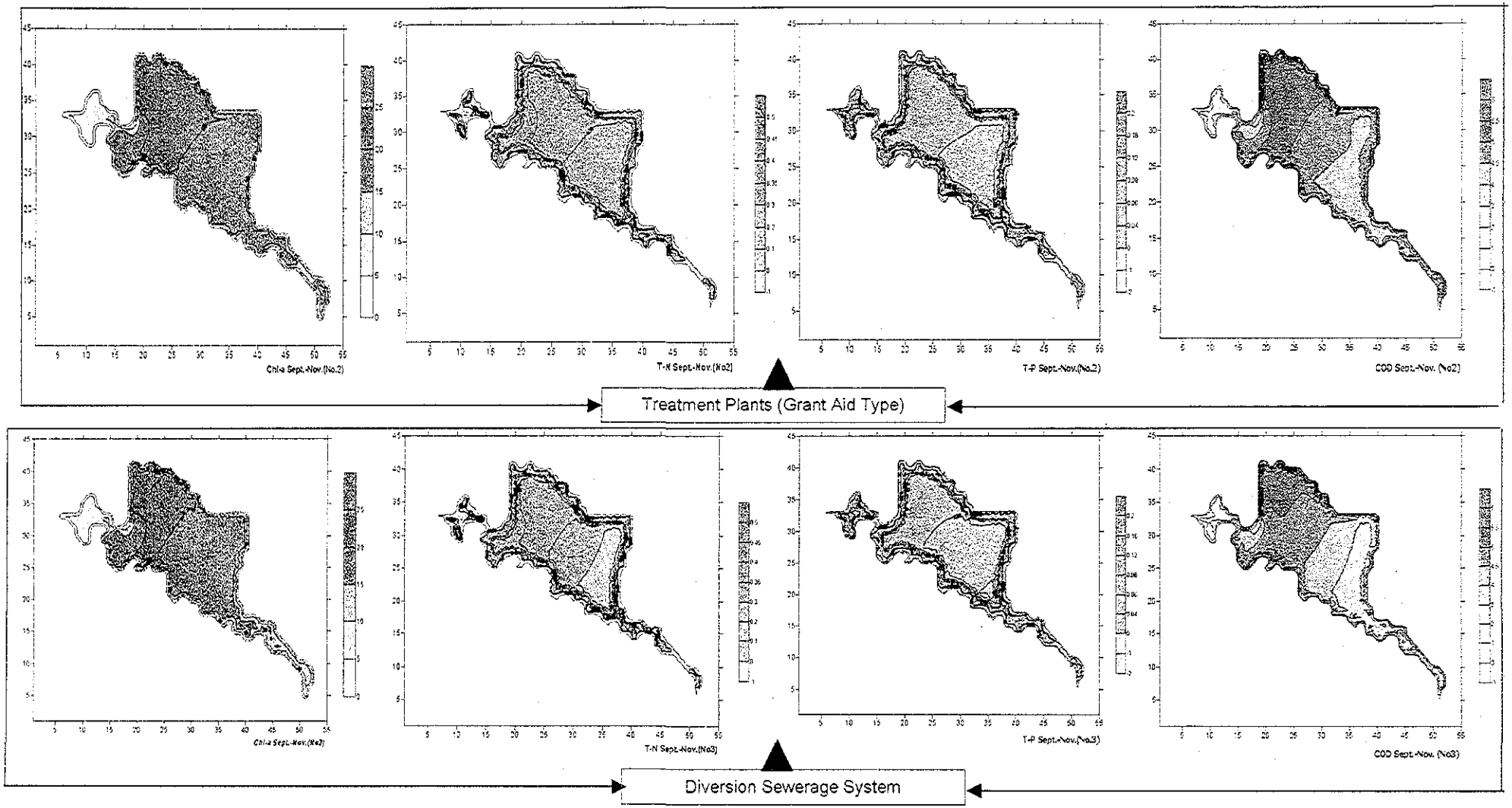


Fig. I-4.11: Lake Water Quality Forecast from Simulation Result after Technical Intervention

Table I-4.3: Comparison and Evaluation of Load Reduction Measures

Classification	Category	Counter measures	Load Reduction Rate (%)					Evaluation Items					General Evaluation	Measures Adopted in this study
			BOD	TN	TP	TSS	Load Reduction Effect	Cost effectiveness	Effectiveness	Local Suitability	Technical Ease	Impact on Environment		
Domestic Wastewater	Septic tank		65			65	Δ	•	O	O	•	◎	Δ	•
Urban Wastewater		Better waste collection rate	20-28	3.6	1.7	25-40	O	O	O	O	O	O	O	O
Agricultural Wastewater	Upland crop	Reduced tillage systems (on farm cosnervation)		55	45	75	O	O	Δ	O	O	O	O	O
		Terrace systems		20	70	85	O	Δ	Δ	Δ	O	O	O	O
		Filter strip (Grassland)		70	70	65	O	O	Δ	O	O	O	O	O
		Riparian buffer strip (width: 4.1m)		4.0	28.5	61	◎	O	O	O	O	O	O	O
		Riparian buffer strip (width: 9.2 m)		22.7	24.2	74.6	◎	O	O	O	O	O	O	O
	Paddy	Controlled drainage	90	90	80	90	◎	O	O	O	O	O	◎	O

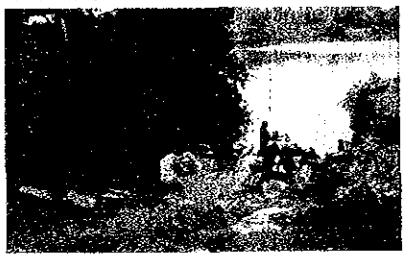
Note: ◎ Excellent, O Fair, Δ Good, • Poor

4.4 PRIORITY PROJECT

(1) **Title:** Establishment of Alternative Laundry Site to check pollution load in Phewa Lake due to laundry washing

Objectives :

1. To check phosphorus related pollution load from soap and detergent into Phewa Lake by existing uncontrolled laundry practices in Lake shore.
2. To provide convenient laundry sites with a provision of drainage into trunk sewer line.
3. To upgrade proposed alternative laundry sites at Pardi area beyond dam site.



Public laundry spot at Damside, Lake Phewa

Justification:

- With respect to chronic shortage of domestic water supply in Pokhara Sub-metropolis and cost free convenient access to open water body of Phewa Lake, there has been traditional practice of laundry, bathing activity in the Lake for a long time. The view deck near Hallan chowk has been misused as a laundry spot. To check pollution load and maintain aesthetic beauty, alternative laundry is most essential from long term social need perspective.
- Due to increase in urbanization, population growth and increase in number of hotels, the trend of using Lake water for laundry is on increase. In absence of proper alternative, cloth washing in the Lake will not abate.
- An estimated input of 100 kg soap and detergent goes in to the Phewa Lake in daily basis assisting in rapid eutrophication of the Lake.

The view deck at Hallan Chowk for tourist has been misused as laundry spot.

- Lately, local people are having laundry activity by boat at middle of the Lake as a result of algal growth and solid waste disposal on Lakeshore area. This indicate an alarming situation and needs to be mitigated.
- Due to laxity in enforcement of ban on laundry activity in Lake proper and inadequate construction of proposed alternate laundry site at Pardi area, below dam site; there exist urgent need to establish some laundry spots to maintain water quality of touristically important Lake through community based collaborative management approach.
- Washed clothes should not be allowed to be dried at the Lakeshore areas.

Proposed Activity:

- Construction of alternate laundry site with overhead tank and Lake water pumping facility connected with taps.
- The discharge of laundry washing should not be allowed into the Lake and instead, should be connected to the sewer line proposed to be constructed (see attached design).
- Completion of on-going work of alternate laundry site at Pardi, Damside.
- Establish a system of cost benefit sharing by local community/ hoteliers or beneficiaries to run the laundry sites in financially self-sustained way.

Location : Lake side, Hallan Chowk, Damsite, Pardi, Birauta Chowk area.

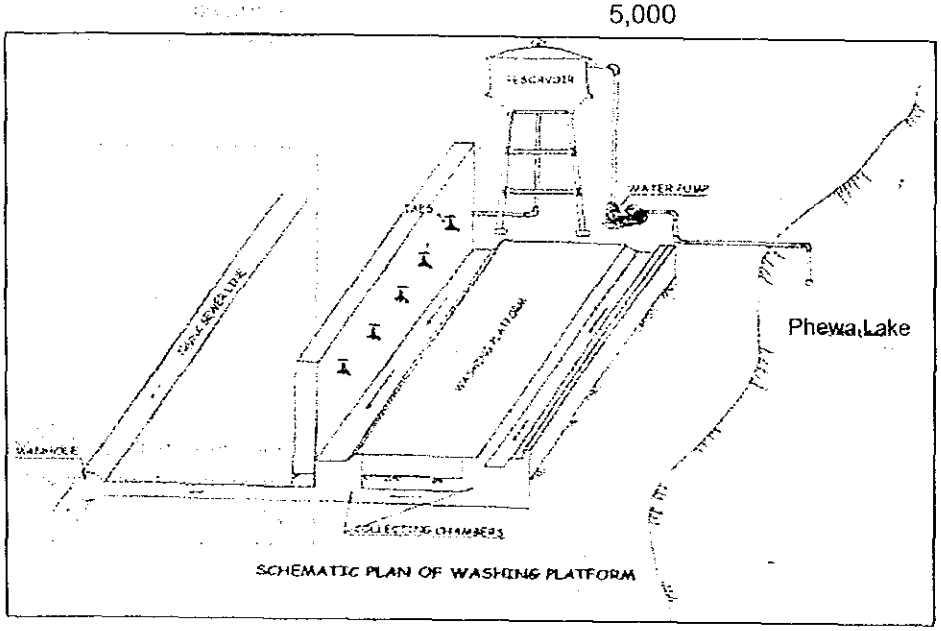
Duration: 3 years

Responsible Agency:

- PSMC, PLECC

Budget Estimate:

Particular	Est. Cost NRs. (,000)
Construction of laundry platforms 4 Nos.	- 1,400
Drainage works	- 500
Construction of overhead tank facility	- 2,000
Plumbing, hardware incl. water pump,	- 1,000
O/M cost (initial)	- 100
	5,000



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CHAPTER 5

SEWERAGE SYSTEM PLAN COMPONENT (2)

The Development Study on Environmental Conservation of Phewa Lake in Pokhara, Nepal

CHAPTER 5
SEWERAGE SYSTEM PLAN COMPONENT (2)

5.1 BASIC POLICY

5.1.1 Background

Phewa Lake has been highly polluted due to the direct discharge of streams, canal and urban drain with high pollutant load into the Lake. The open bottom septic tank constructed by the household at the Lakeshore area has also contributed in Lake water pollution through sub-surface flow of pollution load from their bottom and sides. The recently constructed storm-water drains have also become the point source of Lake water pollution, which is illegally connected with wastewater from the households, hotels and restaurants. These drains will further aggravate the Lake water quality during dry months.

As a result of these, the pollution of Lake water has reached at a threatening level and requires immediate measures to restrict the pollution load from entering in the Lake, particularly from the urban area.

In order to conserve the Lake through proper management of sewage generated in urban watershed of the Lake, various alternatives have been examined in greater depth during the course of this Study. These are:

- prefab type of small treatment plant for treating polluted stream, particularly Phirke Khola and other urban drains, as requested by HMGN for Grant Aid from Government of Japan (GOJ);
- floating type lake water purifier as requested by HMGN for Grant Aid from GOJ; and
- construction of a diversion type of gravity sewerage system for carrying all the wastewater and sewage generated at the urban watershed area of the Lake and discharge it beyond the Lake after treatment.

The qualitative and quantitative analysis on above alternatives has indicated the option of gravity type sewerage system with tunnel to be most viable, efficient, cost effective and sustainable one (refer **Chapter 2** of **Part II** of this Report).

5.1.2 Objectives of the Sewerage System Plan

The objective of sewerage system plan is to control the pollution load flowing in the Lake by appropriately managing the inflowing urban drains, highly polluted streams and seepage from septic tanks such that water quality of Lake is largely enhanced and its recreational and aesthetic value is restored.

5.1.3 Basic Policies for Sewerage System Plan

In order to achieve the above objectives, the following policies have been considered:

(1) Maximum Utilization of Existing Sewers and Storm-Water Drains

Currently, there does not exist any sewerage system in Pokhara city with treatment facilities. The local open drains and unsanitary open-bottomed septic tanks are mostly used for disposing the wastewater and sewage. However, there are some storm-water drains and sewers covering core city area. The PEIP

constructed storm-water drains has also been recently constructed, part of which flows into Phewa Lake. The planning and designing of the proposed sewerage system should be made in such a way that the existing infrastructures related to sewers are optimally used.

(2) Target Year

The planning of the proposed sewerage system should be done considering its design life span of 25 years. The volume of wastewater and sewage up to the design life of the sewerage system should be estimated considering the growth rate of population within the service area. The storm-water of the area, however, should not be accounted for design of sewer system considering that the recently constructed storm-water drains by Pokhara Environment Improvement Project will be optimally used over this period.

(3) Wastewater Treatment Method

The wastewater from the sewerage system should be sufficiently treated before discharging into any natural stream, so as to protect the latter's environmental status. Thus, a treatment system that is sufficient to reduce the pollution load to permissible level should be used. It may encompass mechanized means or other simple natural methods of treatment based on cost, efficiency and sustainability.

(4) Target Lake Water Quality after Diversion

The target Lake water quality after diversion should be limited to the maximum efficiency of diversion of pollution load by the proposed system. Though principally the reduction rate of pollution from urban point sources will be 100 %, only 90% reduction in pollution load inflow in the Lake from urban area should be considered as 10 % pollution load may be contributed from nonpoint sources even after construction of diversion sewerage system.

(5) Recovery of Construction Cost

In order to achieve the recovery of the investment, the beneficiaries should be charged against the services rendered. For cooperation and active participation of the beneficiaries in collection of service charge, promotion of environmental education and awareness should be given equal importance.

5.2 BASIC CONCEPT OF SEWERAGE SYSTEM FOR SERVICE AREA

(1) Overall Planning

The overall planning covers collection and diversion of wastewater through closed conduit and dispose it beyond the Lake after natural treatment. This includes the construction of a trunk sewer line along the eastern urban Lake shore of Phewa with the capacity to accommodate

- low flow of highly polluted Seti Canal (up to 100 lps),
- low flow of highly polluted Phirke Khola (up to 200 lps), and
- household and municipal wastewater and sewage generated in the service area.

A provision of diversion structure across Phirke Khola have been envisaged to allow only low flow discharge with high pollution load (above threshold limit) into the proposed sewer system. In high flow (monsoon), when pollution load is within threshold limit due to dilution, the discharge of Phirke will be allowed to flow into the Lake. The total population served by the proposed sewer system is 49,561 at year 2001. In addition to residential household, service area will also cover the hotels, schools, and administrative buildings accommodating floating population. The planning has been done considering the projected population of 133,459 for year 2027.

(2) Design Period

The design period of the project should be neither too long nor too short, and it should not exceed the necessary useful life of the components of the system. In Nepal and India, the design period of sewer system is taken as 25-30 years in general. For the proposed project under this Study, the design period has been taken as 25 years, effective from year 2002.

(3) Target Population under Proposed Sewerage System

The target population of service area located in urban watershed of Phewa Lake has been estimated for the year 2015 and 2027. The estimation has been done considering the per year population growth rate. The population growth of the service area has been considered as 6% for the year between 2001 to 2011, 5.5% for the year between 2012 to 2020 and 5 % for the year between 2021 to 2027. The estimated population is presented in **Table I-5.1**.

Table I-5.1: Estimated Population of Service Area

SN	Municipal Wards	Year 2001	Year 2015	Year 2027
1	2	5,568	7,951	8,621
2	3	1,276	1,616	1,756
3	4	4,343	5,929	6,582
4	5	5,361	17,300	29,569
5	6	9,387	14,761	20,893
6	7	5,871	12,042	15,590
7	8	11,694	17,139	17,729
8	9	1,352	1,709	1,776
9	17	4,709	10,915	30,943
Total		**49,561**	**89,362**	**133,459**

Note: Population above also includes the population of tourists.

The sewerage system service area within PSMC is shown in **Fig. II-1.1** in **Chapter 1** of **Part II** of this Report.

(4) Design Wastewater Discharge at Each Target Year

The discharge of wastewater from household is proportional to the increase of supply of water for the increased population. At present, the supply of drinking water in the Pokhara city is little below the actual demand. The drinking water requirement estimated under Water Resources Strategy Formulation Project for next 30 years period is 130 liter per person per day (lpcd) in urban centers. The report also suggests that the per capita water supply demand in urban area as 130 lpcd is valid for entire plan period effective from year 2001 to 2027. No increase of water demand with the increase of living standard has been considered.

The standards applicable in Nepal and India suggest that the sewage flow in dry months is about 80 % of total quantity of water supplied through public supply system. In this case, there should be no extra amount of water through private source or illegal connection coming into sewers.

Apart from this, infiltration of ground water takes place through leaky joints and cracks. In general, about 10 % of the dry discharge is taken for ground water intrusion for designing sewers. For design of

proposed sewer conduits system, 90 % of the public water supply i.e. 117 lpcd (130x0.9=117) has been adopted.

(5) Design Water Quality of Discharged Water

In diversion type of sewerage system, there will be no discharge of wastewater from urban centers into the Lake. The final disposal of sewage into Phusre Khola will be naturally treated to bring the final discharge quality within acceptable limit.

5.3 EXPECTED OUTCOMES

Through the implementation of proposed sewerage system, the water quality of Phewa Lake will be suitable for recreational and agricultural use. The reduction of BOD load in the Lake water from the proposed sewerage system is expected to be as presented in **Table I-5.2.**

Table I-5.2: Estimated Reduction of BOD in Phewa Lake after Diversion of Urban Drains

Year	2002	2015	2027
BOD Reduction	0 %	90 %	90 %

The BOD reduction ratio is 0 % in the year 2002 as it is assumed that the construction of diversion type of sewerage system will take about 2-3 years. However, 90 percent reduction will be possible soon after the completion of sewerage system.

5.4 THE PROPOSED SEWERAGE SYSTEM

The proposed sewerage system has been designed in feasibility level and is presented in detail in **Part II** of this Report. The proposed system comprise following components:

- Trunk Sewer from Seti Canal to Phusre Khola including Tunnel (1.286 km) – 5.088 km (total),
- Lateral sewer from Phirke diversion to trunk sewer near Rastra Bank Chowk – 0.840 km,
- Diversion structure (overflow weir) across the confluence of Bulaundi and Phirke,
- Cross regulator and turnout at Seti Canal at Gaira Chautara,
- Cascade structure at outfall of sewer at Phusre Khola,
- Division box at storm-water drainage, and
- Required numbers of manholes (58) and other pertinent structures.

5.5 PROJECT COST ESTIMATE

The cost of the proposed sewerage system with tunnel alternative is presented in **Table I-5.3.**

Table I-5.3: Project Cost with Tunnel

S.N.	Description	Cost in NRS (,000)
1	*Mobilization and demobilization*	*17,055*
2	*Preparatory works*	*17,055*
3	***Main works***	
3.1	E/W in excavation	14,101
3.2	Earthwork in rock	498
3.3	E/W in filling (back filling)	5,900
3.4	*Hume Pipe laying and fitting*	*26,968*
3.5	PCC for hume pipe bed and fitting	7,819
3.6	Manhole	13,083
3.7	Cascade	3,500
3.8	Check gate and turn out	200
3.9	Division box	400
3.10	Weir and head regulator	5,000
3.11	Reconstruction of road	19,295
3.12	Tunnel work	244,340
	Total cost	***341,104***
4	*Miscellaneous works*	*34,110*
5	*Engineering cost*	*34,110*
6	*Administrative cost*	*8,527*
7	*Contingencies*	*34,110*
	Total Project cost	486,074
	In Million (NRs.)	***486***
	In Million (US$)	*6*

The operation and maintenance cost per annum for gravity type system is considered to be about 1 percent of capital cost for 5 years period, 2 percent in next 10 years, 3 percent for next 5 years and 4 percent for remaining five years.

5.6 RECOMMENDATION FOR RECOVERY OF PROJECT COST

The planning of proposed sewer system has been made by considering the requirement of minimum operation and maintenance cost with an aim of quick recovery of investment. Considering the financial limitation of HMGN to undertake such a costly project, external funding should be explored to execute the construction work. However, the Operation and Maintenance responsibility, as proposed in this Study, should be given to Nepal Water Supply Corporation (NWSC), Pokhara.

The operation and maintenance cost of proposed project will be recovered from the beneficiary households with suitable tariff (40% of municipal water supply charge).

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CHAPTER 6

SOLID WASTE MANAGEMENT PLAN COMPONENT (3)

The Development Study on Environmental Conservation of Phewa Lake in Pokhara, Nepal

CHAPTER 6

SOLID WASTE MANAGEMENT PLAN COMPONENT (3)

6.1 BASIC POLICY

6.1.1 Objective

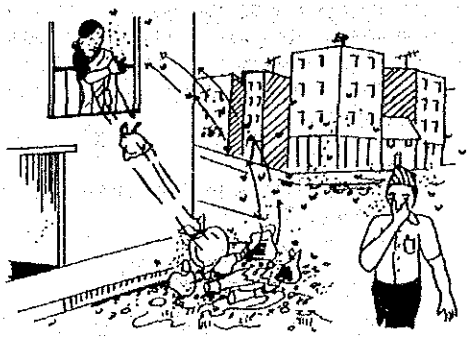
The objective is to prepare an efficient, effective, workable and financially sustainable Solid Waste Management System in the urban and rural areas of Phewa Lake watershed.

6.1.2 Basic Policy

The basic policy of the Master Plan for Solid Waste Management Component is presented as follows:

- Planning and development of a sanitary landfill site is an integral component of any solid waste management plan. However, in case of Pokhara, the Pokhara Environment Improvement Project (PEIP) under Second Tourism Infrastructure Development Project has already identified a suitable landfill site, and has completed its design. The project is now under implementation. Thus, the solid waste management component under this Study needs to cover only localized issues within Study Area, such as (i) efficient door-to-door waste collection system; (ii) street and public space cleaning; (iii) container service; (iv) pick-up service; and (v) promoting environmental education towards practicing reduce-recycle-reuse concept of waste.
- Unmanaged and haphazardly disposed solid waste can have hazardous impact on urban environment and general health and hygiene of people through ***bounce-back effect***. Haphazardly dumped waste produce various bacteria, virus and fungi, which thrives in such wastes and are reason behind spreading various deadly diseases. thus, the policy will be to develop an efficient system such that wastes does not come out and are collected right at their source of generation.

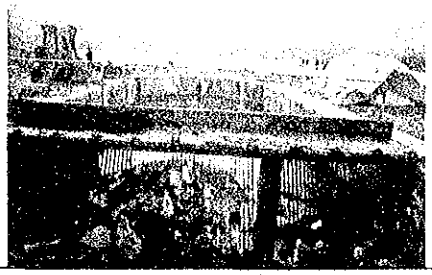
Bounce Back Effect of Solid Waste



- Develop monitoring mechanism to check throwing of wastes in streams and at open areas near the Lake such that these wastes enter into Lake carried by streams, canal, storm-water or air and cause Lake water pollution.
- The policy also includes
  - minimize waste production
  - restrict dumping of waste in street-sides
  - maintain a clean and hygienic environment in the surroundings of Lakeside areas congenial *for tourists as well as residents*
  - prevent choking of drains, canals and their trash-rakes due to solid wastes such as

Waste spilling from these open waste bins are being directly carried by open drain to the Phewa Lake

plastics, cans, bottles, packaging materials etc.
  - provide street side waste bins along Lakeside area
- Avoid leachate from openly dumped solid waste beside the Lake finding its way to ground water and seeping to Lake water
- Train rural people on different methods to reduce waste production and recycle wastes to generate income.
- Promotion of awareness, environmental education and community mobilization to practice environmentally sustainable methods regarding waste.
- The economic value of waste is being realized nowadays. It has given a new dimension in the waste management. Thus, now waste is to be dealt as valuable material for resource generation.



Solid waste chocking trash-rake of sedimentation chamber of storm-water drain

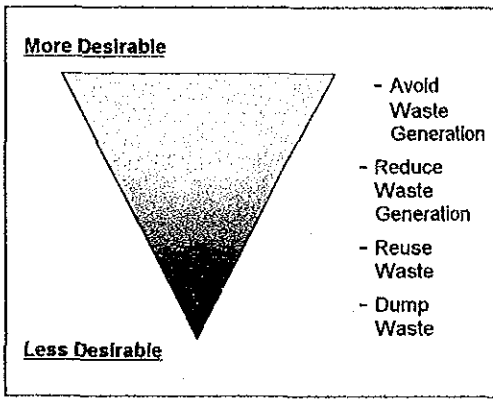
- Develop a solid waste management plan at Study Area which will also confirm with the broader framework of Solid Waste Management Plan and Program recently prepared by the PEIP and PSMC. This is to avoid parallel planning, which has already been carried out after comprehensive study by the PEIP.

6.1.3 BASIC CONCEPT OF SOLID WASTE MANAGEMENT IN THE STUDY AREA

Simple technology, appropriate strategy and mobilization of community self-help is the key to good solid waste management. Priority must be given to minimizing and recycling waste. Throwing should always be considered as last resort.

Confirming to the objective of appropriate solid waste management, the basic concept for establishing an efficient solid waste management system will incorporate followings:

- **Minimization of Waste Production**
  - devise ways of minimization of production of waste through awareness campaign, environmental education, peoples participation
  - encourage tourists to minimize use of packaged food and materials
  - educate for minimal use of packaging materials and prohibit plastic bags
  - devise a system of segregation of recyclable waste at source and provide facility to sell recyclable wastes
  - organize and socially support scavengers to recover reusable and recyclable materials from waste at a designated place, such that the recycling ratio is increased as well as they do not interfere at tourist areas
  - promote derivation of organic manure from waste through composting
  - use wastes to prepare briquettes, hand-made paper, bio-gas etc. at rural areas



- **Improve Collection Ratio**
  - improve primary stage of waste collection through door-to-door source segregated waste collection system at urban areas
  - devise system to totally restrict practices of open throwing of garbage

- develop appropriate system of community waste storage (closed containers) or tractor with prescheduled time and frequency of waste collection at rural watershed areas
- design placing of closed roadside waste bins along the Lakeside street, parks etc. where they also appear as beautiful street furniture.

- **Improved and Efficient Waste Transportation System**
  - use hand-cart or rickshaw to collect waste from door-to-door
  - use non-polluting electric three-wheeler or 2 cum capacity micro pick-up at certain points to collect waste brought from door-to-door collection
  - use hand-cart or rickshaw to collect waste from street sweeping and proposed buffer strip promenade around the Lake. Use of motorized vacuum cleaning can also be adopted.
  - eliminate multiple handling of waste and ensure "handling waste only once"
  - eliminate transportation of waste in open transportation vehicles
- **Proper Management of Hazardous Medical Waste**
  - ensure safe disposal of bio-medical wastes from hospitals, clinics, dispensaries etc. through incineration or bury under deep pit covered by soil layer
  - until sanitary landfill is constructed, dead animal bodies should be buried at least 3 ft below ground level at a designated place
- **Beneficiaries' Share in Operation and Maintenance Cost**
  - separate collection system has to be sustainable for its efficient functioning. Thus, the residents shall be informed about the importance of solid waste management system through environmental education program, awareness programs and campaign etc. and should be charged for the service. Also ensure effective cost recovery mechanism
  - derive income from the processing of waste (composting, sale of recyclable wastes, making handmade papers, briquettes etc.)
- **Final Disposal of Waste**
  - the on-going open dumping of solid waste at Seti River gorge is contaminating the river water, which is envisaged to stop after construction of the landfill site by PEIP.
- **Institutional Strengthening**
  - PSMC is at present coordinating waste collection and street sweeping in all the wards under it. In the absence of landfill site, they are directly disposing the collected waste at Seti gorge.
  - At present, PEIP assisted '*Tole Environment Committees*' formed in December, 2000 in various toles within wards of PSMC mobilize and convince people to practice sanitary waste management system. At the ward level, '*Environment Coordination Committee*' is formed which has representation from all the 'Tole Environment Committees' within the ward and also Ward Chairman. Similar structure is intended to be established at Sub-metropolis level. This already established institutional set-up at local level should be fully mobilized to disseminate environmental education and sanitary practices, as the result of their effort so far has been very encouraging.
  - strict implementation of the By-laws that has been prepared by PEIP for solid waste management in Pokhara
  - integrate urban and rural partnership modality under 'Happy Cycle Model' for efficient and effective waste management, such that each parties are equally benefited both physically through improved and sanitary environment, and financially by sharing the income generated from the commercial utilization of the Lake for development of both the areas
  - promote privatization or public-private partnership of waste management to undertake overall management of solid waste.

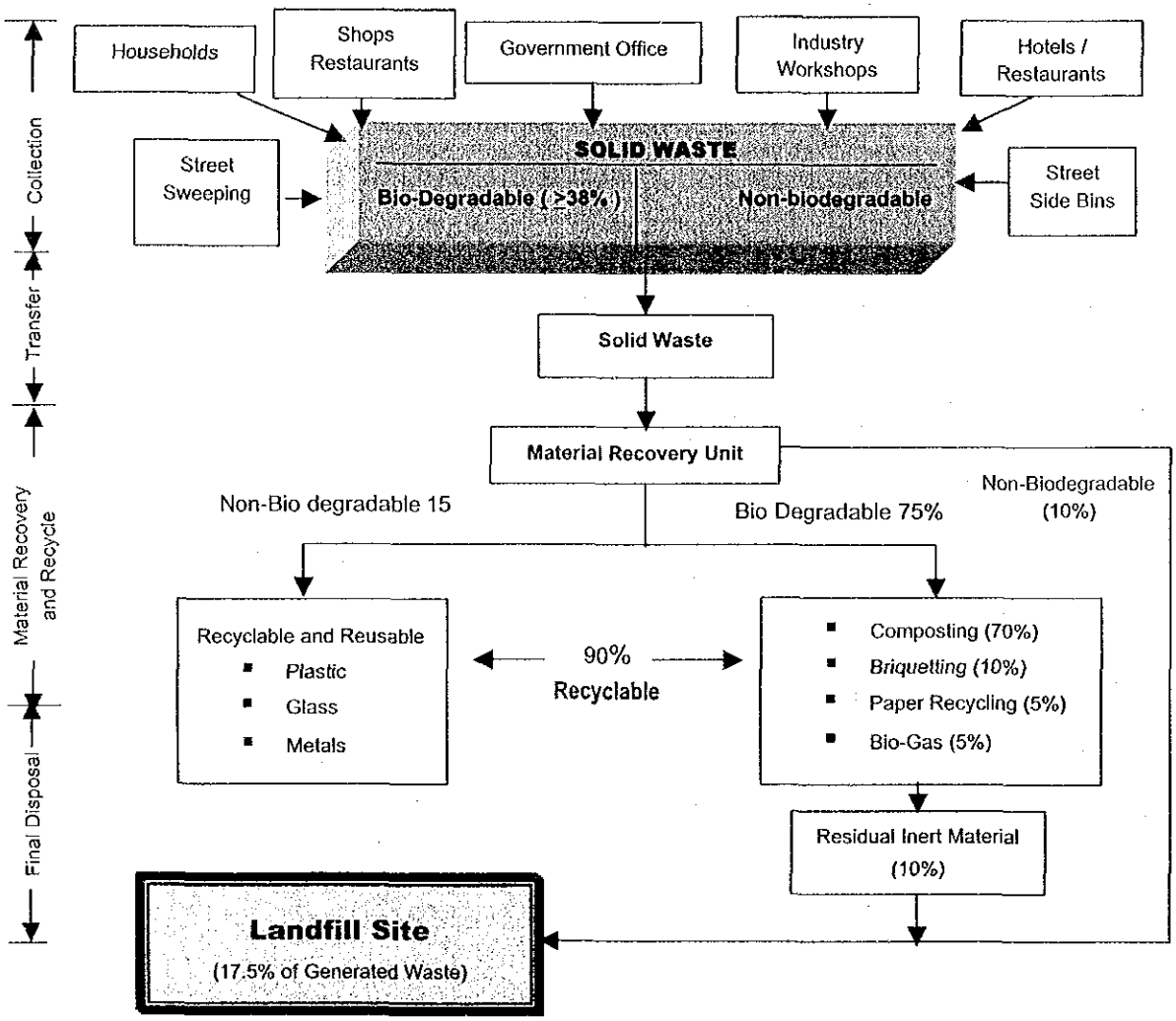
- **Promotion of Environmental Education**

All the issues to be tackled in a solid waste management plan depend on the understanding and cooperation of residents. Their collective and individual participation is fundamental for smooth implementation of the plan. Therefore, environmental education and awareness generation programs and campaigns needs to be further promoted through the local level community based organizations or NGOs.

6.2 SOLID WASTE MANAGEMENT PROGRAM IN STUDY AREA

The principal concept of program design is " Reduce-Recycle-Reuse', and minimum waste to be taken for final disposal. Reusing and recycling of materials back into nature or market place needs to be designed in a manner that will protect both health and the environment. **Fig. I-6.1** presents a general concept of Solid Waste Management design adopted by this Study.

Fig. I-6.1: Concept of Solid Waste Management



(1) Source of Production

The source of waste production in the Study Area can be categorized in four broad types based on the nature of waste generation areas; (i) Residential/Hotels/Restaurants; (ii) Commercial/Touristic Areas; (iii) Vegetable Markets/Hat Bazaars; and (iv) Street Sweeping.

(2) Design Parameters

The design parameter, based on which the system should be designed mainly consists of (i) total population to be served (existing and projected); (ii) rate of waste generation; (iii) total waste generated; (iv) composition and characteristics of waste; (v) total area to be cleaned (length of streets/ promenade); (vi) existing waste handling practices; and (vii) availability of land for waste processing.

(a) Population

The total population of urban portion of watershed area of Phewa in the year 2001 and 2027 is presented below in **Table I-6.1.**

Table I-6.1: Present and Population Forecast at Study Area (Urban)

S.N	Town	Total Population 2001	Projected Population 2027	Growth Factor
1.	Urban portion of Watershed Area of Phewa	46,029	110,251	6% from 2001-2006 and 5.5% from 2006 to 2011 and 5% from 2011 – 2021 and 4.05 % from 2021-2027 (PSMC as a whole)

(b) Rate of Waste Generation

The rate of waste generation will normally be commensurate with the rate of resource consumption. The average waste generation rate for Kathmandu Metropolis is 0.43 kg/capita/day (KMC, 1999). Thus, considering similar economy and character of the KMC and PSMC, rate of waste generation of 0.43 kg per capita per day have been adopted for design of the component.

(c) Total Waste Generation

An estimate of total waste generation is presented in **Table I-6.2** below.

Table I-6.2: Estimate of Waste Generation

S.N	Urban Centers	Existing Urban Population 2001	Projected Urban Population in 2027	Waste Generation Rate kg/capita/day	Existing Production of Waste kg/day	*Projected Production of* Waste (kg/day) in 2027
1	Ward No.6	9,387	20,893	0.43	4,036	8,984

(d) Composition of Waste Generation

Domestic waste in Pokhara comprises 12 different types of organic and inorganic materials, as listed in the following **Table I-6.3.**

Table I-6.3: Physical Composition of Municipal Solid Waste

Type of Waste	Wet Weight (%)	Wet Volume (%)	Wet Volume Sub-total (%)
▪ **Inert Material**			
– Sand, dust ashes	17.3	7.0	
– Stone, ceramic, fragments	6.0	9.5	16.4
▪ **Organic Matter**			
–Veg., kitchen garden waste etc.	44.3	24.3	
–Straw, bamboo etc.	1.4	2.3	26.6
Metal	0.7	1.0	
Paper	5.8	8.9	
Carton	0.0	0.0	45.2
Glass	2.0	1.1	
Plastics	13.2	34.2	
Textile/Jute	4.4	4.9	
Rubber, Leather	2.2	2.7	
Wood	1.3	2.8	11.7
Bones	0.5	0.4	
Others	1.0	0.9	
Total	**100**	**100**	**100**

(Avg. Value for Pokhara Sub-metropolis, 1998) ***Source:*** PEIP

It is observed that organic content is not very high in case of Pokhara, despite the common use of fresh vegetables and cereals in food in Nepali culture. One of the reason for this is because excessive use of canned and packed ready made food due to presence of large numbers of hotels, restaurants and tourists in the area.

(e) Total Area to be Served

The required area to be served by the Solid Waste Management program in the urban portion of the Study Area is area under the catchment of Phirke Khola, which consists portion of areas under Ward Nos. 2, 3, 4, 5, 6, 8, 9 and 17 of PSMC, and proposed Lakeside promenade Area. The total length of roads to be cleaned can be categorized in three types, as follows:

- Major tourist road from Gaira Chautara to Pardi - 3.9 km
- Proposed promenade around Phewa Lakeshore buffer strip - 18 km
- Other roads within the above mentioned wards of PSMC - 38 km

Not all the rural areas under the watershed of Phewa Lake are accessible. Thus, considering only motorable area, tractor can visit from Gaira Chautara to Thulakhet twice in every week to collect waste. Similarly, recyclable wastes should be picked up monthly from the rural areas by a mobile 'waste buying team', and money should be paid immediately. This will encourage people to store all recyclable waste for selling and hence haphazard throwing of waste will be minimized.

(f) Availability of Land

PEIP is developing a sanitary landfill site, where a part of land is also designed to be developed as waste recovery and processing center. The site is at 13 km away from the city center in Ward No. 18 at south-east of the Pokhara Sub-metropolis. The Landfill Site has an area of 10 ha. and lies near the bank of Seti river.

(3) Design of Plan

Based on the design concept, conditions and criteria, a comprehensive integrated solid waste management system has been planned, as presented in the following paragraphs.

(a) Collection and Transportation

(i) Door-to-Door Collection

The waste generated should be collected at the point of generation. The waste should also be collected in bio-degradable (wet waste) and non-bio-degradable (dry waste) types separately. For this, door-to-door source segregated waste collection system has been proposed. Each household, hotel, restaurant and office will be provided with two different colored buckets, one for biodegradable and another for non-degradable, which the Client will buy by their own cost. Minimum size of the bucket should be 25 lt., based on estimation of average household size of 5.4 persons, rate of waste generation for urban centers and frequency of collection. For hotels and restaurants, the size or number of bucket to be distributed will be based on the volume of waste generated by them each day.

Pollution free electric three-wheelers or efficient 2 cum capacity micro pick-ups are proposed as collector vehicles. The narrow body of three-wheelers or pick-ups are suitable for narrow streets in the Study Area. The three wheelers or pick-ups will collect waste from each household at a fixed time in the morning and bring it to the Municipal waste transportation vehicle, which will transport waste to landfill site. However, to reduce number of waste handling, the collected waste can also be transported by the mini pick-up directly to PSMC designated landfill site.

The general household and street sweeping waste will be transported directly to the waste recovery site. Hazardous medical waste will be separately transported to the incineration plant proposed to be installed in Hospital/Health centers. However, till incinerator is not available, these hazardous wastes should be either burned or borrowed in a pit covered by soil layer of at least 3 ft depth.

(ii) Street Side Containers and Waste Bins

Street side closed containers (waste bins) needs to be provided for collecting waste from people/tourists walking along the street, as well as at park and garden areas. These bins should be of 200 liter capacity and look beautiful street side furniture. Waste from these containers shall be collected daily during street sweeping. Also, for rural area, a closed container can be provided at street side. the numbers of these will depend on its volume and numbers of household served by it.

(iii) Street Sweeping

The main tourist area roads and proposed promenade is to be swiped twice, and other roads falling in Study Area needs to be swiped once daily. Vacuum type street sweeping vehicle can also be used, but manual sweeping is preferable as poor sweeper family will get job, and O&M cost of vacuum cleaner is not sustainable. Dust and inert material from the street sweeping will be sent for final disposal at sanitary landfill site, or land reclamation area.

(b) Reduce, Recycle and Reuse

(i) Awareness Campaign

The best way to have Solid Waste Management is not to produce waste at all, or produce minimum amount of waste. The behavior of consumer influences the quality and quantity of waste generated by them. Thus, awareness campaign, training, workshops etc. should be carried out routinely to make them aware to minimize production of waste. School children and women should be made target groups during awareness campaign and training. Campaign should also be carried out to encourage tourist not to throw plastic bottles, cans, package material at street side or open areas.

A waste management awareness session being carried out by the students of a local school is one of the effective means of creating habit of healthy living environment in children (Nov. 23, 2001 Pokhara)

(ii) Material Recovery

Three material recovery unit/sheds are to be established for the separation of recyclable waste at proposed sanitary landfill site. Plastic, glass, metals and other non-bio degradable waste will be separated and will be sent for reuse/recycling. Remaining bio-degradable waste will be sent for processing (composting). Scavengers should be encouraged to collect recyclable wastes only at material recovery site.

The scavengers are doing a great help, as more than 2% of waste is collected by them. They should be organized and trained for better performance. The scavenger children should be given basic education and health facility either by the government or by community. They can also be used for collecting waste from households, and later collect the recyclable at material recovery facility at landfill site. From the money generated from their services they should be given an opportunity to grow up with self-esteem and education, so that later they can be socially and culturally acceptable to the society.

Opening of a Recyclable Waste Purchase Center somewhere near the Study Area will also encourage people to keep storing the recyclable waste and sell it at the center.

(iii) Composting

38% of waste generated being biodegradable, it is proposed that it should be converted into soil conditioners by composting to be used in gardens or agricultural fields. Simple and natural method of composting are proposed, which are (i) organic pit system composting; and (ii) vermi-composting.

- **Organic Pit System Composting**

This is a simple composting system. The size of the pit should be such that not more than three layers of waste be sufficient to fill one such pit. The depth of the pit should be limited to 10 m for easy handling of waste. Each layer of bio-degradable waste are spread in the pit and covered with 25 mm of wet soil layer. The filled pit should be covered by wood, plastics or straw. The waste should be turned-over after one month. The compost will be prepared within three months. This is an-aerobic method of composting.

Waste can also be processed in aerobic condition through 'heap system'. Waste is placed after preparation of ground, in layers of 30-40 cm and each layer covered with moist soil layer of 25 mm depth. Perforated bamboo is inserted from all sides of the heap. Usually the heap of 1.0 m height is appropriate. The compost is prepared within 2-3 months.

People, particularly at rural area of the watershed should be encouraged in practicing such type of simple composting, either individually or in collective groups. The prepared compost can be used in their agriculture fields for organic farming, and as an alternative for chemical fertilizers.

- **Vermi-composting**

Earthworms are used in this method of composting. They feed on wastes and produce vermi-castings with immobilized micro-flora and are enriched with balanced plant nutrients such as vitamins, enzymes, antibiotics and plant growth hormones. They maintain aerobic condition of soil by virtue of its hemoglobin in high saturation. Thus, Vermi-composting will convert 80% of the biodegradable waste into high value bio-fertilizer. Wooden boxes with specific shape and sizes is designed as Vermi-composting units depending on amount of waste. Red-worm type of earthworm are used, which are voracious eater of organic wastes. The composition of waste may include vegetable waste, fruit peelings, paper waste, bread crumbs, leaf and forest litters etc. Each households, hotels and restaurants can also carry out this type of composting in individual basis.

(c) Recycling

- Plastics, metals, glass, cans, papers etc. can be recycled. Thus, such materials can be recovered either at household level or at material recovery unit at landfill site and send for recycling.
- Prepare Honeycomb Briquette from waste at rural as well as urban areas. It is a solid fuel made out of biomass char. Wood, leaves, twigs, branches and other agricultural and forest residues are made into char by carbonizing in a charring drum. This char is ground into powder and mixed with 20-30% bentonite clay by adding required amount of water. This mixture is put into moulds and made briquettes. These briquettes are sun-dried for two days and are then ready for use as fuel wood. The briquettes burn with beautiful flame without any smoke. Only one briquette is needed to cook a complete meal of a family of five to six persons. These are suitable for both cooking and space heating. Such briquettes can replace other types of fossil fuels, forest wood etc. and can be used by hotels for room heating, for boilers, and by households and restaurants for cooking. This can be an alternative source of income for rural housewives.

- The waste papers can be recycled by simple technology and made into handmade papers. Such papers can be used for making cards, handicrafts etc. for selling it to tourists. This can also be an alternative source of income generation.

Handmade paper

(d) Production of Bio-Gas from Bio-Mass

With simple installation, bio-gas can be produced from the bio-mass available from cows and buffalos dung. Biogas should be widely promoted in the rural watershed area, such that the gas can be used for cooking their food and lighting purpose. This will also reduce pressure on forest for fuel wood.

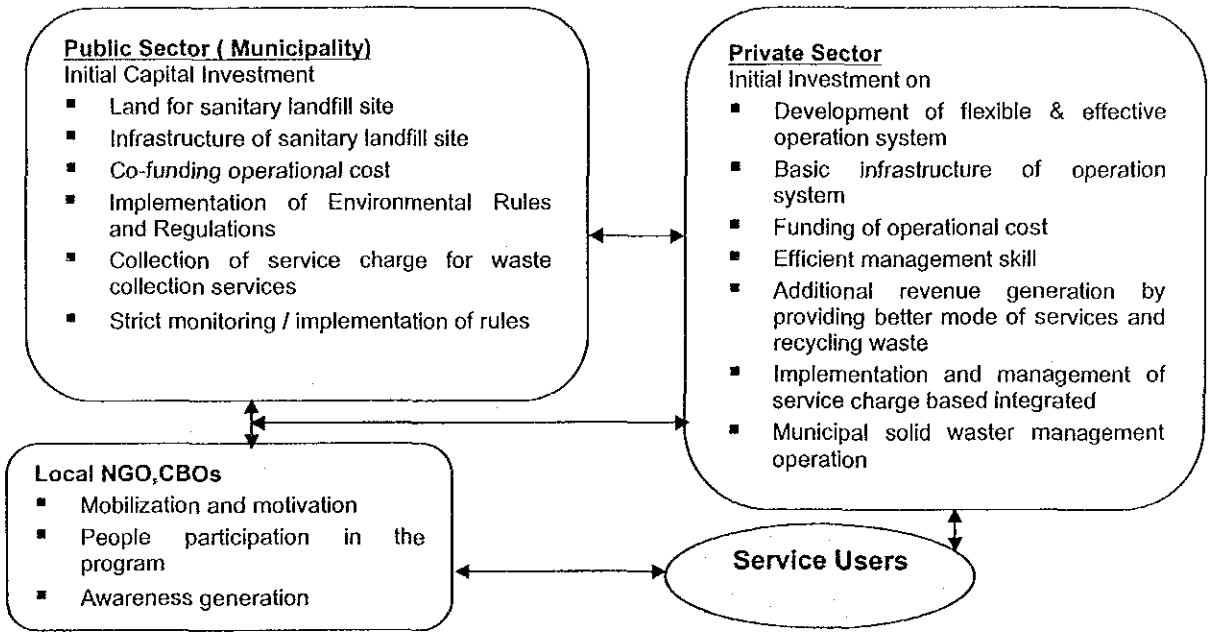
Alternative Source of Energy

Out of 38% of biodegradable waste some 7% will be finally screened out as inert material that has to be sent for final disposal. It is, thus, estimated that out of total waste generated, only 17.5% will be left to be finally disposed. These will be of non-biodegradable nature and thus, can be safely dumped at landfill site or low-lying areas for land reclamation purpose without producing leachate.

6.3 IMPLEMENTATION ARRANGEMENT

Public-private partnership for an effective and efficient solid waste management has proved very successful in numbers of leading municipalities, including Kathmandu Metropolis and Biratnagar Sub-metropolis. Example and lessons learnt from them should be incorporated in designing a more efficient system. The implementation arrangement of the solid waste management by public-private partnership may encompass activities as presented in the following **Fig. I-6.2.**

Fig. I-6.2: Institutional Arrangement Structure



6.4 MODEL SWM PROGRAM IN WARD NO. 6 OF PSMC

A model solid waste management program has been designed for Ward No. 6 of PSMC. Financial analysis has also been carried out to demonstrate its sustainability. Once a program is lunched as a pilot program in this Ward, it can be replicated at other parts of the urban areas under Phewa Lake watershed. Also, the programs prepared based on actual experience and lessons learned from the source segregated door-to-door waste collection at Kathmandu Metropolitan City and Biratnagar Sub-metropolitan City.

While preparing the program, emphasis is given on use of manual waste collection method, which will also contribute for income generation activities to the local people. A tested method of collection of waste is designed in which waste is collected in buckets or sacks, so that there will not be any spill-over as well as transfer of waste to collection vehicle can be done without exposing it. For street sweeping, manual sweeping has been designed, although motorized vacuum vehicle can also be used.

Following are the basic assumptions made for designing the solid waste management program:

- Sweepers capacity to sweep in three hours is approx. 2700 sq. meter
- Door to door collectors are able to collect waste from 252 HH in one day using sack or bucket collection system
- 30% extra door-to-door collectors are included in the calculation
- Each supervisor is allocated 350 HH
- One person produces 0.43 kg of waste per day
- Damage rate of shovels is 10 percent per 3 months and broom 90 % per month
- Damage rate of hand cart is 30 percent per month

Basic Calculations:

- *Households* - 1,800
- *Street Sweeping*
  - A Class Road (Phewa Lake 9m width) - 18 km
  - B Class Road (Main Roads 6 m width) - 3.9 km
  - C Class Road (others 3.5 m width) - 20 km
- *Manpower Required*

Staff	Nos	Staff	Nos
Manager	1	Supervisors	5
Office Assistant	1	Head Sweeper	3
Peon	1	Loaders	3
Driver	2	Sweepers	82
Driver Helper	2	D to D Collectors	9

- *Tools Required*

Tools	No.	Tools	No.
No of Rickshaw Required (Size of rickshaw 34"*48"*16")	9	2 Cum Mini Pick-up Truck	2
No. of Buckets Required for Rickshaw	54	No of Handcarts	18
No of Sacks Required Per Month	322	*To be added per month:*	
Brooms	90	Brooms Per Month	81
Shovels	22	Buckets Per Month	6
Dress, Boot, Glove Per Year	125	Shovels Per 3 Months	2

- *Collection Fee Rate*

Particular	Nos in Ward 6	Rate NRs./Month	Particular	Nos in Ward 6	Rate NRs./Month
Households	1,800	100	Lodge (small)	34	1,500
Shops	444	100	Hotels (big)	158	15,000
Department Store	5	300	Nursing Homes	1	400
Schools	4	150	Workshop	18	200
College	7	150	Entertainment	1	200
Tea/Cafe	61	100	Services	163	200
Restaurant	70	150	Bank	2	200
TOTAL FROM SERVICE CHARGE PER MONTH (NRs.)					

Note: The numbers of household and commercial units are calculated from recent GIS recording of PEIP.

It has been calculated that the total initial investment for the services will be NRs. 17.5 million and income from service charge, considering only 75% household collection rate in average is NRs. 2.7 million per year. At this rate, it has been estimated that the system will comfortably reach a breakeven within four years.

Based on the above assumptions, a Solid Waste Management Project has been designed as Action Plan presented in the following Sub-section.

6.5 MODEL SOLID WASTE MANAGEMENT PROGRAM

***Title:* Solid Waste Management in Ward No. 6**

Aim: To maintain clean and healthy environment, control health hazard, check solid waste disposal at open spaces or Lake, reduce –recycle and reuse, and reduce organic pollution load into Phewa Lake from openly dumped solid waste.

Phase: I

Project Duration: 5 yrs.

Justification: The solid waste generation in Pokhara town area and rural market centers is on increase corresponding to urbanization, modernization and population growth. So far there exist no efficiently managed waste collection and disposal system in the Study Area. Reportedly, less than 40 % waste are only collected by municipal waste collection system. Rest of more than 60 % of waste is thrown at open spaces, streams (Phirke Khola, Seti Canal, urban drains etc.), which finally flows into the Phewa Lake or Seti River. Even the collected waste by municipal tractors are thrown directly in Seti gorge. All this is contributing towards unsanitary and unhealthy environment, visual and odor nuisance. This situation also holds potential for outbreak of disease.

In the above context, there exist dire need of a proper solid waste management system through enforcement of existing relevant regulation and efficient collection system, waste segregation and recovery of recyclable and reusable waste and their management. Also needed is environmental education and community mobilization at both rural and urban areas. The principle of reduce-recycle-reuse needs to be disseminated to the people and minimization of waste should be given priority. The rural and urban people should be given training on composting, briquette making and minimizing use of plastic bags. Incineration facility is also needed for safely disposing hazardous and medical waste.

Scope : For the solid waste management, following will be the scope:

- Source segregated door-to-door waste collection system with service charge.
- hand cart or rickshaw will be used with 'sack system' or ' bucket system' of waste collection.
- The households and other clientele will be distributed two buckets of 25 liter with different color for dry and wet waste. The service taker shall pay for the price of the bucket.
- street sweeping twice at main road from Gaira Chautara to Pardi, around the Lakeshore buffer zone with promenade and once at other roads within the ward.
- The collected waste will be transferred to collection vehicle (mini pickup with 2 cum capacity).
- Sweepers and waste collectors will be provided with proper dress, boot, gloves and face mask.
- Waste will be transported to municipal transfer station and recyclable wastes will be recovered by scavengers.
- Waste buying center will be opened in Ward No. 6 in addition to *Mobile Waste Buying Team.*
- Environmental Education on "3R" principle to people, school children and housewives. This component will be addressed by Environmental Education Master Plan Component.
- Establish a system of regular monitoring to check open throwing of waste into the Lake area and enforce "polluters pays" system.
- Pilot demonstration training on briquette making, vermin-composting, pit composting and bio gas. This will be assisted by Environmental Education Master Plan Component.

Location: Ward No. 6 of PSMC, and Lakeshore buffer strip promenade.

Responsible Agency: Public Private partnership between PSMC and potential Contractor.

Budget: (in million NRs.)

▪ Waste collection and street sweeping equipment /tools (2 nos. of 2 cum mini pickup, rickshaw, handcart, brooms, shovels, sacks, dress etc.)	2.5
▪ Salary of manpower	15
Total	**17.5**