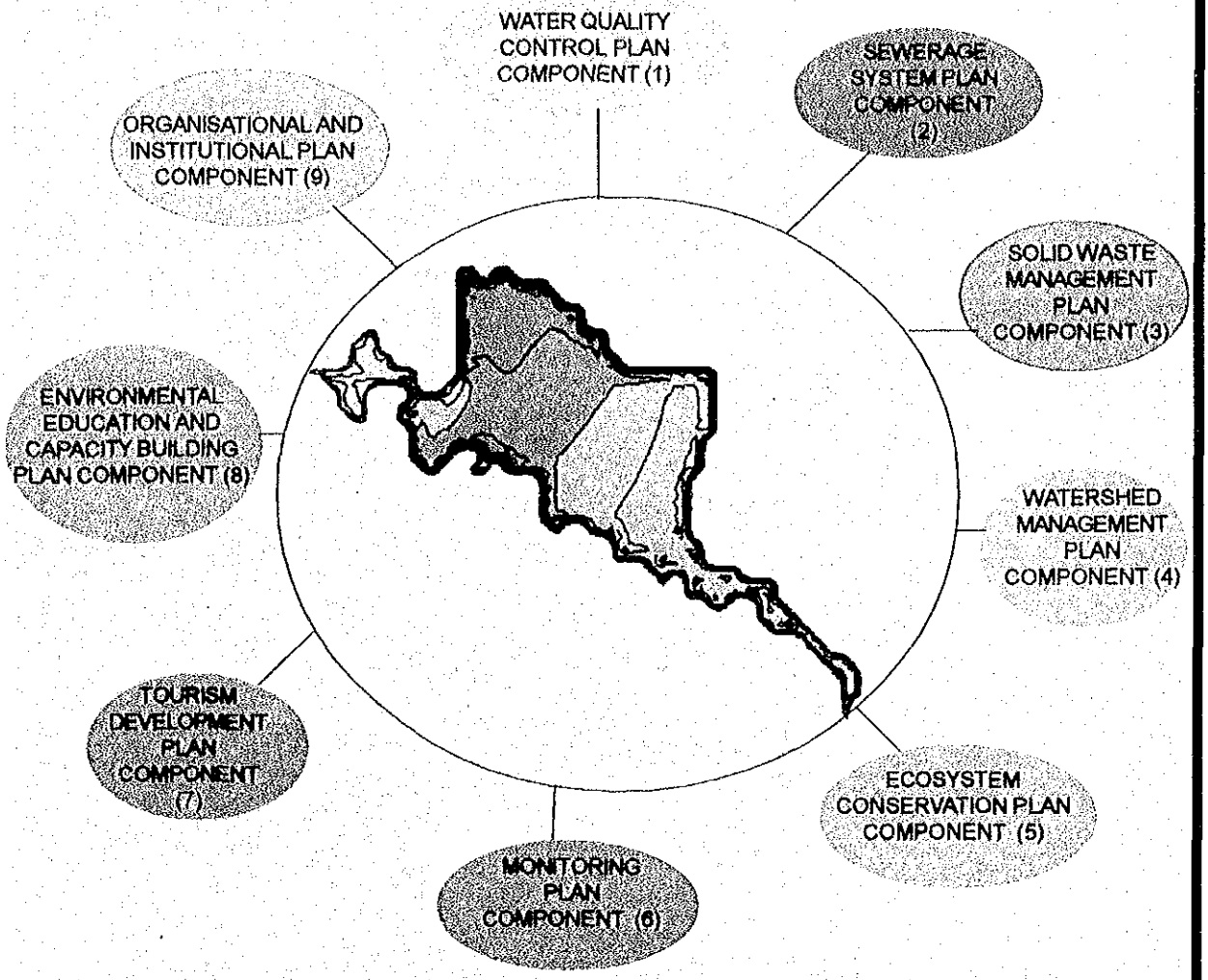


PART - I

MASTER PLAN FOR INTEGRATED CONSERVATION OF PHEWA LAKE

CONTENTS

CHAPTER 1

OUTLINE OF THE STUDY

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

CHAPTER 1
OUTLINE OF THE STUDY

1.1 BACKGROUND OF THE STUDY

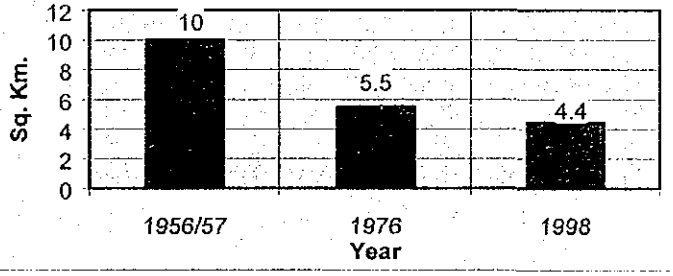
Nepal is renowned in the world on account of her natural beauty, geographical and biological diversity, and cultural and artistic heritage. But, due to lack of proper care, maintenance and conservation of these, they are being polluted, encroached and degraded, and have reached at a critically threatening point. One of such important natural landmark area is Phewa Lake lying in Pokhara Valley at the base of the Annapurna Himalayan Range.

Phewa Lake is the biggest and most beautiful Lake among the seven lakes in Pokhara Valley and is exquisitely situated at its western part. The Lake, with an island temple dedicated to godess Barahi in its middle and a nicely protected forest on the adjoining southern slope, is a legendary Lake (second largest after Rara Lake) of Nepal. While enjoying the water of the Lake one can also see reflection of the famous and virgin peak of Machhapuchre (Fishtail mountain) in it. The Lake and its watershed area is also famous for its rich bio-diversity as well as unique socio-cultural heritage.

Phewa Lake is at present facing following dire consequences due to human activities taking place at both its urban and rural watershed areas.

- **Pollution of Lake Water**
  - raw sewage, domestic wastewater and solid waste are being directly discharged in to the Lake
  - chemical fertilizer being used in the adjacent agricultural fields are contributing nutrients in to the Lake
  - an estimated 100 kg of washing soap and detergent is used everyday for washing clothes in the Lake water (Source: Phewa Lake Conservation Action Plan, NPC/IUCN)
  - Open bottomed septic tanks at the bank of the Lake pollutes its water through seepage of sewage
  - Recently constructed storm-water drain flowing directly in the Lake are being illegally connected with domestic wastewater pipes
  - pollution from freely wallowing cattle in the Lake area
- **Sedimentation of the Lake**
  - the natural streams and rivers from rural watershed has been carrying tons of sediment from their eroded and fragile areas into the Lake resulting in its continued shrinkage, as shown in **Fig I-1.1.**
  - additional erosion initiated by infrastructure development activities at the immediate vicinity of the Lake, such as construction of Baidam-Pame road, construction of hotels on hill slopes at west bank of the Lake, and direct discharge of high sediment load and

Fig. I-1.1: Lake Area



garbage ridden water from Seti irrigation canal in to the Lake are also major sources of sedimentation of the Lake

- at the present rate of sedimentation (175,000- 225,000 m^3/year), it is estimated that the Lake will be completely silted up within next 190 years (Sthapit et. al., 1998)

Pokhara, particularly the Lakeside area of Phewa Lake is attracting large numbers of tourist, and it is estimated that 16% of total income of Pokhara is contributed by tourism sector. In such situation, if the Phewa Lake continues to be polluted and filled up by sediment at present rate, thus resulting in it's diminished recreational and aesthetic value, the tourism industry will sharply decline and will have direct negative impact on local as well as national economy and livelihood of people of Pokhara.

In the above aspect, the necessity of environmental conservation of Phewa Lake has been realized. This includes immediate need for restricting further pollution of Lake water, minimizing sedimentation of the Lake, generating awareness among the people for it's conservation, and establishing mechanism and resources for carrying out routine developmental activities that contributes towards the conservation of the Lake.

Considering all these, His Majesty's Government of Nepal (HMGN) requested Government of Japan (GOJ) to assist through Grant Aid in environmental conservation of the Phewa Lake. Such request to GOJ was made based on the fact that GOJ has been a leading donor country which has continually and immensely contributed in the development endeavors of Nepal.

The GOJ advised HMGN to address the environmental conservation of the Lake through an integrated study, where both technical intervention and educating people on sustainable environmental development should be interlinked.

Subsequently, an understanding was reached between the HMGN and GOJ, and as a result of this the arrangement for implementing this **Study** was signed between Ministry of Population and Environment (MOPE) and Japan International Cooperation Agency (JICA) on July 13, 2001.

1.2 OBJECTIVES OF THE STUDY

The main objectives of the proposed Study is to formulate integrated plan for the environmental conservation of Phewa Lake, that will also contribute towards increasing the quality of life of poor people of its watershed area. To achieve these objectives, the Study will primarily focus on:

- water quality management plan including sewage treatment plan for checking water quality deterioration of the Lake by restricting inflow of polluted water from both point and nonpoint sources
- environmental education program for enhancing awareness of the urban and rural communities residing within the watershed area of the Lake

The Study also aims to formulate master plan on:

- watershed management plan to conserve the Phewa Lake watershed area and control rapid sedimentation of the Lake;
- ecosystem conservation plan of the Lake and its watershed area;
- monitoring system plan (including water quality, hydrological monitoring and soil erosion monitoring plan);
- institutional plan to assist in establishing a Lake focused umbrella organization for undertaking and coordinating all the activities related with the environmental conservation of the Lake, and interlinking urban and rural partnership for optimized utilization of Lake resources; and

- financial resource mobilization from increased tourism sector by developing Phewa Lake area as beautiful scenic place, which will assist in sustainable development of both urban and rural areas.

Accordingly, the main aim of the Study is threefold:

1. Study the feasibility of different alternatives for **Treatment of the Polluted Water of the Lake** and its sources.
2. Formulate an **Environmental Education and Community Empowerment Program** that will generate awareness among the urban and rural population residing at the Lake watershed area, and mobilize them for a collective endeavor for environmental conservation of the Lake.
3. Establish a **Phewa Lake Environment Conservation Committee** and a **'Phewa Lake Conservation Fund'** which will recycle the income generated from commercial use of Phewa Lake to the development of its urban and rural watershed areas, the ultimate result of which will contribute to its effective environmental conservation.

1.3 STUDY AREA

The valley of Pokhara is located at 125 km west from Kathmandu, and at 28^0 10' N to 28^0 16' N Latitude and 83^0 58' 30" E to 80^0 02' 30" E Longitude. It is well connected with all season motorable highway and air routes, with more than half dozen flights daily from Kathmandu. Phewa Lake lies about one kilometer southwest of Pokhara valley, at an elevation of about 793 amsl. The Location Map of the Study Area is given in **Fig. I-1.2** in the following page.

1.4 STUDY IMPLEMENTATION ARRANGEMENT

JICA Nepal office, the official agency responsible for implementation of technical cooperation programs of the Government of Japan has undertaken the Study in close cooperation with MOPE. JICA has appointed Technical Advisors for the Study and has also appointed a Local Consulting Firm, SILT Consultants (P) Ltd., to carry out the Study in close cooperation and supervision of JICA Technical Advisors.

A Steering Committee has been formed for periodic review of the progress of Study and give constructive advise.

The Structure of the Steering Committee is presented in the following **Table I-1.1.**

Table I-1.1: Structure of Steering Committee

Steering Committee Members	Steering Committee Meeting Observers
Chair Person: Secretary, MOPE **Member Secretary:** Joint Secretary, MOPE **Members:** - Joint Secretary, MOLD - Director General, DOF - Chairman, DDC Kaski - Mayor, PSMC - Deputy Resident Representative, JICA Nepal Office - Project Director, ACAP - President, Regional Hotels Association, Pokhara - President, Chamber of Commerce and Industries, Pokhara Chapter	Representatives from: ▪ MOPE - 1 no. ▪ Embassy of Japan - 2 nos. ▪ JICA Nepal Office - 2 nos. ▪ Study Technical Advisors, JICA - 2 nos. ▪ Local Consultant (SILT) - 2 nos.

The Organization Chart of the Study Implementation Arrangement is presented in **Fig. I-1.3.**

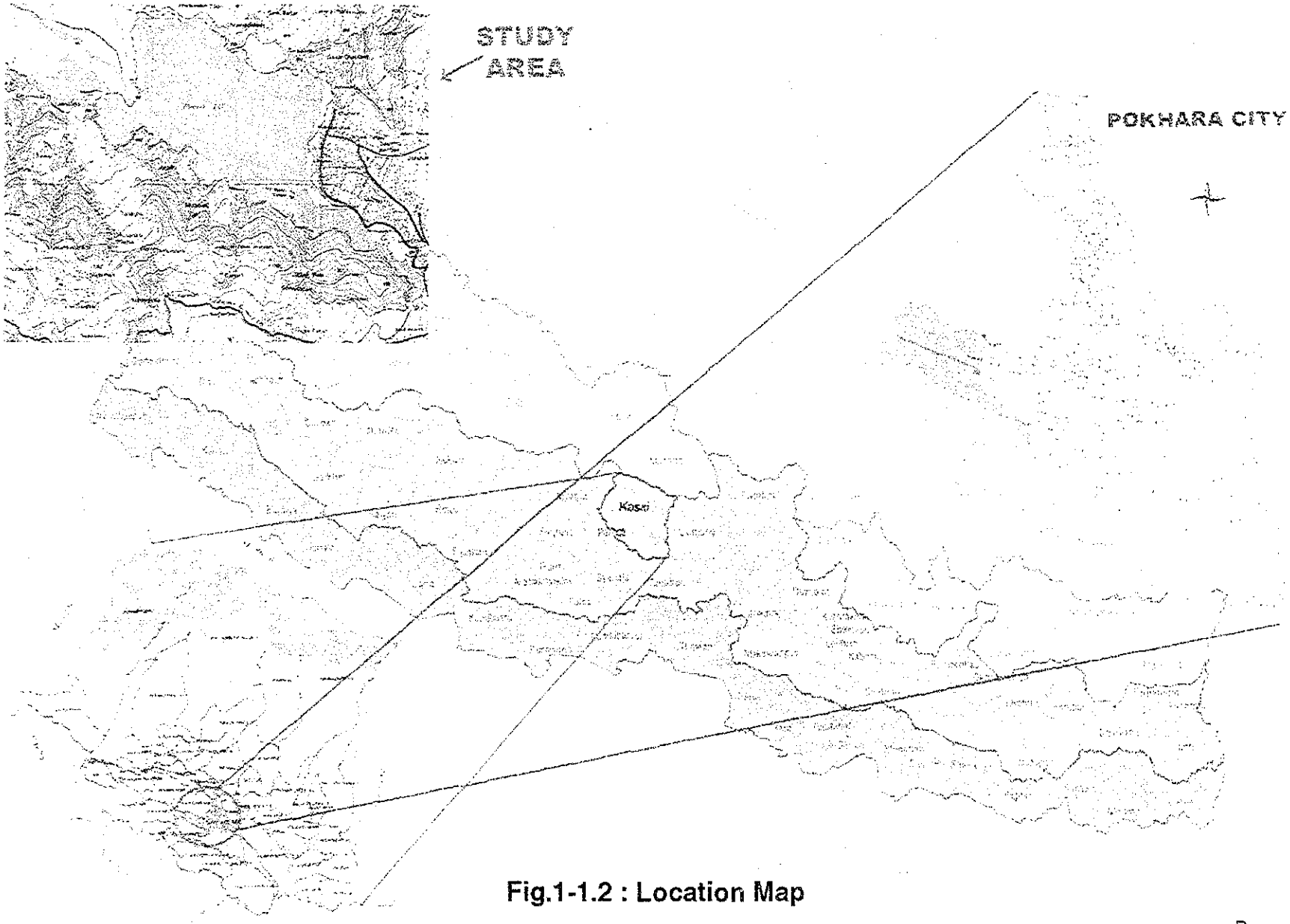
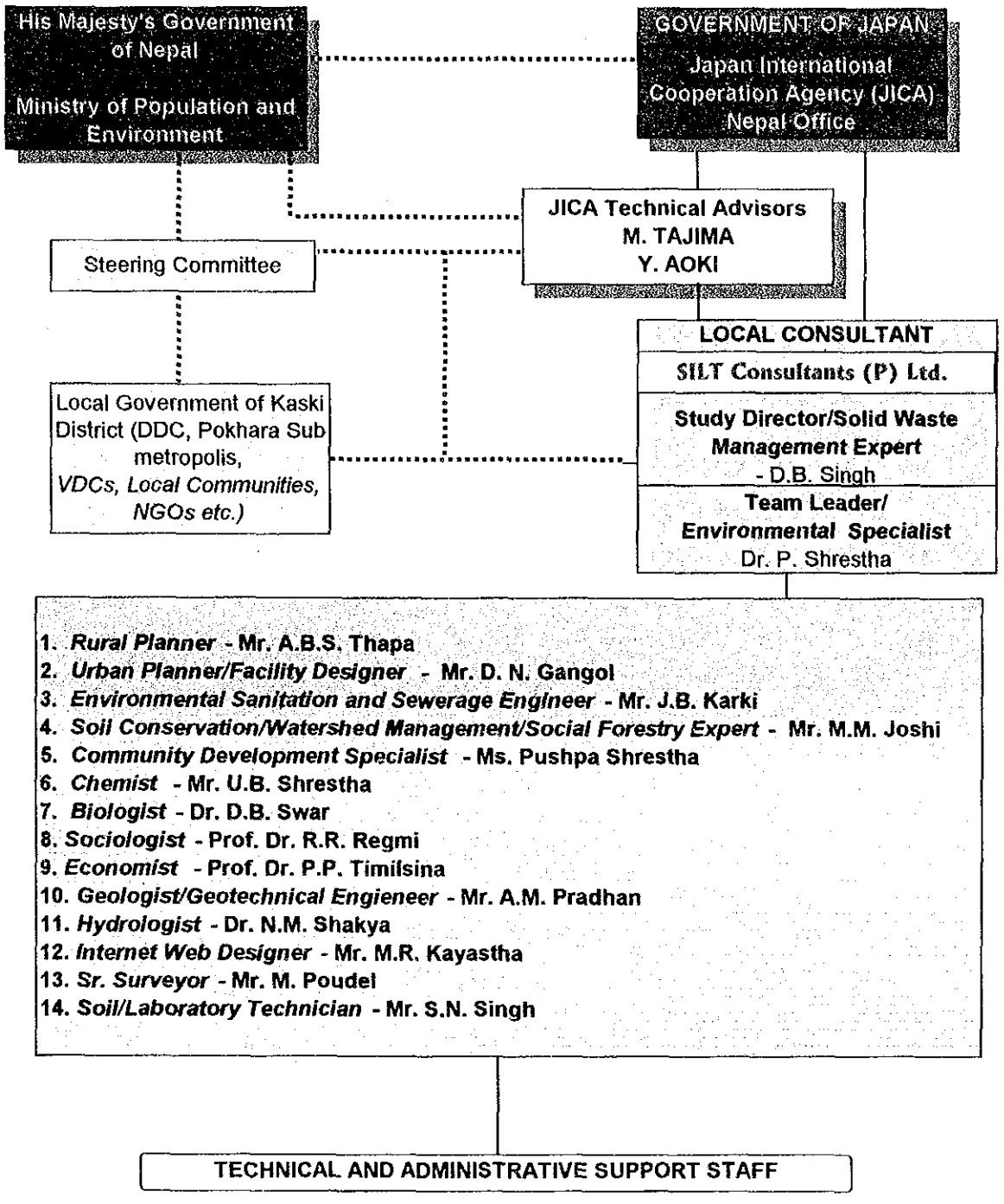


Fig.1-1.2 : Location Map

Fig. I-1.3: Study Implementation Arrangement



1.5 SCOPE OF THE STUDY

In order to achieve the objectives as stated above, the overall scope of the Study have been grouped in following four stages.

STAGE - 1 : DESK STUDY AND INCEPTION REPORTING PHASE

- ***Task 1:*** Mobilization
- ***Task 2:*** Desk Study
- ***Task 3:*** Appreciation of Existing Problems and Issues
- ***Task 4:*** Discussion with Technical Advisors, JICA and with Other Relevant Authorities
- ***Task 5:*** Formulation of Study Plan
- Preparation and Submission of Inception Report
- First Steering Committee Meeting

STAGE - 2: INTERIM REPORTING PHASE

- ***Task 6 : Field (Site) Survey and Investigation***
- ***Task 7 : Analysis of Site Survey and Investigation Data***
- ***Task 8 : Formulation of Project Planning***
  - Identification of Projects
  - Preliminary Design of Projects
- Preparation and Submission of Interim Report
- Second Steering Committee Meeting
- Public Hearing at Pokhara
- Preparation and Submission of Post Interim Report

STAGE 3: DRAFT FINAL REPORTING PHASE

- ***Task 9: Master Plan, Feasibility Level Design and Cost Estimation of Projects***
- ***Task 10: Project Development Fund and Identification of Necessary External Assistance***
- ***Task 11: Project Implementation Schedule***
- ***Task 12: Evaluation of the Project***
- ***Task 13: Recommendation Towards the Materialization of the Project***
- Preparation and Submission of Draft of Draft Final Report
- Third Steering Committee Meeting
- Preparation and Submission of Draft Final Report

STAGE 4 : FINAL REPORTING PHASE

- Preparation and Submission of Final Report
- Preparation and Submission of Phewa Lake Homepage

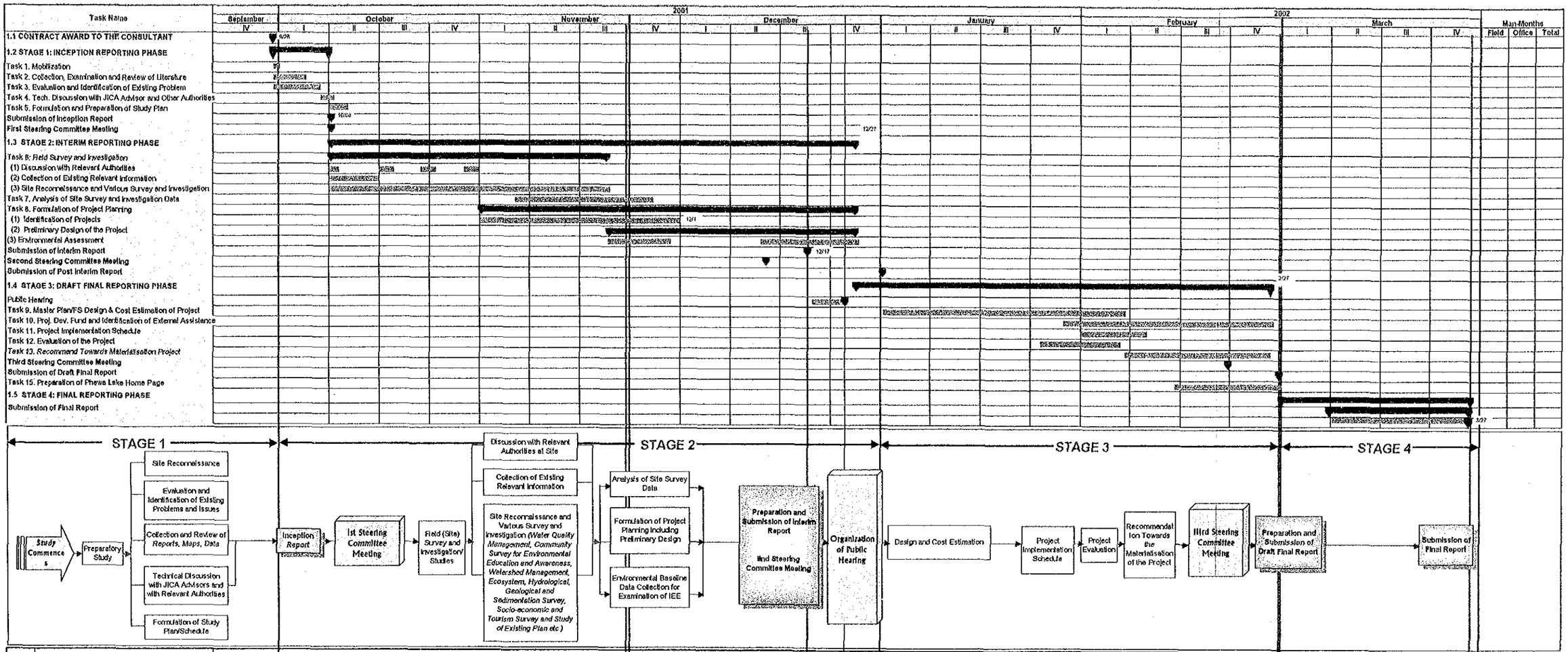
1.6 STUDY SCHEDULE

The following **Table I-1.2** presents the milestones of the Study Schedule. Work Flow Chart, Work Schedule and Manning Schedule of the Study are presented in **Fig. I-1.4.**

Table I-1.2: Study Schedule Milestones

S.No	Activity	Scheduled Date
1.	Signing of Contract Agreement between JICA Nepal Office and SILT Consultants (P) Ltd.	September 28, 2001
2.	Submission of Inception Report	October 08, 2001
3.	First Steering Committee Meeting (Kathmandu)	October 08, 2001
4.	Submission of Interim Report Revised Interim Report	December 10, 2001 December 17, 2001
5.	Second Steering Committee Meeting (Kathmandu)	December 13, 2001
6.	Public Hearing (Pokhara)	December 25, 2001
7.	Submission of Post Interim Report	January 02, 2002
8.	Submission of Draft of Draft Final Report	February 04, 2002
9.	Third Steering Committee Meeting	February 21, 2001
10.	Submission of Draft Final Report	February 28, 2002
11.	Submission of Final Report	March 27, 2002

Fig. I-1.4: Work Flow of the Study including Study and Manning Schedules



No.	Position	Man-Months Field	Office	Total
1	Study Director		1.00	1.00
2	Team Leader/Environmental Specialist	1.00	4.00	5.00
3	Rural Planner	0.50	1.50	2.00
4	Urban Planner/Facility Designer	0.70	2.80	3.50
5	Environmental Sanitation and Sewerage Engineer	0.60	2.50	3.10
6	Solid Waste Management Expert	0.30	1.00	1.30
7	Soil Conservation/Watershed Management/Social Forestry Expert	1.30	1.20	2.50
8	Community Development/Gender Specialist	1.00	3.00	4.00
9	Chemist	0.50	0.50	1.00
10	Biologist	0.30	1.00	1.30
11	Sociologist	0.50	1.50	2.00
12	Economist	0.50	2.55	3.05
13	Geologist/Geotechnical Engineer	0.30	0.90	1.20
14	Hydrologist	0.50	1.00	1.50
15	Internet Web Designer	-	1.00	1.00
16	Sr. Surveyor/Autocad Specialist	0.50	0.05	1.45
17	Soil/Laboratory Technician	0.40	0.20	0.60
	Total Man-months			35.50

CONTENTS

CHAPTER 2

PRESENT ENVIRONMENTAL CONDITION OF THE STUDY AREA

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

CHAPTER 2
PRESENT ENVIRONMENTAL CONDITION OF THE STUDY AREA

2.1 SOCIO-ECONOMIC CONDITION

The Phewa Lake watershed area comprises 6 VDCs of Kaski district and 9 Wards of Pokhara Sub-metropolitan City. The Study Area covers an estimated area of 16 sq. km out of which 12 sq. km is located in rural area followed by 4 sq. km in the urban area of Pokhara Sub-metropolitan City.

2.1.1 Household and Population

The household size and population in rural and urban area of Phewa watershed is summarized in *Table I-2.1*

Table I-2.1: Total No. of HHs and Population in the Project Area

VDC Rural Area	Total HH	Population Total	Average Family Size Person/ HH	Density (nos. / sq. km.)
Dhikurpokhari	1,702	8,097	4.75	385
Kaskikot	1,522	6,597	4.33	412
Sarangkot	1,433	6,631	4.62	276
Chapakot	641	3,252	5.07	162
Pumdi-Bhumdi	1,590	7,901	4.46	359
Bhadaure-Tamagi	766	3,999	5.20	210
Sub-Total	**7,654**	**36,477**	**4.73**	
Urban Area (Pokhara Sub-metropolitan Area)	29,260	46,029	4.05	1128
Grand Total	**36,914**	**195,581**	**4.64**	

Source: CBS 2001, Field survey 2001 and extrapolation for urban watershed area

A higher proportion of female-headed households are found among Gurung and Magar families. In the urban area, male headed household take major responsibility in decision-making process.

2.1.2 Caste/ Ethnic Composition

The distribution of ethnic composition in the Project Area is presented in **Fig. I-2.1**. Out of total, 25% HH in rural area are headed by female due to absence of adult male member during periodic out migration.

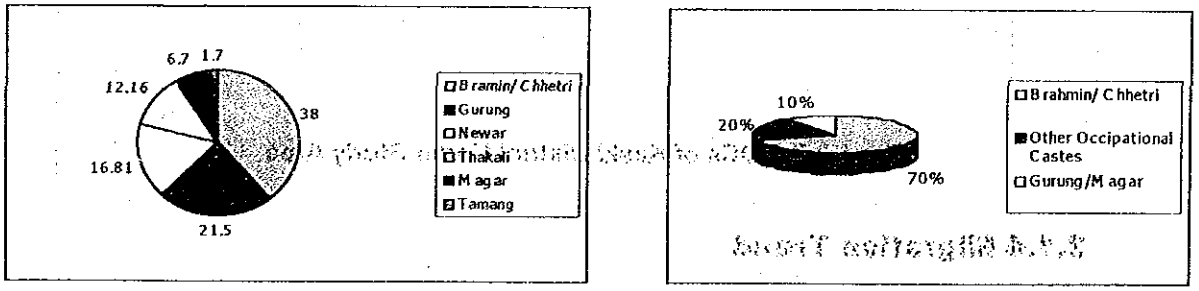


Fig. I-2.1: Caste Composition in %

2.1.3 Settlement Pattern

The settlement pattern is relatively dense in the upstream area of Dhikurpokhari VDC. Naudada settlement located along the Pokhara-Baglung road section is densely settled due to business opportunities for tea stalls, restaurants, small hotels and lodges. The field survey observed that three settlements in Kaskikot VDC are densely clustered with houses on the roadside made of reinforced concrete construction (RCC). Additionally, four settlements in Sarangkot VDC, which are adjacent to the rural road connecting Pokhara Sub-metropolitan City is also densely populated. The settlement in Bhadure, Chapakot and Pumdi-Bhumdi is sparsely populated due to lack of access and rural road network. In PSMC, the major concentration of population is clustered in Ward Nos. 2, 3, 4, 6, 8 and 9 whereas settlement pattern in Ward No. 5, 7 and 9 of the urban areas are sparsely populated. The Ward Map of PSMC is presented with delineating Phewa Lake watershed area in **Fig. I- 2.2.** Similarly, a Map of Kaski District showing the VDCs under Study Area is presented in **Fig. I- 2.3** below.

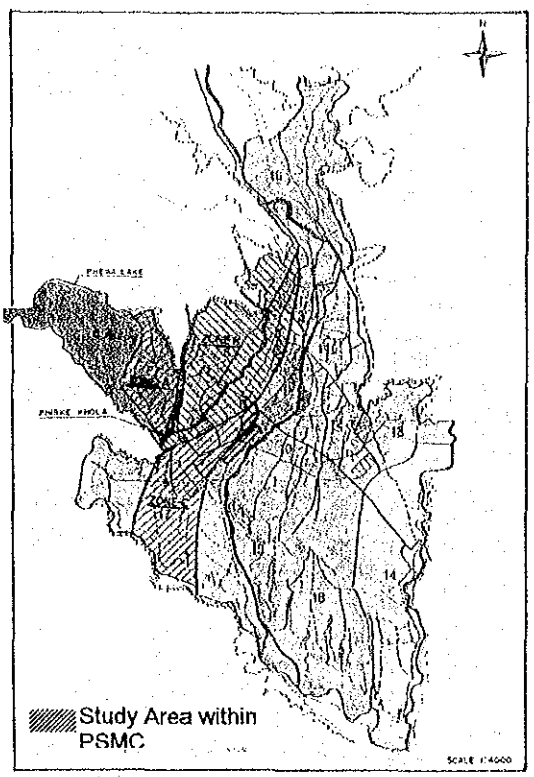


Fig I-2.2: The Ward Map Showing the Study Area under PSMC.

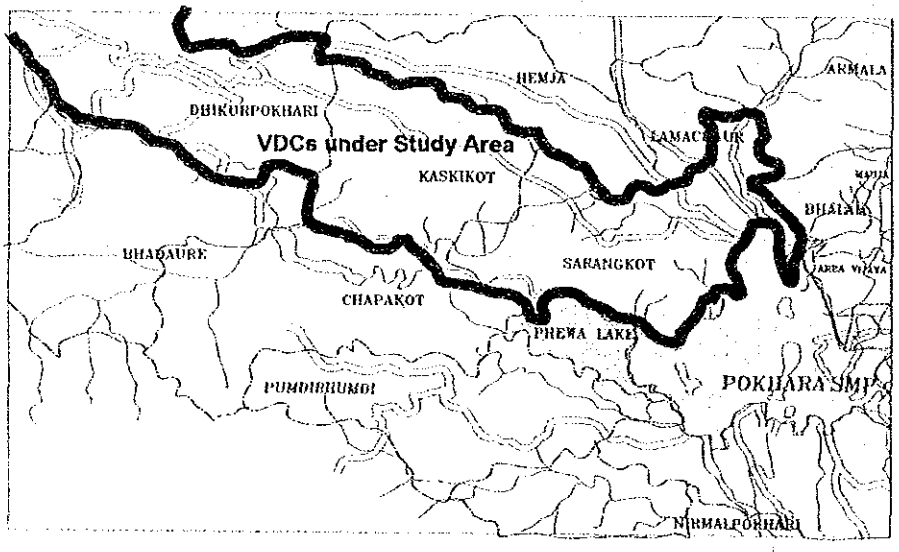


Fig. I-2.3: VDCs of Kaski District Under Study Area

2.1.4 Migration Trend

Periodic-out migration is a major source of cash income in the rural area. The adult male members from the households have been inspired to seek employment abroad.

The Focus Group Discussions (FGD) during this Study found that the landless and disadvantaged groups from occupational castes have permanently migrated to Sarangkot and Kaskikot VDCs. In addition, permanent migration to Pokhara Sub-metropolitan City has been a continuing process due to urbanization and opportunity for employment. Additionally, (8.10%) of the households from the rural area have permanently migrated to Chitwan and other Terai districts of Nepal.

In the urban area, adult male members also opt for periodic out-migration to supplement cash income. The Gurungs who have joined British and Indian armies are more motivated towards periodic out-migration to supplement cash income.

2.1.5 Literacy and Education

70% are literate in Dhikurpokhari, followed by 65% in Kaskikot and 69% in Sarangkot. In Kaskikot, the schools in ward no 1 and 2 are in the process of expansion with external resources. In Ward No. 9 of Bhadure, British Welfare Trust have formulated plan for the expansion of physical facilities for the schools. The urban people with higher level income have literacy rate of almost 80%. However, the Jalharis, who are residing in the urban Lakeshore area of the Phewa Lake are mainly dependent on fishing as main source of livelihood and have low literacy ratio. These occupational caste groups are considered as socially disadvantageous groups with socio-economic status below poverty line.

2.1.6 Economy

The present economic condition in the rural areas of Phewa Lake is characterized by subsistence agriculture system. The average ownership of agriculture land of 70% of the rural household is estimated to be around 0.5 ha. Brahmin and Chhetri caste groups possess more land than Gurung and other occupational castes. In the urban area adjacent to the Phewa Lake, the land owned by the Hotels is relatively higher with around 1.0 ha of commercial land.

The cash income in the rural area is derived from sell of livestock products supplemented by income generated from periodic migration to third countries (Arab, South Korea, Japan and Malyasia).

The urban area around the Phewa Lakeside of Pokhara Sub-metropolis derive income from tourism sector with annual income of NRs. 4.0 million on average by the hotels.

2.1.7 Agriculture Land and Distribution

The ownership of agriculture land is rather skewed in the rural area. The average ownership of cultivated land in the rural area is estimated to be 0.5 ha to 2.0 ha. Brahmin and Chhetri castes own fertile land. Irrigated land is limited in five VDCs. The estimated distribution of land by household is presented in the following **Table I-2.2.**

Table I-2.2 : Estimated Land Distribution of Three VDCs in the Rural Area

VDCs	Land				
	0-0. 5 ha	0. 5-1 ha	1-2 ha	2-3 ha	Landless
Dhikurpokhari	44	26	24	1	5
Kaskikot	36	35	8	1	20
Sarangkot	73	23	2	1	1

***Source:** Focus Group Discussion, 2001*

Agriculture Crops and Production: Given the subsistence nature of the rural economy, farmers grow cereal crops in khet land (irrigated paddy cultivation land) and bari (mainly not-irrigated upland). The crops cultivated comprise of paddy, millet, maize and potato. Vegetable cultivation in the rural area is confined to meet only household consumption and is not marketed to Pokhara city. Despite the availability to market in Pokhara city, the farmers have not been able to undertake diversification of agricultural crops to enhance cash income. This is mainly due to lack of extension services, improved seeds and training to the farmers. The average income earned by farmers in the rural area varies from

NRs. 20,000 to 35,000 per annum from the sell of agriculture and livestock products. The urban area population have to depend on vegetable imported from Chitwan, Biratnagar and India with relatively high price.

2.1.8 Food Availability

Food deficit constitutes a prominent feature in the rural areas. Field survey found that only 9% of the total households in Dhikurpokhari are able to maintain food surplus out of which some portion is marketed.

In addition, 6% of the total households in Kaskikot and Sarangkot have surplus food production. The availability of food in the remaining (3 VDCs) of the rural area are also similar indicating food shortage for most of the part of the year.

The coping of food requirement in the rural areas is supplemented with income from periodic out migration and remittance.

The distribution of food availability among the household in the rural area is summarized in **Table I-2.3.**

Table I-2.3: Food Availability in Sampled Area (HH%)

VDCs	Month				
	0-3	3-6	6-9	9-12	Surplus
Dhikurpokhari	24	33	17	17	9
Kaskikot	31	28	24	11	6
Sarangkot	32	29	15	18	6

Source: Focus Group Discussion, 2001

2.1.9 Livestock Management

The local communities in the upstream areas of six VDCs and even in some wards of Pokhara Sub-metropolis raise buffalo, rather than cow, oxen, pigs and fowls. The distribution of livestock composition in upstream areas is summarized below in **Table I-2.4.**

Table I-2.4: Distribution of Livestock Population in Upstream Areas

Livestock	Sarangkot (%)	Kaskikot (%)	Dhikurpokhari (%)	Bhadhaure Tamagi (%)	Chapakot (%)	Phumdi Bhumdi (%)
Cow/ Bullock	2	2	2	3	6	19
Buffalo	15	38	41	42	29	9
Sheep/ goat	7	20	24	20	16	5
Chicken/ Swine	0	1	0.8	0.1	0.2	0
Chicken/ Duck	21	36	29	32	46	65

Source: Annual Report, District Livestock Office and Focus Group Discussion, 2001

2.1.10 Livestock Feed and Sufficiency

Open grazing is largely practiced by the farmers in rural areas. However, crop residue (straws of paddy and millet) and grain comprise of major livestock feed used by the farmers in the rural areas for stall feeding. Perennial fodders such as Napier is being gradually introduced in the rural area.

2.1.11 Health Status

Out of the six VDCs, the community health post of Dhikurpokhari is the only one rendering better services. The local communities in the rural areas were found to be affected by dysentery and other diseases due to contamination of water. In the urban area respiratory and waterborne diseases are of major occurrence.

2.1.12 Public Facilities

Public Drinking Water Supply System, Schools, Health Post/ Sub-health Post, Agriculture and Livestock Service Center are major locally based institutions delivering services in the rural area. Some VDCs of the rural area with lack of fair weather road have to face hardships during monsoon season, and suffer due to lack of access to market and other social services.

Communication Facilities: The majority of the households own radio as main source for access to information. In addition, households in Dhikurpokhari, Kaskikot and Sarangkot also have access to TV.

2.1.13 Cash Income Source

Non-agricultural sources of income for the majority of the household in the rural area is employment outside the village. The majority of the adult male members opt for periodic-out migration to towns of Nepal and India and more recently, they have been seeking employment in Gulf countries, Japan and South Korea.

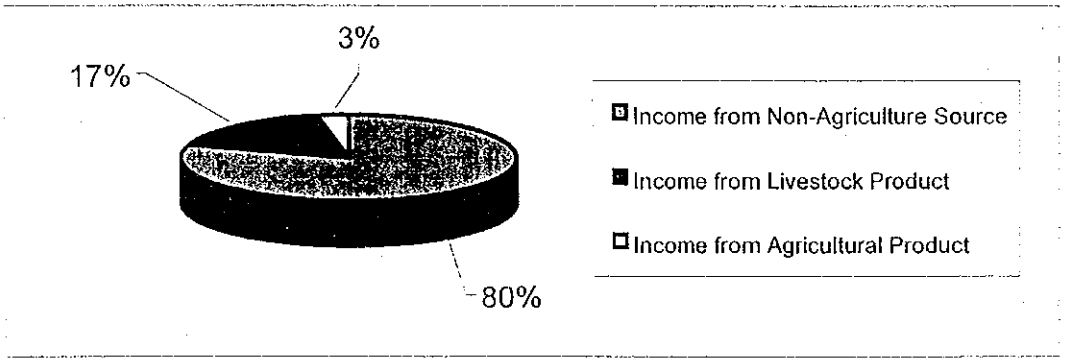


Fig. I-2.4: Income Source

Among the income sources summarized in **Fig. I-2.4**, remittance from family members working outside the village constitutes to be the major cash income source to supplement household income. Livestock raising is another important source of income. The income earned from agricultural export to Pokhara from the rural area is very limited. The major volume of vegetable supplies are from Janakpur, Chitwan, Bhairahawa and Dhading.

The majority of the urban household income in the Study Area is from tourism business.

2.1.14 Cottage Industries

The major cottage industries in the rural area comprise of furniture, "dhaka" cloth, slate and traditional vessels. The Jalahari fishermen are involved in making fishing nets.

In case of the urban areas, handicraft production constitutes to be a major potential cottage industry.

2.1.15 Gender Specification

Gender discrimination is uncommon in the rural society of the rural area. In general there is differentiation of men and women in domestic, farm and economic activities. Women household in the rural areas are overburdened in all activities. The time devoted by men, women and children of rural area for domestic and economic activities is presented in **Table I-2.5.**

Table I-2.5: Involvement in Different Activities

Activities	Time Devoted % (Hours/ day)		
	Male	Female	Children
Domestic Activities			
Fetching Water	36	57	7
Collection Fodder and Fuel Wood	39	51	10
Involvement in Environmental Conservation	72	23	5
Child Care	24	72	4
Economic Activities			
Agriculture Farming	52	40	8
Marketing of Products	46	46	8
Attending Public Meeting	71	26	3
Access of Credit	86	14	0
Decision Making	54	46	0

Source: Focus Group Discussion, 2001.

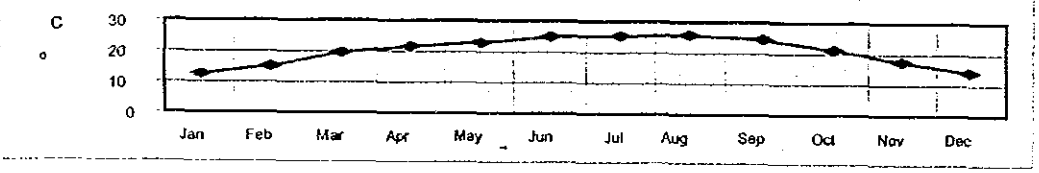
2.1.16 Village Tourism

Tourism business is concentrated mainly in urban area. Sarangkot is recently most popular destination in the VDCs, and some tourist visiting Pokhara Sub-metropolis have been trekking to Panchase hill, which is the highest hill of Phewa watershed with rich biodiversity. There are a few hotels, lodges and restaurants operated by local rural people to cater to the needs of the tourist in villages. Despite potential for wider promotion of village tourism in the rural areas, lack of adequate infrastructure has been the major constraints.

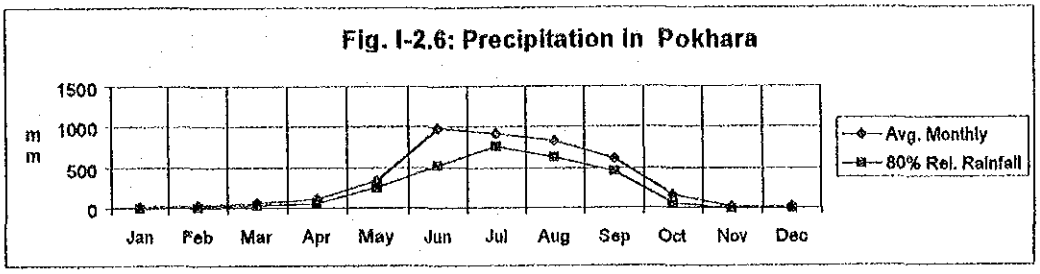
2.2 HYDROLOGICAL CONDITIONS OF PHEWA LAKE

Pokhara Valley experiences humid subtropical climate. Mean temperature vary between 12^{0}C in the winter to 30^{0}C in the summer. The rainfall pattern is monsoonal, with 80%of the total rainfall occurring during June to September. The average annual precipitation in Pokhara is 3885 mm and that of Lumle which lies at an altitude of 1675 m just outside of Lake watershed is 5407mm. This value is highest recorded so far in Nepal. The annual average runoff from the Lake has been calculated as 9.20 m^3/s. The monthly average temperature of Pokhara Valley is presented in **Fig. I-2.5** below (Source-DHM).

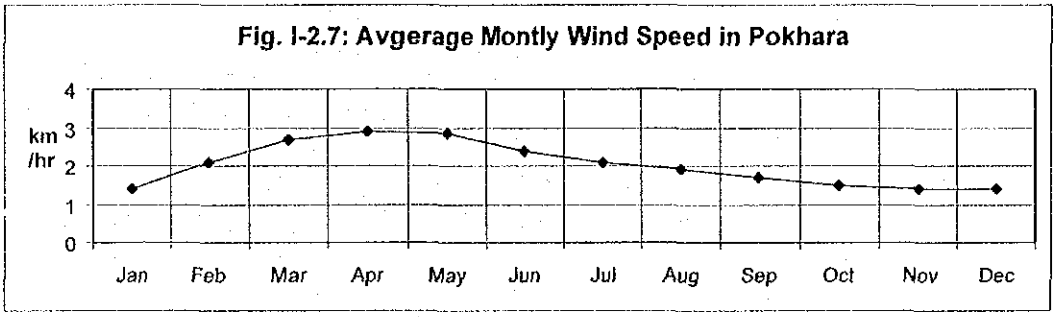
Fig. I-2.5: Avg. Temperature in Pokhara



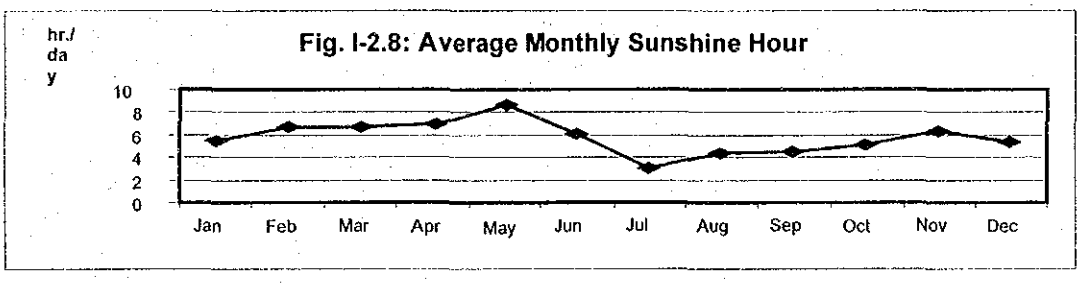
The average monthly rainfall of Pokhara valley is presented in **Fig. I-2.6** below (Source-DHM).



Wind is one of the important climatological parameter. In the dry season, the wind direction is normally northwest with little moisture. In general wind is not very strong with average annual wind speed of 22.2 km per hour. The monthly average wind speed is present in **Fig. I-2.7** below (Source-DHM).



The sunshine hour of Pokhara valley is presented in **Fig. I-2.8** below (Source-DHM).



There is a small hydroelectric plant which is fed by Phewa Lake water, stored by constructing a dam. After the construction of the Dam, the storage capacity of the Lake was increased from 30 x 10^6 m^3 to 53 x 10^6 m^3. The hydroelectric plant generates 1,000 KW of electricity throughout the year. The water from Phewa Lake is also used for irrigation. The irrigated area is about 320 ha.

2.3 WATER STORAGE OF PHEWA LAKE

Harpan Khola is the major inflowing stream of the Lake with a drainage area of about 123 km^2. Sedi Khola, Seti Canal discharge and Phirke Khola are small and temporary (seasonal) tributaries of Phewa Lake. Phewa Lake water is used for Seti Hydropower Plant and irrigation. While the monthly mean run-offs were estimated as 1.03 m^3/s in April to 34.00 m^3/s in August, the run-offs in 1989 had been calculated as 1.30 m^3/s in February to 49.06 m^3/s in August.

Probability of 30 m^3/s or higher flow occurring was 60% in September and might be noted that flushing action due to the high flow occurred till September. Gross water storage of Phewa Lake varies from 40x10^6 m^3 in the dry season to 53x10^6 m^3 in the monsoon season.

Retention times for the Lake average about 250 to 450 days from December to May; decreased to 50 to 30 days from June to July and to 18 days in mid-August. Subsequently, they gradually increased to

28 days by September and were maintained between 62 to 150 days until November. The retention time decrease to 12 days (for a few days) in July-August 1989. A decrease in the hydraulic retention time induces better mixing and aeration due to turbulence, thereby decreasing the deposition of nutrients to the bottom; decreasing primary productivity and growth of rooted plants.

Mixing effect in Phewa Lake takes place in winter season, and short and temporary mixing during heavy rainfall in August.

2.4 WATER QUALITY CONDITION OF PHEWA LAKE

2.4.1 Present Condition

(1) Lake Water Quality

(a) Eutrophication

Increase in nutrient load in Lake water has initiated eutrophication, biological growth and consequent decrease of oxygen supply in the Lake (Fleming, 1983). Excessive nutrient discharge from wastewater and run-off from agriculture fields containing nitrogen and phosphorus represent major causal agents of accelerated eutrophication. This has resulted in cases of algal bloom in Phewa Lake, particularly during 1993-1995 (refer Fig.I-2.5). Result of test carried out during the Study record a high concentration of chlorophyll "a" content at deepest point of reservoir zone (refer Table I-2.10). This indicate serious potential condition of future outbreak of algal bloom or high growth of aquatic filamentous plant in the Lake.

Comparison of Total Nitrogen (TN) and total Phosphorus (TP), both key nutrients for eutrophication, in different inlets indicate high to very high contents in inflowing streams from rural and urban area respectively. The existing level stands high to very high against the desirable level of TN (0.2-0.3 mg/L) and TP (0.02-0.03 mg/l) for the preservation of the natural environment.

Though relationship of land use to water quality is difficult to assess, the effects of nonpoint sources are found to be greater than those of point sources of pollution in Phewa Lake. This can be corroborated by the present Study finding that 60-70% nutrient load of TN and TP to Phewa Lake is from surrounding agricultural land of watershed area. Also the area lying north-eastern portion of Lakeside come under relatively more polluted zone as compared to opposite sides of the Lake.

(b) Organic Contamination

High external loading of organic nutrients from urban drainage and agriculture run-off will cause depletion of oxygen particularly at Lakeside and dam site area as compared to rural area. There will be release of nutrients from the lake bottom sediment in anaerobic condition. Such situation ultimately leads to formation of algal bloom. In severe case of continuous oxygen depletion, foul smelling occurs due to formation of hydrogen sulfide gas. This results in mass fish mortality. In one of the dry season of 1993, Phewa Lake has already experienced a case of foul smell and high fish mortality indicating critically high load of organic contamination in the Lake. Present level of biological and chemical oxygen deficiency at Hallan Chowk, Seti Canal and Phirke Khola in urban area and Andheri Khola in rural area indicate higher organic load of eutrophic level (<5mg/l). This implies case of severe oxygen depletion at the urban portion of Lakeside area. Present field survey data indicate inadequate sanitary toilet facility and absence of proper solid waste management system, which has been contributing to organic pollution of the Lake.

(c) Fecal Bacterial Pollution

The Lakeside and dam site area, especially Baidam area, which receive direct discharge of untreated domestic sewers have recorded very high level of fecal coliform, far exceeding the permissible WHO

(World Health Organization) level (SAIC, 1994 and test results of present Study) . This creates the Lake water quality at this touristically important site, unfit for swimming and other water recreation. It holds public health hazard with respect to its potential of water borne disease, skin rashes etc.

Recent record on level of fecal pollution load indicate very high level at Phirke Khola and Hallan Chowk drain, both lying in urban area as compared to relatively low at Chankhapur lying in rural area (refer **Table I-2.6**).

Table I-2.6: Mean Values of Water Quality Parameters at the Sampling Points

Parameters	Unit	Adheri Khola	Harpan Khola	Chankapur	Sedi Khola	Seti Canal	Phirke Khola	Hallen Chowk	Barahi Chowk Boat Dock	Lake Reservoir	Fish Tail Lodge	Damside	Damside Irrigation Canal	Phusrae	Dam Side Drain	Principal
TC	cfu/ 100ml	$1.2x10^3$	$8.4x10^2$	$3.9x10^4$	$8.7x10^2$	$7.1x10^3$	$3.5x10^4$	$1.4x10^5$	$1.4x10^4$	$5.9x10^3$	$5.5x10^3$	$1.3x10^4$	$1.3x10^4$	$6.4x10^3$	$9.5x10^4$	<1000 /100ml
FC	cfu/ 100ml	7.1x10	4.0x10	$1.7x10^2$	4.6x10	$2x10^3$	$8x10^2$	$2.2x10^3$	2.5x10	10	$1.4x10^2$	$4.2x10^2$	$1.2x10^2$	$1.1x10^2$	$7.6x10^3$	
TN	mg/l	0.97	0.79	1.59	0.78	1.65	3.14	3.13	1.36	2.46	1.21	0.84	1.54	1.22	21.69	<0.3
TP	,,	0.12	0.17	0.13	0.26	0.13	0.08	0.40	0.09	0.06	0.07	0.09	0.12	0.04	1.54	<0.03
COD ($KMnO_4$)	,,	1.74	1.76	1.28	2.1	2.61	2.4	10.72	1.84	2.08	1.04	1.28	1.60	1.28	36.0	<20.0
BOD	,,	0.25	0.42	0.67	0.52	1.92	1.21	6.67	1.44	1.14	0.72	1.13	0.34	0.21	17.5	<5.0
Chlorophyll -a	µg/L	-	-		-	-	-	-	2.4	15.59						<3.0

Source: Field Sampling and Testing, 2001/2002 (Oct.-Jan.)

Note: TC - Total Coliform, FC - Fecal Coliform, TN -Total Nitrogen, TP - Total Phosphorus

(d) Contamination by Agriculture Fertilizers

Most local people are not aware of technical knowledge on appropriate dosage of chemical fertilizers. Their over use combined with unscientific traditional terrace farming practices have led to an increase in entry of nutrients through run-off from these agricultural fields in the Lake. This trigger water pollution in the form of eutrophication of Phewa Lake.

(2) Lake Sedimentation

Land use analysis indicate nearly half of the land in watershed area of Phewa Lake is under agricultural land including irrigated lowland level and non-irrigated upland steep terrace. The drainage inlet at urban area not only carries organic pollution load but also sediment load resulting formation of delta at their inlets (Seti Canal). It is estimated that during the period of 1990-94, annual sedimentation rate has a high range of about 175,000-225,000 m^3/year. At the continuation of this rate of sedimentation, the open Lake water portion will decline and subsequently the Lake will be filled-up by next 190 years, assuming loss of 80% to 100% of water volume. It is estimated that up to 70% of sediment load is carried by Harpan Khola, which is the major source of Lake water (SAIC, 1994; Sthapit et. al., 1998).

(3) Lake Ecosystem

(a) Unsustainable Use of Wetland Habitat

The flood prone wetland habitat of Harpan Khola is subjected to unsustainable use such as intensive farming of rice along with ploughing activity right up to the Lakeshore margin without buffer zoning. It is reported that 3000 ropanies (150 ha) of land has been even registered illegally, mostly during the collapse of Phewa dam by early 1970s. Such practice has threatened the ecosystem of the Lake.

(b) Loss of Bio-diversity

Uncontrolled growth of water hyacinth due to nutrients from agricultural land, deposition of solid wastes and cases of extensive algal growth have reduced aquatic biodiversity of both flora and fauna of the Lake. The abundance of zooplankton or microscopic aquatic animals in Phewa Lake follows the pattern of eutrophic or polluted lakes. In Phewa Lake, the population of native species like Sahar (Himalayan Trout), Bam (Eel), and Asla (Snow Trout) are becoming rare. While the population of fishes like Silver Carp and Big Head Carp has increased significantly. The decreasing biomass of native fish is also recorded in the yield of the year 2000/2001. If the pollution level continue to increase above the existing level, economically important and excellent game fish like Shahar, Katle and Asala will disappear from the Lake.

In this Study, only seventy-one species of birds in Phewa watershed area were recorded, whereas the previous studies noted more than 350 species of birds from the same area during the summer and winter seasons of 1972. Thus diversity and population of birds appear to be sharply decreasing. Long distance seasonal migratory and globally significant rare birds such as demoiselle crane and wild duck, which used to visit Phewa Lake from Siberia region, have stopped to visit it any longer. According to the villagers, the population of mammals is also declining, suggesting that the environment of the area is becoming unfavorable to many species.

(4) Impact of Degraded Lake Environment on Local Economy

The greenish cast of Lake, prevalence of water hyacinth, garbage, sediment and dead animal bodies with wandering pigs and buffalo wallowing along the Lakeshore gives a dirty look to the Lake. Its recreational value such as boating, swimming as well as fish production potential has gradually declined. All this has resulted in decline of aesthetic beauty of the Lake and its surrounding areas. This will lead to decline in interest of tourist to visit the Lake, which will ultimately cause significant adverse impact on local economy.

(5) Lack of Environmental Awareness

People, both at urban and rural areas are not environmentally aware on the harmful impact of their activities on the quality and healthy survival of Phewa Lake. There has been inadequate change in attitude and practice of local people in adoption of environment friendly approaches. People at urban areas are directly draining their wastewater and sewer in to the streams and drains that finally discharge in to the Lake. Open bottomed septic tanks allow seepage of septage in to the Lake. Illegal connection of the domestic waste water pipes in to the storm-water drainage that discharge into the Lake indicate lack of environmental consciousness of the hotel/ restaurant owners, as well as urban households in general. There is inadequate enforcement of laws by the concerned local agencies.

(6) Lack of Responsible Institution and Resource Generation Source

Based on the present legal system, at present there is no distinct central or local level authority which is responsible for sustainable management and development of the Lake. However, some committees have been formed for this purpose, such as Phewa Lake Area Conservation Committee with representation from all the related district level HMGN line agencies, DDC and Pokhara Sub-metropolis (PSMC). However, it has remained grossly inactive for carrying out necessary environmental conservation of the Lake. Similarly, despite establishment of Phewa Trust Fund for

generating financial resources to be used for environmental conservation of the Lake, there is general lack of support from both government and private sectors despite their commitment for annual contributions.

2.4.2 Annual Trend

Fig. I-2.9 shows the monthly distribution of Chl-a at Khapaudi, observed by Fisheries Research Centre. The temporal distribution shows that the level of Chl-a concentration is high during March-April and post-monsoon season (after rainy season). The high concentration during March-April is mainly due to increase in water temperature and sunshine hours. However, the increase in concentration during post-monsoon season attributes excessive addition of nutrients into Lake from *nonpoint sources*.

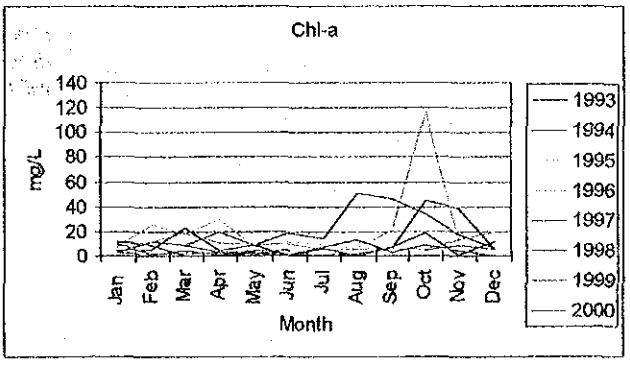


Fig. I-2.9: Temporal Distribution of Chl-a at Khapaundi, Phewa Lake

Similarly, annual trend of various key water quality parameters at Khapaundi is presented in following **Fig I-2.10.**

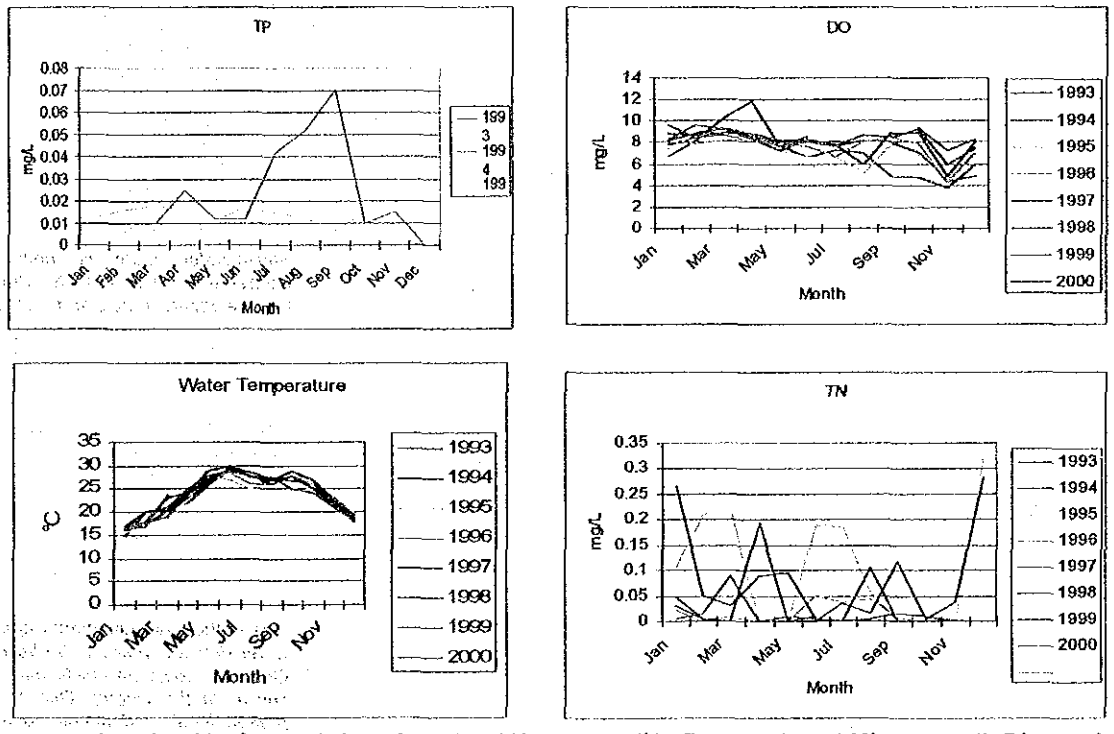
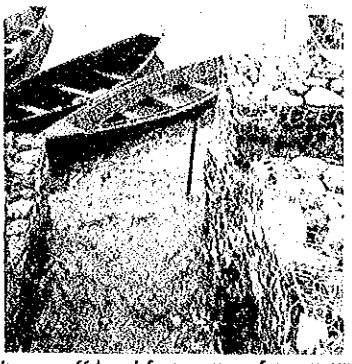


Fig. I-2.10: Annual Trend of Key Water Quality Parameter at Khapaundi, Phewa Lake

2.5 SEWERAGE SYSTEM IN URBAN AREA

The urban areas under Phewa Lake watershed completely lack an efficient sewerage system. Most households in the urban centers have traditional system of septic tank combined with soak-pits. The recent household survey conducted under this Study suggested that 94 % of people located in service area have private septic tanks and soak-pits. However, 77 % of these are bottomless, unsanitary and non-standard. 6 % of population does not have septic tank or even toilets, and they use open space for defecation. The septic tanks are connected to the lavatories or human excreta and soak-pits for liquid disposals. The liquid in the soak-pits are allowed to percolate freely from the bottomless septic tanks. Also, during heavy rain, the households discharge their sewage and septic tank overflow opening on street drains which are carried by rainwater into the Lake. Thus, ultimately, the septic tank overflow and seepage finds its way into the Phewa Lake.



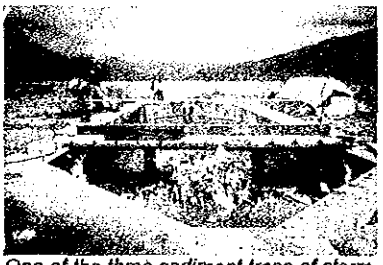
High run off load from one of open urban drain. Construction of storm-water drain will further increase the load in future.

Storm-water drainage has been constructed within the city in recent years by PEIP under Second Tourism Infrastructure Development Project. It has been reported that a large number of household including hotels have connected their households sewers into the storm-water drains. Although this is an illegal act, very little success has been achieved to distract people in reversing the trend. The future concentrated load brought by the storm-water drain mixed with domestic wastewater will cause further pollution load in the Lake.

Milky colored polluted water entering into Phewa Lake from the same open urban drain during dry season

Nepal Water Supply Corporation (NWSC) is responsible to provide potable water supply for household, municipal, commercial and industrial usage in conjunction with sewage management, including recently constructed storm-water drain. The water supply situation of Pokhara city at present is not adequate to meet the demand. The per capita consumption of water supply in Pokhara city currently is designed to be 130 liter per day per person. The statistics suggests that total demand of water supply in Pokhara city is about 25.3 million liter per day against the maximum supply capacity of 23.4 million liter per day. Moreover, the loss estimated in conveyance system is about 45 percent. Thus, the supply of water is far less than demand due to inadequate supply of water. The people, hotels and restaurants near the Lakeshore are using Phewa Lake water for cleaning and other purposes.

Storm-water drain is being illegally connected with wastewater drain by the local residents, hotels and restaurants.



One of the three sediment traps of storm-water drains planned to be built by PEIP. Only one could be finally built (the one shown in the Photo). Due to aesthetic reason, local residents did not allow PEIP to construct the remaining two sediment traps.

2.6 WATERSHED CONDITION

2.6.1 Land Use in Watershed Area (Present)

Phewa Lake watershed lies in the Mahabharat Range and is

situated in the western part of Pokhara Valley, Kaski District. The terrain in general is rugged comprising of several folds of steeping hills and tropical to temperate in climate and vegetation.

The hills are mainly made up of metamorphic schist phyllite and quartzite. Sandy gravels are distributed in the hill slopes and unconsolidated sediments are found in the alluvial fan deposits. The geological condition is generally fragile i.e. there are large scale thrust faults and many small faults and thus the rocks have undergone intense deformation in many places.

The watershed area of Phewa Lake suffer from severe natural conditions. 9% of the watershed area is too steep (above 60% slope) needing perennial vegetation and 55% of the area having 30-60% slope need intensive care for human use. The average slope of Harpan Khola and its tributaries range from 5% in the Harpan Khola to 25% in Marse Khola. Such natural conditions are major forces that induce watershed degradation. However they are beyond human control.

Harpan and Andheri Khola are the main rivers feeding the Lake. Several soil conservation activities have been performed to control the sedimentation in the Lake in past, but as yet the transportation of sediment has not been considerably reduced. Nevertheless some of the exposed areas have been vegetated.

The soil in the Study Area mainly consists of planosol, podzol and lithosol, the latter being erosive, and infertile, and, therefore unsuitable for crop production.

Table I-2.7 : Land Use in Phewa Lake Watershed Area

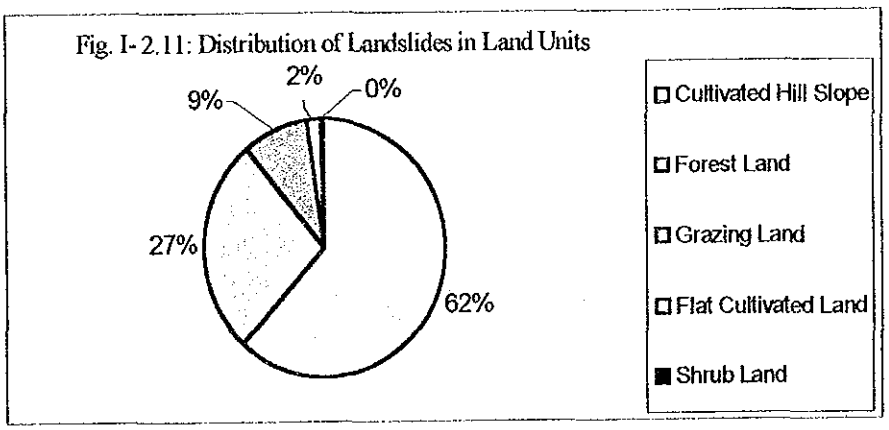
Land Use Category	Area (km²)	Percent (%)
Hill agricultural land	40.3	32.9
Lowland and tar agricultural land	7.0	5.7
Forested area	54.3	44.3
Shrub forest	3.5	2.8
Pasture and barren land	4.5	3.7
Urban land	5.7	4.7
Lake	4.4	3.6
Rivers and Others	2.8	2.3
Total	122.5	**100.00**

Source: *The Land-use Map of Leminen, K.et al., 1991, IWMP and Sikrikar et al., 1996 and the Areal Photos of 1996*

The maximum annual soil erosion amounts to near 23.5 tons/ha/year in Sasurke Khola sub-watershed in Chapakot VDC on annual average of 12.2 tons/ha/year in the entire watershed. (HMG/FINNIDA 1992).

Landslides and gullies cover about 5.69 km² (almost to the size of urban area) of which 61.8% landslides occur in the cultivated hill slopes and 26.7% in the forest areas **Fig. I-2.11** (Sikrikar et al., 1998).

Fig. I-2.11: Distribution of Landslides in Land Units



Highly degraded sub-watershed areas are Harpan, Sasurke Khola and Betani Khola (Kaskikot VDC). However, in terms of areal, Betani sub-watershed receives priority for watershed management and landslide protection purposes.

2.6.2 Sedimentation of Lake

A bathymatric map of Phewa Lake (MOFC, DSC, 1994) is presented in **Fig I-2.12** below.

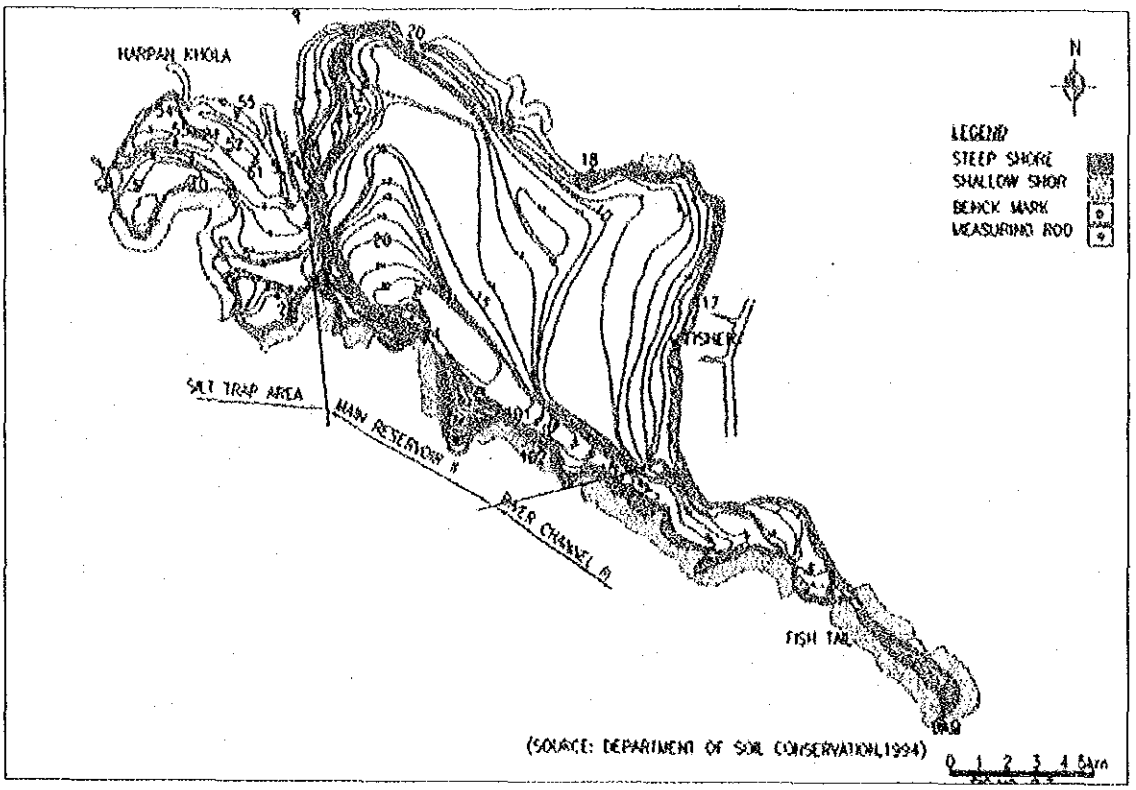


Fig. I-2.12: Bathymetric Map of Phewa Lake (1994)

Based on the sedimentation survey of Phewa Lake from March 1990 to February 1998, the average annual sedimentation rate in Phewa Lake is about 180,000 m^3 and in the silt trap area of the Lake is 94,000 m^3. Rapid sedimentation in the Lake started the formation of delta at the mouth of Harpan Khola. Through the comparison of aerial photographs of 1973, 1989, 1991, 1994 and 1996, it was observed that about 25.5 ha. of delta has been formed between 1973-90, additional 12.9 ha. of delta between 1990-94 and 4-6 ha. between 1994-96. Thus the delta formation has continued at the rate of about 2 ha. annually since 1973. Meanwhile, the Harpan Khola is also shifting its course within the deltas. It drained the upstream part of the silt trap area during 1989-91, the down stream part during 1991-94 and the main reservoir area near the end part of the silt trap area at present. If the present average annual sedimentation rate continues, 80% of Phewa Lake storage capacity would be silted up in the next 190 years (Sthapit & Balla 1998). Much of the sediment load reaching Phewa Lake is carried by Harpan Khola but the ultimate sources of sediment are stream bank/riverbank cutting, landslides, irrigation canals, road/trail construction without slope stabilization/proper conservation measures and agricultural practices further upstream in rural watershed area. The proportion of land affected by landslides above is 4.68% which transport 200 tons/ha. However, boulders and cobbles are not transported into the Lake but clay is the dominant material of sediment in the Lake. The major source of this material is slash and sheet erosion.

Sediment transportation efficiency in the watershed is also affected by the slope gradient of the river system. Marse Khola, Khahare Khola, Sidane Khola, Hadi Khola and Singare Khola have 25%, 23%, 22%, 22% and 19.2% average slope respectively. The first, third and fourth river system run

through the northern forested aspect of the watershed and south of the Harpan Khola (beyond the scope of the Study). Hence, the sub-watersheds of the southern aspect of the watershed particularly Khahare and Sidane Khola need greater attention for watershed management programs. Moreover the sediment contribution from the sub-watershed areas directly draining into the Lake will be more than the distant sub-watersheds. This is more so in case of the sub-watersheds lying in the southern aspect.

Besides the Harpan, the major Kholas/streams responsible for carrying sediments are its tributaries, namely Andheri, Handi, Tora, Thiri, Marse, Noule, Betyani etc.

Table I-2.8: Landslide Zone Status in VDC and Sub-watershed

VDC / Magnitude	Sarangkot	Kaskikot	Dhikur-pokhari	Bhadaure Tamagi	Chapakot	Pundi Bhumdi
Large	1	1	-	3	1	-
Medium	3	2	4	3	-	3
Small	6	6	19	13	10	1
Total	10	9	23	19	11	4

NB Large: >200 ha, Medium: 100-200 ha; Small: <100 ha

Dhikurpokhari VDC is the most sensitive landslide zone area, followed by Bhadure Tamagi VDC. However the latter contains more large sized landslide zones.

2.7 ECOSYSTEM CONDITIONS

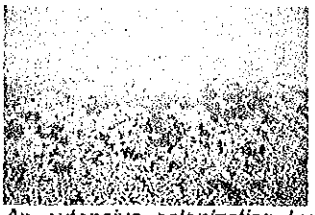
The Study Area belongs to a semi-agricultural watershed and a mid hill (800-2500 m asl) mountain ecosystem. It can be broadly divided into 3 ecosystems: aquatic, wetland and terrestrial. The aquatic ecosystem in turn constitute 2 distinct zones: limentic (central zone with deep open water) and littoral swampland (peripheral/ shoreline with shallow depth) zone of Phewa Lake. The wetland ecosystem consist of swampland and marshland located along the floodplain and inlet mouth portion of Harpan Khola and other inlets e.g. Phirke Khola, Sedi Khola and Seti Irrigation Canal etc. Most wetland sites are converted into rice field and some are left as wastelands subjected to solid waste disposal. The terrestrial ecosystem consists of different land use types: forest, grazing land and agricultural land. Urban and rural settlements are located along Lakeshore and hill slopes respectively. Villagers are interspersed into agricultural lands and slums has been developed by the Lakeshore.

Land use has been significantly modified, such as conversion of forest area into either agricultural land or into grazing lands. Open spaces are fast disappearing in urban area and adjacent agricultural level terraces are gradually being converted into housing development area due to growing and unplanned urban expansion. Inadequate management of drainage, sewerage, road condition and housing development and rapid increase in population growth have led to an increase in water, air, solid waste pollution and high noise level at prime tourist area. Natural forest patches lying at crest of hills, community managed forest blocks and steep slope rocky barren area is relatively less human disturbed.

- **Floral Diversity**

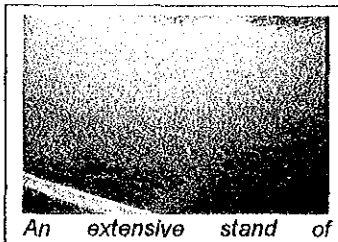
The biodiversity status of the Study Area records a substantial richness in floral and faunal species. There has been record of 75 plant species comprising trees, shrubs and herbs at terrestrial forest. The common tree species include *Schima wallichii, Castanopsis indica, Alnus nepalesnsis, Shorea robusta, Bombax ceiba, and Ficus spp.* Notable economically important and commercially threatened species under IUCN Red Databook include: *Swertia chirayita, Bergenia ciliata, Choreospondias axillaris, Elaeocarpus sphaericus.* Protected species in forest area of Raniban, Andau and Bhadaure

Tamagi include: *Psitotum nudiusm sp*, (a living fossil fern plant), *Podocapus neriifolia, Shorea robusta, Bombax ceiba,* as well as several orchid and lichen species, of which most except the first one come under HMG/N list of protected species banned for cutting and export. Alien invasive species include "ban mara" Crofton weed/ *Eupatorum adenophorum*, and 'Masino kande" Lantana/ *Lantana camara.*



An extensive colonization by Trapa quadrispinosa during summer season in Phewa Lake

There are record of 29 phytoplankton species, 39 species of aquatic macrophytes comprising 23 hydrophytes, 16 helopghyte species and 20 phytoplanktons. Common submerged, floating and emergent species include *Hydrilla verticillata, Nymphoides indica* and *Leersia hexandra* respectively. The problematic alien invasive species include: "Jalkumbhii" water hyacinth/ *Eichhornia crassipes,* coon tail/ *Ceratophyllum demersum* and torpedo grass/*Panicum repens.* Economically important species include: Hydrilla as feed for grass carp, edible nuts of Water chestnut/ *Trapa bispinosa, Cutgrass/ "Karaute" Leersia hexandra* and wild rice/ *"Nabodhan" Oryza rufipogon* as fodder.



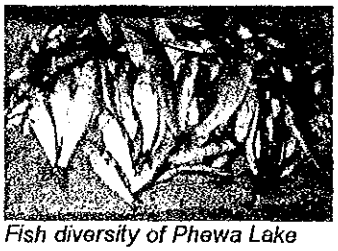
An extensive stand of submerged Vallisneria spiralis in Phewa Lake

- **Faunal Diversity**

There has been record of 18 zooplankton species. Common species include rotifers, copepoda and cladocera. Comparatively zooplanktons were more abundant at the mixing points of Seti Irrigation Canal, Khapaudi and Phirke Khola than at other parts of the Lake. The copepoda are represented by *copepod naupli, cyclops ricinus and eodiaptomus japonicus.*

- **Fishery Resources**

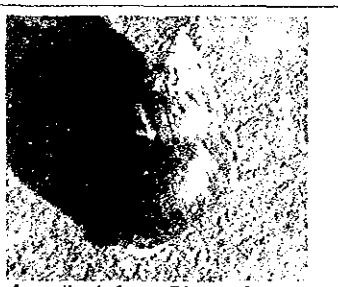
The fish species reported from Phewa Lake are 24. Out of 24 species 18 were collected during the Study period. Phewa Lake support diverse species like snow trout (*Schizothorax richardsonii*), large scale barbel (*Tor putitora, Tor Tor, Neolissocheilus helagondepis)*, in addition to exotic carps which include grass, big head, common and silver carps. "Sahar" and "Katle" are decreasing. Total yield of fish from the Lake is 65 metric ton per year.



Fish diversity of Phewa Lake

- **Cage Fish Culture**

At present there are 11,291 m^3 of cages in the private sector and over 5,000 m^3 of cages in the public sector in Phewa Lake. The species of fish raised in the cages are mainly silver carp and big head carp. Both these species are planktivorous and feed on phyto and zooplankton, thus helping to reduce the plankton population when the fish are stocked at reasonable densities. Other stocked species are grass carp which graze on aquatic weed and help to reduce the aquatic microphytes in the Lake, as well as common carp *(cyprinus carpio,)* rohu *(labeo rohita)* and naini *(Cirrhina mrigala)*, which feed on the detritus, colum feeders zooplankton and other wastages at the bottom of the shallow parts of the Lake. Total fish yield from cages is 33 metric ton per year. However, at present rate of degrading water quality, the yield of fish will sharply decrease, as the previous trend has indicated. This will bring economic loss to the fishermen.

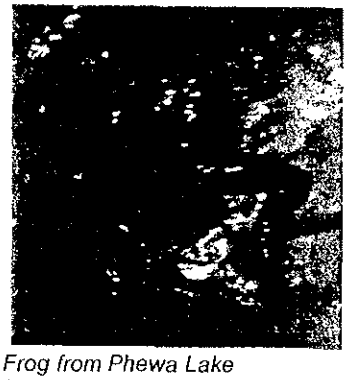


A mollusk from Phewa Lake

- **Amphibians/ Mammals/ Birds**

One phython and two frogs *Bufo melanos tricutus, Rana tigrina* were observed. Thirty species of mammals were recorded during the field survey. Out of these species leopard cat and clouded leopard are protected species under Nepalese law. All of the mammalian species were reported to be living in forest and shrub lands. However bats, rats and shrew are common in the villages and cultivated lands. Seventy one species were recorded during the field observations. Sixty species are common to Phewa Lake watershed and 18 species are seen occasionally. Among the seventy one species 14 are migratory birds and remaining 57 species are native to the area.

District morphometric and hydro-biological differences along northern and southern shore of the Lake exhibit contrast conditions of eutrophic and oligotrophic condition. This highlight apparent impact of human disturbances and land use type variation in the status of biological diversity of the Lake.



Frog from Phewa Lake (Rana tigrina)

2.8 SOLID WASTE MANAGEMENT SYSTEM

The solid waste management of entire Pokhara Sub-metropolis (PSMC), including the Lakeside area of Phewa is carried out by its separate department. It was noted during field survey that only 40% of the total generated waste is collected by PSMC and dumped directly into the gorge of Seti River. Similarly, a schedule has been prepared for sweeping of street of PSMC, including the Lakeside area.

2.8.1 Waste Generation

The following **Table I-2.9** presents generation and physical composition of municipal solid waste.

Table I-2.9: Generation and Physical Composition of Municipal Solid Waste by Wet Weight & Volume (Average Value for Pokhara Sub-metropolis)

Waste Generation: = 153.0 m^3/d by Wet Volume and 61.2 t/d by Wet Weight

S.N.	Materials	Wet Weight		Wet Volume	
		%	tons/day	%	m^3/day
1.	Inert Materials	23.3	14.3	16.5	25.3
2.	Organic Matters	47.5	29.1	29.8	45.6
	2.1 Bio-degradable	44.3	27.1	24.3	37.2
	2.2 Others (Bamboo, Wood, Bones, etc.)	3.2	2.0	5.5	8.4
3.	Metal	0.7	0.4	1.0	1.5
4.	Paper/carton	5.8	3.6	8.9	13.6
5.	Glass	2.0	1.2	1.1	1.7
6.	Plastics	13.2	8.1	34.2	52.3
7.	Textile/Jute	4.4	2.7	4.9	7.5
8.	Rubber and Leather	2.2	1.3	2.7	4.1
9.	Others	0.9	0.6	0.9	1.4
	Total	100	61.2	100	153.01

Source: PSMC

Out of total waste generation, inorganic recyclables (which include metal, paper/carton, glass, plastic, textile/jute, and rubber/leather) consist of 17. 3 tons/day. Organic recyclables (Bamboo, Wood, Bones etc) consist of 2 tons/day. Biodegradable organic waste consists of 27.1 ton/day.

2.8.2 Existing Practice

The existing waste management practice is presented in following **Table I-2.10.**

Table I-2.10: Existing Waste Management Practice

Practice	Volume		Weight	
	%	cum	%	Ton
Composting	5.8	8.9	9.9	6.0
Recycling	8.9	13.6	8.9	5.5
Burning	7.6	11.7	4.1	2.5
Municipal Collection form Street & Households	20.2	30.8	20.2	12.3
Illegal Disposal in Street, Public Places, Drains, Rivers, Uncollected Waste	57.5	88.0	56.9	34.9
Total Waste Generation	*100*	*153.0*	*100*	*61.2*

Source: PSMC

2.8.3 Waste Characteristics

One of the survey carried-out has recorded the estimate of 5.4 tons/day of recyclable waste collected by the Kawadis (rag pickers) mainly at the source of waste generation against the potentiality of collecting 22.7 tons (including 17.3 tons recyclable waste thrown away by the people and 5.4 tons collected by the Kawadis at the source). The existing recycling practice is estimated to be 8.9 % of the total waste generation.

Bio-degradable Waste Generation & Composting Practice: Sample survey carried out during study identified 23.8% of the households already involved in composting practice. Total estimated percent of households involved in composting is 37.7%. The survey has observed big differences in composting practice between toles (areas within wards) and wards. They are mainly caused by the characteristics of the toles and wards including household and population density, settlement patterns, their urban nature, households with and without practice of kitchen garden/farming, lack of composting knowledge and skill of the people and lack of willingness to be involved in composting.

2.8.4 Waste Management at Lakeside of Phewa

An impressive trend was observed at the urban part of the Study Area that people do not throw waste at the street side but keep into plastic bags and dispose into the waste collection tractor that serves the area on alternative days. This has contributed to keep the street side clean. The residents, particularly hotels and restaurants, have also demonstrated the enthusiasm for an efficient waste management as they shared 50% of cost with PSMC to buy a new tractor with trailer for collection of solid waste regularly (daily) from the Lakeside area. The residents, hotels, restaurants and commercial shops paid NRs. 50.00 per month for the services. However, later this tractor was engaged in collecting waste from other areas of the Sub-metropolis and the service started to become irregular. Due to this, households stopped paying for the services. Solid waste and garbage has been observed to be dumped in the streams or canal entering the Lake. The discharge point of Seti Canal and Phirke Khola is full of plastic, waste and dead animals. Trash-rack of irrigation canal is blocked by solid waste. An urgent need of an efficient waste management system is immediately necessary to keep the Lake and its shore areas free from openly dumped waste and reduce organic pollution load in the Lake.

2.9 ENVIRONMENTAL EDUCATION IN THE STUDY AREA

2.9.1 Governmental Organization

Relevant HMGN agencies have respective environmental education and extension program and services, as presented below:

- **Department of Agriculture:** Agriculture information, education, communication and extension services is institutionalized. Field-based basic level technicians are provided regular training, who advise and motivate farmers on new techniques and improved seeds and saplings.
- **Department of Soil Conservation and Watershed Management:** The programs include mainly mass awareness campaign, which includes lecture, audio/video presentation, afforestation, essay competitions, title award, training of trainers etc.
- **Department of Forestry:** It provides training to the user groups, and in-service training to middle level technicians and officers.
- **Women Development Office:** The training programs includes conservation topics.
- **Non-formal Education Department of Ministry of Education and Sports:** It has conservation related topics in the curricula.
- **Health Education, Information, and Communication Centre, Ministry of Health:** It is involved more on the publication and mass communication of educational materials, training workshops, and demonstration.
- ***Environmental Education in Schools:*** *There are topics related to conservation in the curricula* for environment, science, health and social studies. The curricula devotes about 10% of total course time. However, it lacks trained teachers.

It has been realized that due to lack of resources and skilled manpower, that is common in developing country, it would be difficult for government agencies to solely undertake the environmental education program at the grassroots level.

2.9.2 Non-governmental Organization

Several NGOs are performing extension services in the field of conservation. They undertake exemplary work with the local people. There are more than 571 NGOs registered with Kaski District Development Administration Office. About 479 NGOs are said to be active. However, they also lack trained staff and resources.

The various programs assisted by NGOs related with income generation activities in Phewa watershed areas belong to various farm and off-farm activities such as (i) horticulture, (ii) animal husbandry, (iii) fisheries, (iv) poultry farming, (v) manual wheel spinning, (vi) rope belt making, (vii) household goods from bamboo, jute, (viii) mushroom farming, (ix) sewing, knitting, (x) handicrafts, (xi) coffee farming, (xii) beehive farming,, (xiii) ginger, turmeric, cinnamon, and amriso farming, (xiv) seed production, (xv) herbs farming etc.

2.9.3 Community-based Organization

Numerous community-based organisations and social groups have been working in the Study Area. Community level committees and organizations have been formed in various watershed, community forestry, irrigation, water supply, micro-credit, local area improvements and other community-based programs. The committees mostly consist of local leaders, beneficiaries and women. In many cases

they are no more functional after completion of targeted activities. In some cases they are still active. They help promote people's participation in conservation and represent the local people's voice in decision making and other processes.

In urban area, formation and functioning of Tole Area Environment Improvement Committees have been popular mainly after intervention by ADB-funded Public Environment Education Program.

2.9.4 Environmental Education in Community

- Public understanding of major environmental issues is found to be poor
- There is lack of interaction and transfer of techniques due to which exemplary work done by communities at certain locality could not get replicated
- Lack of practicing on at least what is known
- Tendency to reap immediate benefit rather than plan for future
- Mass media has been popular for getting general information but have limited effect in changing the behavior

- **Radio**: Conservation-oriented programs including forestry, agriculture, science, health and sanitation comprise about 8% of total radio hours, but timing of broadcast does not match with the listeners' time
- **Newspaper/Newsletters**: They carry news from time to time on soil conservation, deforestation, floods, landslides, epidemics and environmental events. They have a low circulation
- **Films**: More than 3 dozens environmental films have been made. But they are not accessible to the general public.
- **Posters/Pamphlets**: The conservation agencies have produced many types of posters/ pamphlets. The people reported that the posters damage aesthetic environment and suggested that they should be rather used for stimulating discussion.
- **Exhibition/Demonstration**: Conservation institutions have occasionally organized the exhibitions/ demonstration. But they are not regular.
- **Television**: Nepal Television occasionally telecast conservation related program.

2.9.5 Municipal Public Environmental Education Program

Pokhara Environmental Improvement Project under ADB financed Second Tourism Infrastructure Development Project included Public Environmental Education and Staff Training Program as an important component.

The Public Environment Education and Staff Training Program component accomplished studying existing waste management practice and sanitation facilities, estimating waste generation quantity and quality and assessing needs of environmental education, community consultation and enhancing capability of PSMC to sustainably undertake such activities. It also prepared municipal and community level rules and regulation and participatory action management plan. The Project designed, prepared and undertook public environmental education programs, with following activities

- Developing public environmental education plan
- Developing environmental education materials and methodologies
- Pilot testing environmental education program
- Community-based institutions building for environmental education and improvement system
- Developing municipal capacity by undertaking municipal staff training

- Establishing and strengthening Environmental Education Section within municipal organizational structure.

Apart from the institutional strengthening of the PSMC, the project incorporated the institutional strengthening of community groups also. Local Environmental Improvement Committee has been formed by the communities at each tole area where the program has been initiated, giving institutional base for the sustainable environmental improvement process.

Table I-2.11: Local Organizations in Phewa Lake Watershed Areas

Ward	No. Tole	Ward Environment Committee Members No.	Volunteer CBOs	Volunteer NGOs	Volunteer Women Groups	Active Volunteer Local Organizations
1	28	23	20	4	3	27
2	13	17	7	1	3	15
3	9	11	6	2	4	12
4	8	17	9	2	4	15
5	11	9	5	3	4	11
6	14	21	12	3	1	16
7	9	9	2	1	4	8
8	18	9	12	3	5	20
9	21	13	7	3	4	14
17	19	17	9	2	6	17
Total	165	146	89	24	30	244

Source: *PSMC, 2000*

2.10 ENVIRONMENTAL MANAGEMENT SYSTEM IN THE STUDY AREA

2.10.1 Legal Framework for Aquatic Environmental Conservation

Some of the relevant state and local level legislative measures for aquatic environment conservation in the country, which will also be applicable in the Study Area is listed in following Table I-2.12.

Table I-2.12: List of Aquatic Environmental Conservation Related Legislation of Nepal

Year	Legislation	Details
1961 amended in 1999	Aquatic Lives Protection Act Clause nos.3,4,5	It provides legal protection of the aquatic animals and their habitats. It bans application of harmful fishing gears such as explosives, poisonous chemicals, electric rod, hunting of waterfowls and destruction of water resource development related infrastructures. The first amendment in Section 5a permits only the use of safe pesticides in case of any poisonous material is to be used for catching aquatic life. Penalty measures include fine of up to NRs.5000 and confiscation of any destructive items.
1982	Soil Conservation and Watershed Conservation Act	It empowers HMGN to declare any area as a protected watershed area. The Act outlines the essential parameters necessary for proper watershed management (including both of rivers and lakes). It is also authorized to implement land use planning system, prohibit activities that trigger soil erosion. Maximum penalty measure for violators include a fine of NRs. 1,000 or imprisonment of 1 year or both.
1992	Water Resources Act Clause nos.3,7,18, 20,22,24	It implies state ownership of any surface/ground water bodies of Nepal and stress on utilization of water resource by any individual or organization without causing harm to others in terms of landslide floods. It embodies that HMGN can fix, monitor and formulate regulations pertaining to water quality standard, pollution tolerance level and development of water resource. It prohibits any action that may pollute water resource surpassing the threshold value. It has prioritized use of water resource in successive order: drinking /domestic use, irrigation, fishery, electricity, water transport, recreation based and other works. Violators can be fined from NRs.5,000 to 10 years imprisonment.
1996-1997 (amendment 1999)	Environment Protection Act and Regulations	It categorizes lake/wetland habitat under Environmentally Sensitive Area (ESA) and stipulates mandatory requirement of Environmental Impact Assessment (EIA) prior to implementation of any development activities including hydropower, irrigation project in and near such ESAs. It also envisage a penalty measure of up to NRs. 0.1 million (=U$1500), for the defaulters and has categorized list of development activity which require either IEE or EIA. It also empower the Environmental Inspector to inspect and report on the implementation status of agreed upon conditions. The EPR, 1997 have emphasized public consultation process during the preparation and approval of EIA reports.

Year	Legislation	Details
1998	Local Governance Act: Regulatory System for District Development Committee (DDC)	The District Development Committee (DDC) is entitled to carry out plan and implement activities related to mitigation measures in landslide/river cutting prone area and promotion of soil /forest /biodiversity /soil conservation activities as well as touristically important natural and cultural heritage of the district.
1993	Local Governance Act: Regulatory System for Town Development	The rights and duties of a municipality include conservation and sustainable utilization of water-bodies such as streams, lakes, pond lying within its territory, as well as conservation of natural resources with an emphasis on forest, vegetation, control /mitigation of potential soil erosion/land slide/flood prone area and management of solid wastes. The municipality is also authorized to resolve squatter problem, public sanitary toilets and promote environmental conservation activities such as of a Lake in the town area.

2.10.2 Water Quality Standard

Water quality parameters indicating threshold/permissible value load for different use of a water body including recreational use based upon World Health Organization (WHO) Standard is described in following **Table I-2.13**. This will be the target value of pollution load.

Table I-2.13: Targets of Water Quality Criteria for Environmental Conservation

Class	Purpose of Use	Transparency m	Turbidity NTU	pH	BOD mg/L	COD mg/L	DO mg/L	SS mg/L	TDS mg/L	TN mg/L	TP mg/L	No. of Coliform Groups Fecal MPN/100 ml
I	Environmental Preservation	≥ 4	10	6.5~8.5	≤ 3	≤ 10	≥ 6	≤ 1	-	≤ 0.2	≤ 0.02	≤ 50
II	Fisheries Recreational	≥ 3	25	6.5~8.5	≤ 5	≤ 20	≥ 5	≤ 5	500	≤ 0.3	≤ 0.03	≤ 1000
III	Fisheries (commercial production)	≥ 2	50	6.0~9.0	≤ 10	≤ 30	≥ 4	≤ 15	500	≤ 0.6	≤ 0.05	≤ 5000 Total Coliforms (T.C.)
IV	Agricultural	≥ 2	50	6.0~9.0	≤ 10	≤ 30	≥ 3	≤ 15	500	≤ 0.6	≤ 0.05	≤ 5000 T.C.
V	Environmental Conservation	≥ 1	100	6.0~9.0	-	-	≥ 2	No floating material	-	≤ 1.0	≤0.09	≤ 5000 T.C

Source: World Health Organization

2.10.3 Legal Framework for Protection of Biodiversity

Directive principles of the present Constitution of Nepal (1990), clearly indicate the need for environmental conservation. Article 26(4) places priority in the protection of the environment of the country. To deal with environmental issues, there has been establishment of an Environment Conservation Committee in the Lower House of Representatives. MOPE has also recently prepared a five year strategic plan with a view to mainstreaming environmental aspects in socio-economic development plans and programs with due emphasis on human capacity development, institutional strengthening, institutionalize stakeholders' participation on environmental management, minimize pollution load and enforcement of environmental legislation and standards.

The Ministry of Forest and Soil Conservation is currently finalizing the National Biodiversity Action Plan, identifies key biodiversity issues and includes a number of priority programs in the field of

forest biodiversity, agro biodiversity, wetlands, rangelands, mountain biodiversity and cross sectoral areas along with time-frame, estimated budget, and monitoring mechanism in the field of biodiversity management for 13 year projection (2000-2012).

The HMGN, which is a signatory to various biodiversity conservation related legally binding international treaties/conventions such as UN Convention on Biological Diversity (CBD) 1994, Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) 1975, United Nations Framework on Climate Change 1992, Convention on Wetlands of International Importance especially as waterfowl habitat (Ramsar Convention) 1988 , Agreement on the Network of Aquaculture Centers in Asia and the Pacific 1990, and Plant Protection Agreement for the South East Asia and Pacific 1965 etc. hold substantial global commitment.

The following **Table I-2.14** presents different environmental legislation other than those listed in Table I-2.12 that address issues of environmental conservation.

Table I-2.14: Environmental Legislation

Year	Legislation	Details
1957	Private Forest Nationalization Act	It launched nationalization of forest area, It ignored the traditional forest management practices of the people.
1961	Forest Act	The amendment of Forest Act in 1961, '77 and '78 categorized natural forest into 6 classes: Panchayat protected, religious, leasehold, private and government forest, community, leasehold and national forest.
1992	Forest Act	It made provision for the purpose of enhancing private sector participation in forest management and categorized national forest into 5 management classes: government, community, leasehold, religious and protected forest. It has enlisted 21 plant species under legal protection for the conservation of threatened species.
1972	Plant Protection Act	It envisaged a system of procurement of a certificate from competent government authority for export of plant and plant products
1974	Pastureland Nationalization Act	It legally abolished the pasturelands "Kharkas" previously owned by certain community, without paying tax. The Act discourage overgrazing, private ownership and encourage use of pasturelands in horticulture, animal husbandry, herbal farming and tea plantation purposes from collaborative approach.
1977	Land Tax Act	This Act defined lands with forest as government lands
1992	National Park and Wildlife Conservation Act (NPWCA), 1962, Amendment 1992	Introduced concept of "Conservation Area", "Buffer Zone" to facilitate regular supply of forest products to local people with less impact on protected area and it envisaged a system of conflict resolution through benefit sharing in terms of allocation of up to 40% income of protected area to the local community development. The NPWCA 1973, has enlisted 39 wildlife species including 27 mammals, 9 bird and 3 reptile species under protected status.
1995	Forest Regulations	Forest Regulations, 1995 stipulate the procedure of forming user groups, and the rights and responsibilities of these groups and the District Forest Officer.
1998	Livestock Health and Livestock Service Act	It promulgates quarantine and need of permission on import or export of biological materials animals and animal feed from prescribed authority.
1998	Local Governance Act: Regulatory System for VDC	VDCs are entitled to prepare resource map, formulate and implement land use plan, biodiversity conservation related works, carry out plantations, in erosion prone area/ barren lands of village, promote herbal farming and tax on commercial utilization of natural resources of VDC area.

2.10.4 Legal Framework for Environmental Education

The National Conservation Strategy of Nepal (1994) and Nepal Environmental Policy and Action Plan (NEPAP) 1994 has emphasized for generating public environmental awareness as a cost-effective and long-term sustainable means for environmental education. The Charter of Pokhara Sub-metropolis deals on public responsibilities of the urbanites in general about the environmental conservation activity. There is penalty for violator against haphazard disposal of solid waste. To upgrade public environmental awareness, the municipality has launched "Public Environmental

Education Program" initiated through ADB-funded Pokhara Environmental Improvement Project (PEIP). The environmental education program has provision of educating residents on legal issues and By-laws. Sanitation and waste management By-laws of Pokhara Sub-metropolis have provision that the By-laws will be considered legal only after publicizing its clauses in mass media. Together, educating and consulting the communities on the By-laws clauses before its approval by the municipal council was important for public acceptability and support of By-laws clauses.

Article 7 of the Soil and Watershed Conservation Act and **Article 6** and **9** of the Soil and Watershed Conservation Rules can be related to conservation education and extension. The rules relating forestry have articles related to free advisory facility on forestry.

Otherwise, legal provisions for environmental education and extension are low. The elaborate acts and rules relating to the environment do not have articles clearly defining education and extension activities. The legal status of an education and extension activity is not an obstacle. The legal framework should contain technical environmental education conservation assistance in terms of advice, materials and training.

2.10.5 Legal Framework for Solid Waste Management

Following are some of the legal and policy setup which address various issues related with the solid waste management sector:

(1) Town Development Act, 1988, Clause 9

(2) Nepal Environment Policy and Action Plan, 1993 (NEPAP -3), Project number and Code, 0608 ITEC, 1000 XLAW, 099 WSOL, 113 WSOL

(3) Environment Protection Act, 1996, Sub-article 7.1

(4) National Waste Management Council, 1996 has adopted National Solid Waste Management Policy

(5) Ninth Plan, Policy and Implementation Strategy has encouraged public-private partnership and promotion of recycling

(6) Local Self Governance Act, 1999

The Local Self Governance Act, 1999 has given authority to VDC, Municipalities and their wards to manage solid waste appropriately. It has given them legal authority to prohibit people to throw waste openly, in water-bodies, open spaces or in a way affecting its neighborhood. The defaulters can be punished by charging them the cost of management of waste thrown by them with additional charge of NRs. 100 by VDC, and up to 15,000 by municipalities. The Act has also given them authority to raise service charge from beneficiaries.

(7) Sanitation By-laws, 1999 for Pokhara Sub-metropolis

The Sanitation By-laws, 1999 for Pokhara Sub-metropolis for solid waste management has defined solid waste disposal method, and has provisioned penalties for defaulters. Service charge from the beneficiaries has also been provisioned. Any disposal of solid waste into roadside drains, storm-water drains, kholas (rivers), tals (lakes), streets/lanes, alleys, chowks (crossings) or any public land is prohibited.

2.10.6 Construction By-laws on the Phewa Lakeshore

With the increase in the tourist arrival and flourishing tourism industry, the otherwise nonproductive and limited Phewa Lakeshore suddenly became a precious spot in Pokhara. The area slowly became one of the economic and commercial hub of the city. The land in the Lakeside area, because of this, became so sensitive that many exercises were undertaken for its development plan and many By-laws were prepared and reviewed repeatedly. In 1974, a land use plan was developed for Pokhara and the

present Ward No. 6 was designated 'recreational and restricted preservation zone'. Lakeshore was designated as a green belt and housing construction was prohibited.

In 1981, building of temporary type and one storey houses was permitted along a 45 feet corridor on the Lakeside from the road (west to the road) from Barahi Chowk and Khahare, currently the main commercial area. At present, permanent multistoried building has emerged on both sides of the road.

In 1990, another construction By-laws was introduced by the Department of Housing and Urban Planning with an objective to increase the attraction of the Lake. The main feature of this By-laws are:

- Houses should follow the traditional Nepalese architecture
- 70% of the roof should be sloped
- maximum number of stories - two
- right of way
  - From Phirke to Hemagriha - 36 feet
  - Hemagriha to Ratna Mandir on the north side only - 66 feet
  - Ratna Mandir to Barahi Chowk on the north side only - 60 feet
  - Barahi Chowk to Khahare - 30 feet

Economical potentiality of this area is so large that the By-laws are not followed at all. The violation of By-laws was made easier due to lack of monitoring by the concerned governmental and municipal agencies.

Except these By-laws, Sanitary By-law for mandatory construction of scientific toilets with hygienic septic tanks was also prepared and implemented by Pokhara Sub-metropolis in 1995. This By-law restricts the connection of domestic waste and sewage into the surface drain or disposal on the street. Implementation of this By-law is also poor.