Journal of Global Environment Engineering, Vol. 6, pp. 33-49, 2000

PERCEIVED ENVIRONMENTAL PROBLEMS BY NEPALESE OF THREE ECOLOGICALLY DIFFERENT AREAS

Tohru Futawatari [1]
Hiroshi Kashiwazaki [2]
Taeko Hamai [3]
Mathura P. Shrestha [4]

Abstract

Nepal is one of the least developed countries in the world. Environmental pollution and its influence on human health are the growing concern of national health planners. The purpose of this study was to examine the relationship between the resource use and environmental perception of inhabitants, and to discuss the environmental sustainability in Nepal. We carried out a preliminary study on environmental pollution and a questionnaire survey in three districts, Kathmandu, Mustang, and Rupandehi, which were selected with a consideration of geographical, ecological and urban-rural conditions in the country. Environmental concentrations and personal exposure levels of nitrogen dioxide (NO_2) and volatile organic compounds (VOCs) were measured by using small passive air samplers/gas tubes, and drinking water quality was examined by a portable test-kit. Using questionnaire, we collected information for a total of 585 persons through local interviewers on residential conditions, agricultural activity, environmental conditions, health effect, and attitude toward environmental sustainability. We found that the environmental concentrations and personal exposure levels of NO_2 and total VOCs differed by regions, reflecting the different type of emission sources. Although the levels were generally lower than the international guideline, the indoor levels of NO_2 and total VOCs were commonly higher in three districts than outdoor levels. Some of the samples from the potable water sources in urban area were contaminated unexpectedly with a high level of nitrate. Analysis of the response to questionnaire indicated marked regional differences in subjects' environmental perception and focus on the major environmental problems.

KEYWORDS: *environmental problems in Nepal, environmental resources, air quality, water quality, questionnaire survey*

1 Dr.Eng, Assoc. Professor, School of Health Sciences, Univ. of Occupational and Environmental Health, Fukuoka, JAPAN.
2 Professor, School of Health Sciences, Univ. of Occupational and Environmental Health, Fukuoka, JAPAN.
3 Res.assoc., School of Nursing Sciences, Shizuoka Prefectural University, Shizuoka, JAPAN.
4 Professor, Dept. of Community Medicine and Family Health, Inst. of Medicine, Tribhuvan Univ., Kathmandu, NEPAL.

1. Introduction

In many of the least developing countries with rapid industrialization, the environmental pollution is growing as a big national and international concern that might have severe effects on human health. In recent years, sustainable development is the key issue in controlling environmental pollution and preventing adverse health effects. A number of countries are focusing their attention toward policy-making relevant to this issue. Using the international statistics, several agencies have developed indicators for evaluating status quo of the development, pollution and human health in the national levels. For example, the World Resource Institute has proposed new risk indices to human health (World Resources Institute, UNEP, UNDP, and The World Bank, 1998), which are derived from the data consisting of three environmental sectors; air, water and nutrition. Although these indices are useful as a tool for international comparison, cooperation, and decision-making relevant to sustainable development, no information is provided on regional variation within a country such as environmental resources, economic development, pollution and human health. Such information and the detailed views from the local people on their socio-economic conditions and surrounding environments should be taken into account for seeking effective measures of the present environmental issues.

This research is an attempt to examine the state of environmental pollution in the urban and rural areas of Nepal, and to provide information relevant to regional development and environmental policy from the viewpoint of environmental sustainability. The analysis was made using the data obtained by questionnaire survey on the resource consumption and production activities of the people living in those regions. The field research in Nepal was carried out during July - August 1998. During this period we made on-site air and water pollution monitoring by using small passive air samplers/gas tubes and by a portable test-kit.

2. Geographic and socio-economic characteristics of the regions surveyed

2.1 Regions surveyed

Nepal is a country facing the national borders of Chinese Tibet to the north and India on the other three sides, with a wide stretch of land from east to west. The land is typically classified into a northern mountainous region including the Himalayas, a central hilly region, and plains (terai) in the south. The total population is about 21 million, comprising of diverse ethnic groups. In general, Nepal is known as a country with rich resources for tourism represented by the Himalayas, but has several difficulties in economic development. Nepal's economy is primarily based on agriculture. Due to a limited arable land area in the mountainous area and insufficient irrigation facilities, agricultural productivity is low. The basic infrastructure (transport, communication, electric power, water supply, etc.) is at the primary stage of development as compared to other Asian countries. Minimal opportunity for education among the people has been a major obstacle in achieving significant economic development. The Nepal's gross domestic product (GDP) is US$220 per capita (1995/96). The lower income group comprising 20% of the population shares only 3.7% of the national product, while the upper 10% of the population draw some 50% of the national product. Forty five percent of total population has income below the poverty line (Nepal South Asian Centre, 1998).

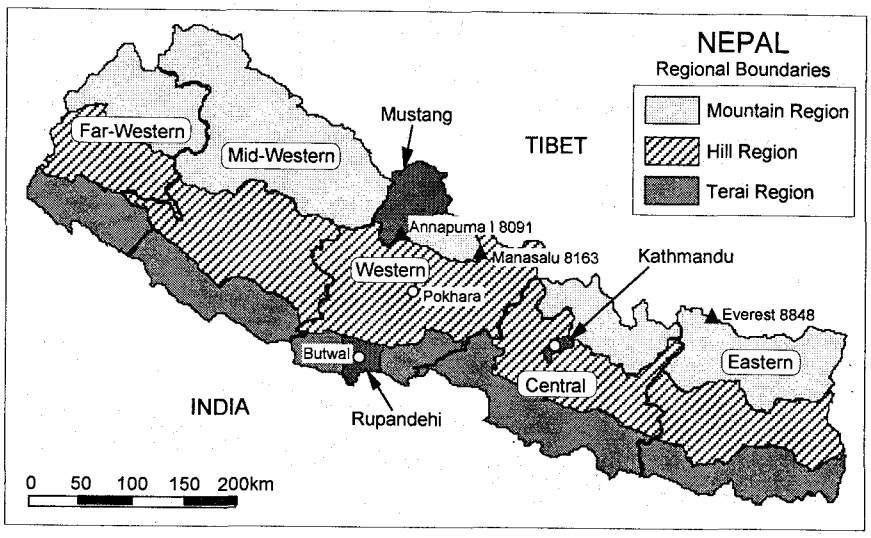

Figure 1. Surveyed regions in Nepal.

Mountain, hill and terai are three ecological regions that characterize the country. It is divided administratively into five development regions (eastern, central, western, mid-western and far-western). There are 75 administrative districts in Nepal, divided further into 3,912 VDC (Village Development Committees) and 58 Municipalities. When the 75 districts are classified according to these ecological and development boundaries, a total of 15 areas represent the nation.

This research was carried out in the three districts of Kathmandu, Mustang and Rupandehi, as shown in Fig. 1. Kathmandu is situated in the central hill region, Mustang in the western mountain region and Rupandehi in the western terai region.

2.2 Demographic and economic trends

Nepal is a country of multi-ethnic groups, and the composition of ethnic groups differs by regions. Living conditions and agricultural activities vary from a region to another. This section describes the social and economic conditions of the regions of our research, based on the data from the Statistical Year Book of Nepal 1997.

As indicated in Table 1, the population of Kathmandu in 1991 was 675,000, 1.60 times increase from 1981 (422,000). The population in Mustang for the same period increased from 13,000 to 14,000 (1.11 times), and in Rupandehi from 379,000 to 522,000 (1.38 times). The national population growth for the same decade was 1.23 times. Four districts in Nepal showed a growth rate of 1.5 times or higher, including Kathmandu, and two of these were in the far-western terai region.

The population density (1991) was the highest in Kathmandu at 1,710 people/km^2, 4 people/km^2 in Mustang, and 384 people/km^2 in Rupandehi. The national average, excluding the capital of Kathmandu, is quite low, at 28 people/km^2 for the mountain region, a high of 254 people/km^2 for the terai region, and a mid-range value of 137 people/km^2 for the hill region. Only 7.8% of the population lives in the mountain region accounting for 35.2% of the nation's land area, 45.5% in the hill region

Table 1. Population and population density in surveyed regions.

District	Nepal	Kathmandu	Mustang	Rupandehi
Population in 1981	15,022,789	422,237	12,930	379,096
Population in 1991	18,491,107	675,341	14,292	522,150
Population Increase in 1981 to 1991	1.23	1.60	1.11	1.38
Area [sq. km]	147,181	395	3,573	1,360
Population Density in 1981	102	1,069	4	279
Population Density in 1991	126	1,710	4	384

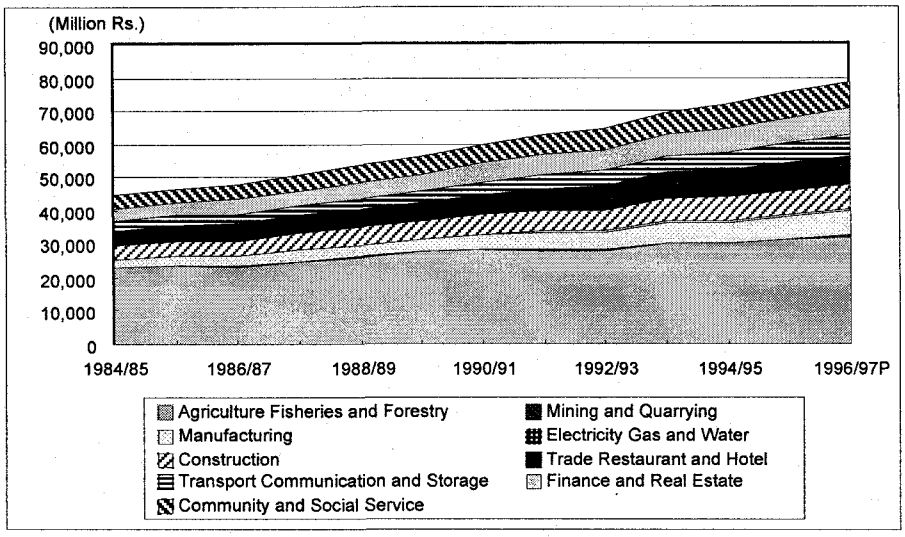

Figure 2. Change of GDP in Nepal (at constant price; 1984/85=100).

(41.7% of national land area), and 46.7% in the terai region (23.1% of national land area). Regional differences in population density and growth are apparent in Nepal, with the southern plains (terai) showing the highest rate of increase.

The GDP has been increasing annually, but the rate of increase fluctuates. The average for the 12-year period from 1984/85 to 1996/97 was 4.8%. Products from the primary industry, agriculture and forestry account for the largest share, but show a very low average growth rate of only 3.0% for the same 12-year period. The productions from the manufacturing and construction sectors are low, but the growth rates are high as compared to agriculture and forestry. Growth rates are generally high in these sectors, with an average annual growth rate consistently over 5%.

GDP trends by industry are indicated in Fig. 2. The share of the products from the primary industry shows a steady decline over time, and indicates 41% of the GDP in recent years. Manufacturing has increased to 8.9% in 1996/97 from its low share of 5.7% in 1984/85. Similar sharp growth rates are observed in the construction; commerce; restaurant and hotel; transport, communications and warehousing; finance and real estate; and social service sectors.

3. State of environmental pollution in Nepal

3.1 Survey methods

Air and water samples were collected to investigate environmental pollution. Measurement items for air pollution were nitrogen dioxide (NO_2) and volatile organic compounds (VOCs). Samplers (NO_2: passive gas sampler, Toyo Roshi Kaisha; VOCs: passive gas tube, Shibata Scientific Technology) were attached to the places (indoor and outdoor) and to the residents. Suitable places in kitchen and living room were selected as indoor places, and outside-wall of houses and shops along the street as outdoor places. Especially, in Kathmandu, central areas, Tenda Tahanan and Gambahal, were selected as sampling places. After 24 hour of exposure to air, the samplers were collected and sealed in the containers until analysis in Japan. The following VOCs were analyzed, benzene, toluene, p-xylene, ethyl benzene, decane, dodecane and methyl isobutyl keton (MIBK). The total VOC concentration (TVOC) was calculated as toluene equivalent from the results of GC/MS analysis.

Water quality was examined using a portable test-kit (Packtest, Kyoritsu Rikagaku Kenkyusho). Drinking water, well water and other water sources were sampled into 100-ml plastic bottles, and tested promptly with the Packtest. Measurement items were pH, ammonium ion (NH_4), nitrate ion (NO_3), phosphate ion (PO_4) and chemical oxygen demand (COD).

3.2 Air pollutants

Results of analysis are given in Table 2. By exposure methods, which determine indoor, outdoor and personal exposure levels, mean values for the three areas are indicated. For comparison, results of analysis in the Kitakyushu region in Japan during the corresponding time period are also given (Hori et al., 1999). In calculation of mean and standard deviation, samples lower than the detection limits were treated as zero.

The highest personal exposure level of NO_2, 9.26 ppb, was observed in Mustang. However, the regional differences were small, and all results were below the values reported for the Kitakyushu region. Benzene was detected only in Kathmandu. For toluene and other VOCs, and TVOC, the levels for all three Nepalese regions were higher than those of Kitakyushu. The average TVOC was 1.7 to 2.8 times the value of the Kitakyushu region (69.4 ppb), and the peak values ranged from 318 to 517 ppb.

For the indoor samples, concentration levels were higher than that of Kitakyushu, with the exception of p-xylene, ethylene and MIBK. Indoor NO_2 was significantly higher in Mustang and Rupandehi than those of personal or outdoor exposure levels. In Kathmandu benzene and toluene levels of indoor were higher than those of other regions. TVOC concentrations in all Nepalese regions were higher than that of Kitakyushu. This represents the indoor use of fuels for cooking, primarily firewood and kerosene; kerosene in Kathmandu, kerosene and firewood in Mustang, and firewood in Rupandehi. In fact, incomplete combustion of kerosene generates benzene, and firewood burning produces NO_2.

The results for outdoor samples from Kathmandu showed the highest concentrations in all items. NO_2 and TVOC concentrations in Rupandehi and Mustang showed somewhat higher levels.

As outlined above, all three Nepalese regions commonly showed higher indoor levels of NO_2 and TVOC than those of outdoor levels. The indoor pollution levels, however, vary by type of fuel mainly

Table 2. Atmospheric environment measurement results.

Location		NO2 [ppb]	benzene [ppb]	toluene [ppb]	p-xylene [ppb]	ethyl benzene [ppb]	decane [ppb]	dodecane [ppb]	MIBK [ppb]	TVOC [ppb]
Personal										
Kathmandu	Mean	6.10	3.02	23.63	10.05	9.59	7.15	10.77	18.45	195.19
(N=7)	SD	0.96	6.66	15.17	6.39	2.98	8.68	14.71	3.66	160.66
	Max	7.63	18.03	55.90	20.30	13.40	22.22	40.74	22.30	517.42
	Min	4.86	0.00	8.50	3.22	5.78	0.44	0.00	13.51	71.02
Mustang	Mean	9.26	0.00	11.29	7.41	0.01	12.21	11.08	13.36	153.54
(N=5)	SD	4.53	0.00	7.26	11.28	0.01	14.76	8.30	10.23	122.65
	Max	15.90	0.00	17.93	26.71	0.02	37.91	22.87	25.97	345.07
	Min	3.92	0.00	0.00	0.00	0.01	0.00	0.00	0.00	10.56
Rupandehi	Mean	8.79	0.00	6.35	1.77	8.99	0.96	2.69	12.91	117.75
(N=5)	SD	5.76	0.00	3.64	2.47	2.89	2.15	3.19	9.07	113.99
	Max	18.10	0.00	8.66	5.05	12.82	4.81	7.56	20.19	317.77
	Min	3.48	0.00	0.00	0.00	5.82	0.00	0.00	0.00	37.53
Overall	Mean	7.82	1.24	14.92	6.84	6.60	6.82	8.48	15.32	160.17
(N=17)	SD	4.00	4.36	12.77	7.83	4.97	10.18	10.76	7.69	133.42
	Max	18.10	18.03	55.90	26.71	13.40	37.91	40.74	25.97	517.42
	Min	3.48	0.00	0.00	0.00	0.01	0.00	0.00	0.00	10.56
Kitakyushu	Mean	12.66	0.00	4.98	1.31	7.49	0.36	0.43	25.28	69.35
(N=26)	SD	7.73	0.00	5.59	3.24	4.01	0.93	1.52	33.47	33.27
	Max	35.13	0.00	18.85	11.90	16.18	3.57	6.28	183.86	198.74
	Min	2.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.76
In-door										
Kathmandu	Mean	12.49	18.76	43.80	10.60	11.38	7.70	9.90	17.64	256.99
(N=9)	SD	11.49	44.55	32.69	8.54	4.86	11.61	12.77	6.24	260.63
	Max	37.50	135.69	109.40	23.28	21.94	32.00	36.04	25.81	875.59
	Min	4.02	0.00	7.32	0.00	6.38	0.00	0.00	8.54	58.94
Mustang	Mean	32.08	8.11	16.78	7.27	0.01	14.22	16.61	10.91	221.70
(N=5)	SD	23.54	12.13	11.27	7.43	0.01	14.48	18.87	5.56	202.27
	Max	60.70	27.19	27.84	17.05	0.02	37.42	48.79	18.44	548.82
	Min	4.42	0.00	0.00	0.00	0.01	0.00	0.00	5.64	27.23
Rupandehi	Mean	66.30	0.00	18.34	3.05	8.89	6.13	11.97	19.36	182.65
(N=4)	SD	96.12	0.00	12.89	6.09	1.62	10.27	17.27	11.79	140.72
	Max	210.20	0.00	34.52	12.19	10.49	21.37	37.60	32.17	382.39
	Min	12.20	0.00	7.46	0.00	7.40	0.00	0.00	4.58	73.56
Overall	Mean	29.89	11.63	30.64	8.00	7.67	9.16	12.23	16.15	230.66
(N=18)	SD	47.92	32.11	27.31	7.96	6.04	11.93	14.89	7.86	214.53
	Max	210.20	135.69	109.40	23.28	21.94	37.42	48.79	32.17	875.59
	Min	4.02	0.00	0.00	0.00	0.01	0.00	0.00	4.58	27.23
Kitakyushu	Mean	13.39	0.00	5.69	17.64	13.19	1.19	1.44	36.58	146.79
(N=22)	SD	8.30	0.00	8.63	34.20	17.57	2.43	2.19	58.97	231.93
	Max	40.60	0.00	32.92	101.22	60.69	9.41	5.63	217.25	963.95
	Min	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.29
Out-door										
Kathmandu	Mean	9.29	3.06	26.29	6.00	8.49	1.61	2.81	23.72	118.28
(N=10)	SD	2.89	4.33	22.27	5.46	3.10	1.35	2.41	7.04	53.40
	Max	14.30	14.53	75.12	14.54	12.87	3.79	7.09	37.42	243.56
	Min	4.80	0.00	7.22	0.00	4.08	0.00	0.00	14.59	63.43
Mustang	Mean	5.50	0.00	2.41	0.00	0.01	0.00	2.34	22.40	68.92
(N=2)	SD									
	Max	9.37	0.00	4.81	0.00	0.01	0.00	4.69	23.57	72.03
	Min	1.62	0.00	0.00	0.00	0.01	0.00	0.00	21.22	65.81
Rupandehi	Mean	4.84	0.00	1.24	3.19	5.12	1.44	3.16	20.52	177.30
(N=3)	SD	6.26	0.00	2.15	5.53	4.44	2.50	5.47	8.24	147.30
	Max	12.00	0.00	3.73	9.57	7.78	4.32	9.47	29.31	341.72
	Min	0.37	0.00	0.00	0.00	0.00	0.00	0.00	12.97	57.38
Overall	Mean	7.89	2.04	18.09	4.64	6.68	1.36	2.82	22.91	123.51
(N=15)	SD	4.16	3.78	21.55	5.32	4.27	1.54	2.97	6.59	77.45
	Max	14.30	14.53	75.12	14.54	12.87	4.32	9.47	37.42	341.72
	Min	0.37	0.00	0.00	0.00	0.00	0.00	0.00	12.97	57.38
Kitakyushu	Mean	13.40	0.00	3.71	0.00	5.86	1.61	0.94	16.29	59.26
(N=19)	SD	7.62	0.00	4.89	0.00	2.83	3.92	1.97	8.65	17.69
	Max	29.08	0.00	16.13	0.00	12.24	15.64	6.34	35.93	85.73
	Min	3.92	0.00	0.00	0.00	0.00	0.00	0.00	4.77	11.06

SD: Standard Deviation, Max: Maximum value, Min: Minimum value

Table 3. Water quality observed results.

Items	Range	Kathmandu (N=15)	Mustang (N=11)	Rupandehi (N=15)
pH	6.5	4		
	7	3		3
	7.5	7	2	10
	8		7	2
	8.5		2	
	9	1		
NH_4	0	7	3	4
[mg/l]	0-0.5		8	7
	0.5	2		3
	1			
	2	1		
	10	4		1
NO_3	1	5	11	10
[mg/l]	2	5		1
	5	1		1
	10	1		1
	45	3		2
PO_4	0.2	1	11	5
[mg/l]	0.5	6		7
	1	1		2
	2	2		1
	5	1		
	10	3		
COD	0, 0-2, 2	2	9	11
[mg/l]	5	8	1	2
	10	4	1	1
	20	1		1

used. Kathmandu showed high levels of outdoor concentration of benzene and toluene, but the levels of Mustang and Rupandehi were much lower than those of Kathmandu.

3.3 Quality of water

Results for water analysis by the test-kit are given in Table 3, mainly focused on drinking water. Measurements of pH showed between 6.5 and 7.5 for Kathmandu, 7.5 and 8.5 for Mustang, and 7.0 and 8.0 for Rupandehi; the mountainous region of Mustang showed slightly higher value. Ammonium ion concentrations over 10 mg/l were observed in four sites in Kathmandu, and one site in Rupandehi. Both Kathmandu and Rupandehi had high concentrations of nitrate ion, accompanied by high phosphate ion concentration and COD.

In Kathmandu, water samples from several sites showed high values in the analysis. These samples derived from wells and piped water mainly used for drinking and we suspect some contamination in water supply system. The water quality in Mustang was, in general, excellent. Several years ago a piped water system was installed in Kagbeni (Mustang) using the water resources in the upper tributary of the Kali Gandaki River passing through the community. The piped water, however, is only accessible at about 10 communal sites, with no indoor pipe water supply. In Rupandehi, communal or residential (hand-pumped) wells are used, and the drinking water supply system is not developed in the farming areas. Nitrate ion concentrations exceeding WHO guidelines (45 mg/l) were detected at several sites in both Kathmandu and Rupandehi. This is mainly due to the lack of piped water supply system and/or of appropriate management system. For prevention of drinking water from contamination, drainage and sewerage facilities are also required to develop.

4. Economic activities and perceived environmental problems

4.1 Survey method

The questionnaire survey was carried out in five areas: Kathmandu, Tokha, Mustang, Rupandehi/Mun and Rupandehi/VDC. In Kathmandu, the capital city, the survey was carried out in the center of the city: a mixture of commercial and residential zones. Tokha is an agricultural community situated on the outskirts of Kathmandu, while Mustang (Kagbeni) is a mountainous agricultural community. The Rupandehi district lies on the Indian border, and the urban (Mun) and agricultural (VDC) areas were selected for the survey.

The questionnaire consisted of items related to the economic activities and environmental perceptions of the people in each area. Using questionnaires written in Nepalese, the interviewers noted the responses of the subjects by a house-to- house visit. Meetings were regularly held to train and minimize the bias of the interviewers. The numbers of respondents were 585 in total; 239 in Kathmandu, 93 in Tokha, 90 in Mustang, 51 in Rupandehi/Mun and 112 in Rupandehi/VDC.

4.2 Basic attributes

Average age, sex and relation to the head of household for the respondents are given in Table 4. The average age of subjects was about 40, slightly higher age of 44.5 in Mustang region. More than half of the respondents were women in Kathmandu and Tokha, while men exceeded in Mustang and Rupandehi/VDC. In Kathmandu, spouses of the household head were the majority of the respondents, while in other regions the head of the household was most common. Random sampling procedure, generally used in the similar surveys, was not used, but essentially all households in the selected areas were visited. Therefore, we assume that the results represent the population of each area.

Table 5 indicates the data on income, type of land, and livestock for each region. Subjects from Kathmandu have the highest average annual income, followed by, in descending order, those from Tokha, Rupandehi/Mun, Mustang and Rupandehi/VDC. The highest annual income was recorded in a household of Kathmandu, but the lowest range was recorded similar to the other regions ranging between 1,200 and 3,000Rs. At the time of the survey, 1US$ was 66Rs, and 1Rs was about 2 Japanese Yen. Tokha and Mustang has the highest proportion of people holding their own agricultural land as well as residential land.

The percentage of households with livestock was about 80% in Tokha and Mustang, the highest regions, while the percentage was between 20% and 40% in Kathmandu, Rupandehi/Mun and Rupandehi/VDC. Because of urban areas, it is difficult to hold livestock in Kathmandu and Rupandehi/Mun. A breakdown figures of livestock by species and number of holding shows that 26% of households in Tokha hold buffalo and cattle, but small in numbers. In Mustang, cattle were the major livestock common in 83% of households, followed by horses in 54%. Though small in numbers, thirty four percent of households held goats and 13% sheep, but the average number of heads for these two species was about 50. These figures indicate that animal husbandry is practiced on a fairly large scale.

The ethnicity affects life-style and traditional manners of agricultural production and resource use. By ethnic group, 80% of the respondents in Kathmandu were Newar, while Tokha was entirely Newar. In Mustang the most common group was Gurung (83%), with various minorities. The largest

Table 4. Average age, sex and relation to head of household.

	Kathmandu (N=239)		Tokha (N=93)		Mustang (N=90)		Rupandehi /Mun. (N=51)		Rupandehi /VDC (N=112)	
Age										
No. / %	230	96.2	92	98.9	89	98.9	49	96.1	109	97.3
Average / SD	38.5	15.4	39.3	16.8	44.5	13.7	40.4	14.0	42.7	13.1
Max / Min	82	15	78	17	74	20	72	20	75	16
Sex [No. & %]										
Male	97	40.6	34	36.6	60	66.7	26	51.0	70	62.5
Female	142	59.4	59	63.4	30	33.3	25	49.0	42	37.5
Relation to Household head [No. & %]										
Head	53	22.2	40	43.0	68	75.6	25	49.0	64	57.1
Wife or Husband	99	41.4	16	17.2	13	14.4	19	37.3	40	35.7
Son or Daughter	41	17.2	3	3.2	5	5.6	6	11.8	6	5.4
Others	20	8.4	5	5.4	3	3.3	1	2.0	1	0.9
NA	26	10.9	29	31.2	1	1.1	0	0.0	1	0.9

Table 5. Income, type of land, and livestock data.

	Kathmandu (N=239)		Tokha (N=93)		Mustang (N=90)		Rupandehi /Mun. (N=51)		Rupandehi /VDC (N=112)	
Household Income										
Income-last month										
No. / %	237	99.2	91	97.8	87	96.7	49	96.1	109	97.3
Average [Rs.]	5,529		3,216		2,147		3,217		2,163	
SD [Rs.]	6,465		2,449		2,118		2,481		1,889	
Max [Rs.]	80,000		10,000		15,000		15,000		12,000	
Min [Rs.]	300		400		200		100		100	
Income-last year										
No. / %	231	96.7	88	94.6	87	96.7	41	80.4	109	97.3
Average [Rs.]	76,694		39,220		28,090		35,722		25,490	
SD [Rs.]	171,720		39,729		20,261		24,587		22,295	
Max [Rs.]	2,400,000		300,000		150,000		120,000		150,000	
Min [Rs.]	3,000		3,000		3,000		1,200		1,200	
Kind of land [No. & %]										
Residential land	150	62.8	47	50.5	71	78.9	28	54.9	41	36.6
Agricultural land	65	27.2	77	82.8	71	78.9	2	3.9	51	45.5
Forest	0	0.0	1	1.1	0	0.0	0	0.0	0	0.0
Others	18	7.5	2	2.2	1	1.1	7	13.7	9	8.0
NA	29	12.1	2	2.2	3	3.3	15	29.4	19	17.0
Livestock [No. & %]										
Yes	49	20.5	73	78.5	79	87.8	15	29.4	43	38.4
No	77	32.2	12	12.9	11	12.2	23	45.1	58	51.8
NA	113	47.3	8	8.6	0	0.0	13	25.5	11	9.8

ethnic group in Rupandehi/Mun was Magar (24%), followed by Chhetri (20%). The remaining 31% were composed of small numbers of various ethnic groups, making Rupandehi/Mun a multi-ethnic community. In Rupandehi/VDC, 22% was Muslim, 15% each Brahmin and Chhetri, and the remainder of various minorities.

In all regions, the average numbers of household members were greater than five, with the largest age groups in the 20s and 30s. Nuclear families were more common than extended families. The most common and major sources of income were "Salaried/Service" and "Business" in

Kathmandu, while in Tokha and Mustang "Agriculture" accounted for over 80% of all respondents. "Business" was also a common major income source in Mustang, indicating that agriculture and business coexist. In Rupandehi/Mun over half the respondents indicated "Salaried/Service." In Rupandehi/VDC the most common response was "Agriculture" (45%), but "Salaried/Service" was about 30%, again indicating coexistence. In Tokha, Mustang and Rupandehi/VDC, 50% to 70% of respondents indicated they had received no formal education, due to a lack of opportunity in the farming areas. In the urban regions (Kathmandu and Rupandehi/Mun) the percentage of respondents with no education was 34% and 26%, respectively; significantly lower percentage than those in the farming areas. These figures correlated with those for literacy, with the highest percentage of people capable of both reading and writing in Kathmandu (47%), and the lower percentages in other regions (8% to 29%).

4.3 Residential environment

Table 6 indicates residential environment. In all regions, "Own house" was the most common type of residence, although in Kathmandu and Rupandehi/Mun there was a high percentage of "Rented house" responses. Concerning drinking water, piped taps in both residential unit and in a community were used in Kathmandu and Rupandehi/VDC, while piped taps in the home were the most common type in Rupandehi/Mun, and piped taps of communal use was the most common in Tokha and Mustang.

In Kathmandu and Tokha, kitchen was located frequently on the 3rd or higher floor, in Mustang on the 1st or 2nd floor, and in Rupandehi/VDC and Rupandehi/Mun on the 1st floor. Tokha is an agricultural area in a hilly region, and most of the level land is used for agriculture. Small portion of level land remained urged to construct a house with four or five stories. Toilets in Kathmandu were usually within the house (67%), while in farming communities like Tokha, Mustang and Rupandehi/VDC most respondents did not have toilets inside their houses.

Energy sources for cooking were primarily of oil in Kathmandu and Rupandehi/Mun, and firewood in Tokha, Mustang and Rupandehi/VDC. In Tokha, 60% of respondents used agricultural wastage. In Tokha and Mustang firewood was purchased or cut from private forests. Garbage and waste were kept most often on the places designated by the local government and by the community in Kathmandu and Mustang, but were thrown to an arbitrary place in the other three regions.

4.4 Agricultural activity

The majority of the respondents in Kathmandu and Rupandehi/Mun engaged in occupations other than agriculture. On ownership of agricultural land, the responses in Tokha showed that 84% owned paddies and 32% had dry fields, and in Rupandehi/VDC 48% had paddies. In Mustang, 86% had dry fields, but no one had paddies because of the adverse topographical and climatic conditions to maintain paddy fields. As compared to Tokha and Rupandehi/VDC, the fields in Mustang were roughly split into small parcels of land on the sloped and level grounds.

Agricultural fields were cultivated by using a combination of human and animal (livestock) power. Livestock dung followed by chemical fertilizers were the most commonly used materials in keeping land fertility. In Mustang, however, the percentage of using of chemical fertilizer was significantly lower than the other two agricultural regions. About 50% of the respondents in Tokha

Table 6. Questionnaire results on residential points.

	Kathmandu (N=239)	Tokha (N=93)	Mustang (N=90)	Rupandehi /Mun. (N=51)	Rupandehi /VDC (N=112)
In what type of House/room do you live?					
Own house	80.8	96.8	85.6	68.6	77.7
Offered house	2.1	0.0	1.1	0.0	4.5
Rented house	13.0	1.1	11.1	25.5	4.5
Others	4.6	1.1	2.2	5.9	13.4
NA	0.8	2.2	0.0	0.0	0.0
From where do you usually take water for drinking?					
Piped taps in a house	57.3	2.2	4.4	82.4	50.0
Piped taps in a community	33.1	95.7	94.4	17.6	44.6
Kuwa/dug/well	9.2	4.3	3.3	0.0	2.7
Others	8.8	1.1	4.4	0.0	3.6
NA	2.5	2.2	0.0	0.0	0.0
Where is the kitchen you usually use?					
First floor	18.0	9.7	55.6	92.2	92.9
Second floor	11.7	12.9	37.8	5.9	0.0
Third floor	38.5	68.8	5.6	0.0	0.0
Others	31.0	7.5	0.0	2.0	7.1
NA	2.9	1.1	1.1	0.0	0.0
Where is the toilet?					
Inside house	66.9	31.2	27.8	35.3	6.3
Outside house	23.0	15.1	18.9	43.1	21.4
No toilet	6.3	48.4	51.1	21.6	71.4
Others	2.9	7.5	0.0	0.0	0.9
NA	2.5	2.2	2.2	0.0	0.0
What type of fuel energy do you use for cooking?					
Wood	20.1	73.1	97.8	7.8	83.9
Wastage of agriculture product	0.4	60.2	0.0	0.0	3.6
Dung of livestock	1.7	3.2	1.1	0.0	29.5
Petroleum	82.4	26.9	28.9	96.1	32.1
Coal	0.0	0.0	7.8	2.0	0.0
Electricity	2.5	2.2	0.0	0.0	0.0
Others	2.1	9.7	0.0	0.0	0.0
NA	0.8	3.2	1.1	2.0	0.0
How and from where do you usually get wood for fuel?					
Purchase	23.0	18.3	13.3	9.8	44.6
Gathering from own forest	11.3	43.0	73.3	0.0	6.3
Gathering form the forest by getting permission from the owners	4.2	9.7	0.0	0.0	3.6
Gathering from the public forest	0.4	9.7	15.6	0.0	33.9
Others	2.5	6.5	0.0	0.0	0.0
NA	65.3	24.7	4.4	90.2	15.2
Where do you discard the garbage/ wastage of your family?					
Designated place by the local government	28.9	0.0	8.9	0.0	0.0
Designated place by the community	12.6	10.8	63.3	11.8	3.6
Fixed place in a household compound	23.4	39.8	32.2	29.4	25.9
Anywhere by arbitrary decision	7.5	33.3	2.2	43.1	62.5
Others	10.9	11.8	10.0	13.7	6.3
NA	19.2	8.6	1.1	3.9	1.8

and Mustang, and almost of all in Rupandehi/VDC used pesticides and insecticides. As indicated in Fig. 3, people in Tokha and Rupandehi/VDC preferred to use chemicals as the best method to maintain land productivity, while the most common choice of Mustang was introducing new seeds.

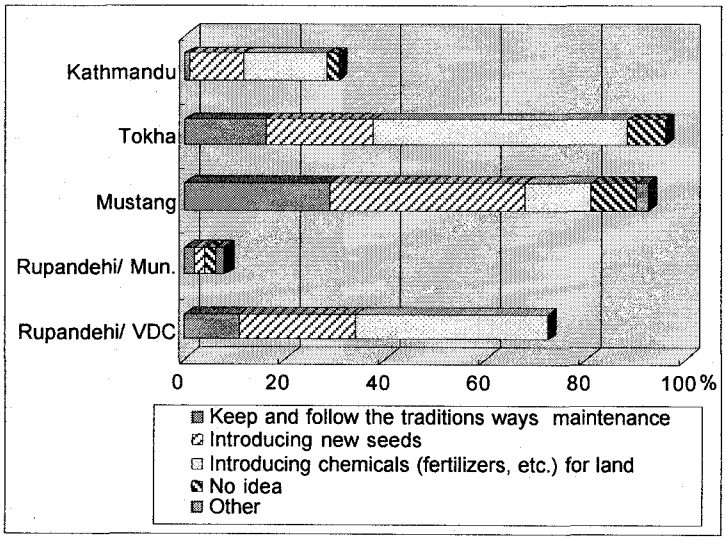

Figure 3. Inhabitants perception for agricultural productions.

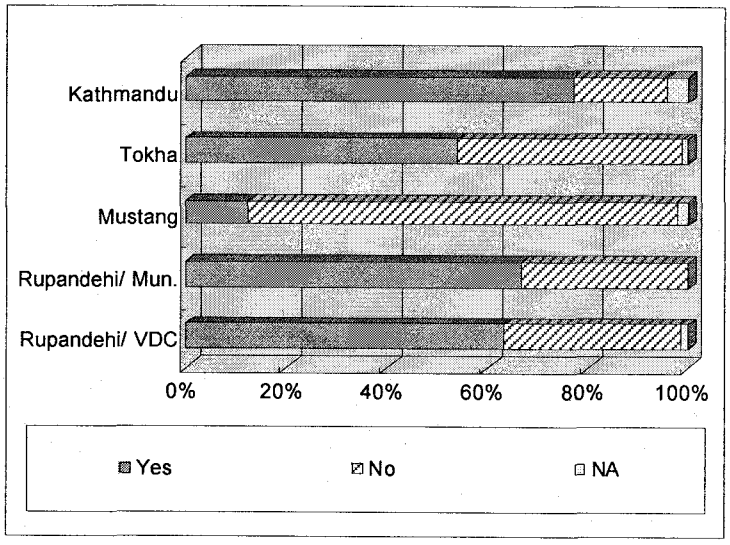

Figure 4. Recognition for environmental problems in regions.

4.5 Perceived environmental conditions

As indicated in Fig. 4, more than half of the respondents recognized some environmental problems, 77% in Kathmandu, 54% in Tokha, 67% in Rupandehi/Mun and 64% in Rupandehi/VDC. Only 12% of the respondents in Mustang depicted environmental problems. Figure 5 shows the kinds of environmental problems that they feel. With the exception of Mustang, the most common concern was the environmental pollution caused by wastes (34% to 56%). In Kathmandu, types of environmental problems mentioned were air pollution (44%), drinking water contamination (44%), noise and vibration (39%) and bad-smell (39%). In Rupandehi/Mun, 43% of the respondents

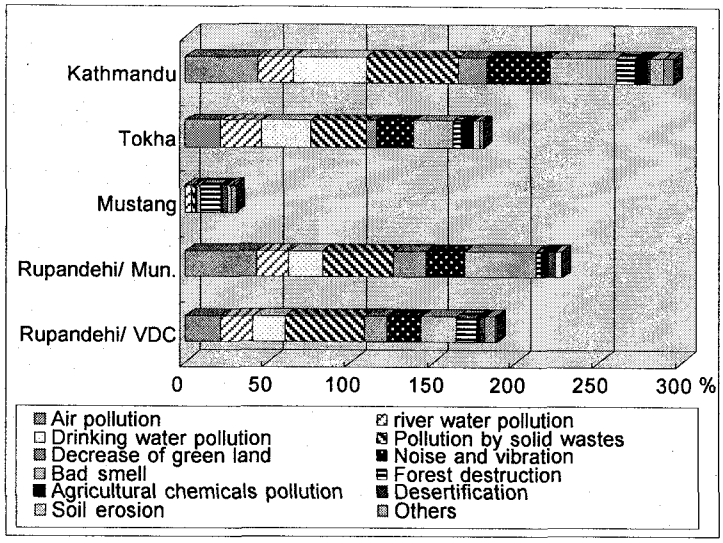

Figure 5. Kinds of environmental problems in regions (multiple answer).

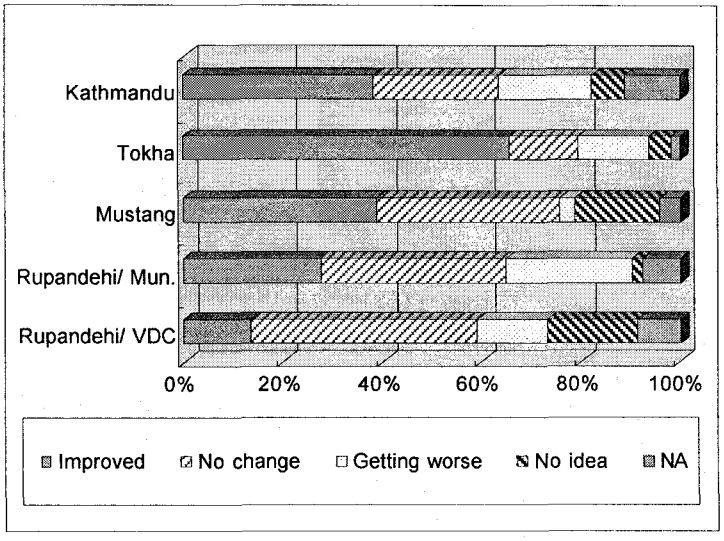

Figure 6. Responses for the 5-year changes in the environment.

mentioned air pollution, pollution by waste and bad-smell as the major environmental problems.

The responses differed among five regions on the changes in the environment during the last 5-year as indicated in Fig. 6. In Kathmandu, responses of "Improved" slightly exceeded over "No change" or "Getting worse." In Tokha 65% of the responses were "Improved." In Mustang, the percentages of "Improved" and "No change" were equally distributed. In Rupandehi/Mun, "No change" was the most common response, but more than 25% responses were obtained in "Improved" and "Getting worse", respectively. In Rupandehi/VDC, the majority was "No change."

In the urban regions of Kathmandu and Rupandehi/Mun considerable proportion of people had serious concerns about the immediate environmental conditions such as air pollution, wastes and

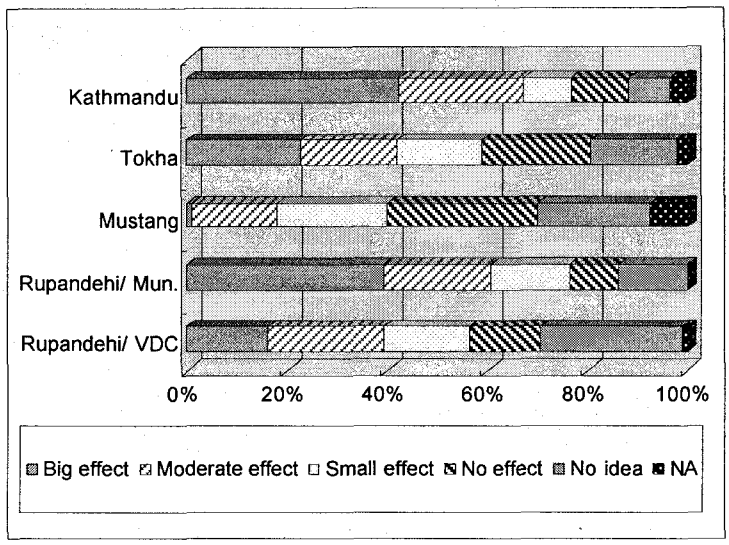

Figure 7. Perceptions of the effects of environmental pollution on health.

smell in the environment. They feel the conditions are getting worse.

4.6 Perceived effects of environmental pollution

Perceived effects of environmental pollution on health are presented in Fig. 7. In the urban regions of Kathmandu and Rupandehi/Mun, about 40% of the respondents had a concern as "Big effect," while the majority of people in Mustang had responded as "No effect." The responses in Tokha and Rupandehi/VDC were equally mixed with optimistic and pessimistic views.

To the question asking about the relation of daily resource consumption with environmental degradation, the majority (53%) of respondents in Rupandehi/Mun replied it as having "Big effect." In Kathmandu and Rupandehi/VDC, "Big effect" followed by "Moderate effect" as the common responses. In contrast, the responses from Tokha and Mustang were concentrated toward "Small effect."

As indicated in Fig. 8, perceived effect on health of the future generations differed by regions. In Kathmandu and Rupandehi/Mun the majority replied as having "Big effect." The similar pattern of response was obtained in Tokha and Rupandehi/VDC. In Mustang, the response of the majority was "No effect." Most of the respondent believes that the environmental pollution will continue to exist or will be getting worse in the future, and the effects on health will be much more serious.

4.7 Actions and perspectives for environmental protection

Radio and TV, and health officials were the common sources of information on environmental conditions. In Mustang, the major source of information was the local leaders. With respect to environmental protection actions actually done as indicated in Fig. 9, the highest rate of responses was obtained in the category of "Always" (43%) in Rupandehi/Mun. Rupandehi/VDC showed percent of response to "Always" as high as 29%, and 28% marked the category of "Sometimes." In

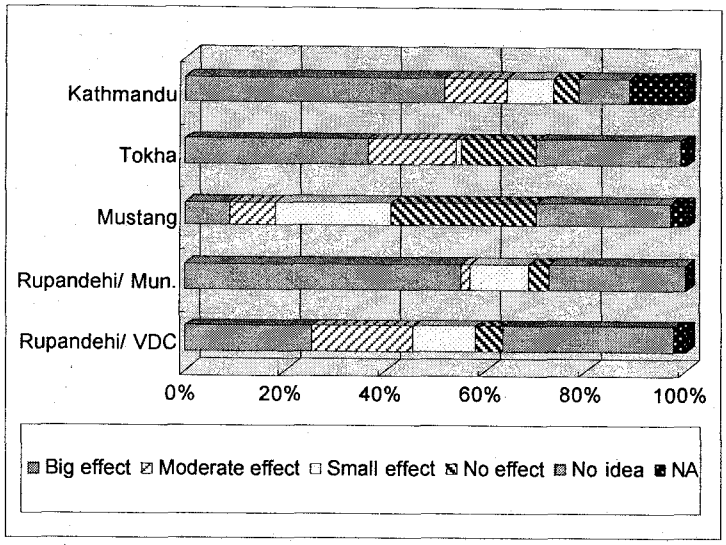

Figure 8. Perceptions of the effect of the health of future generations.

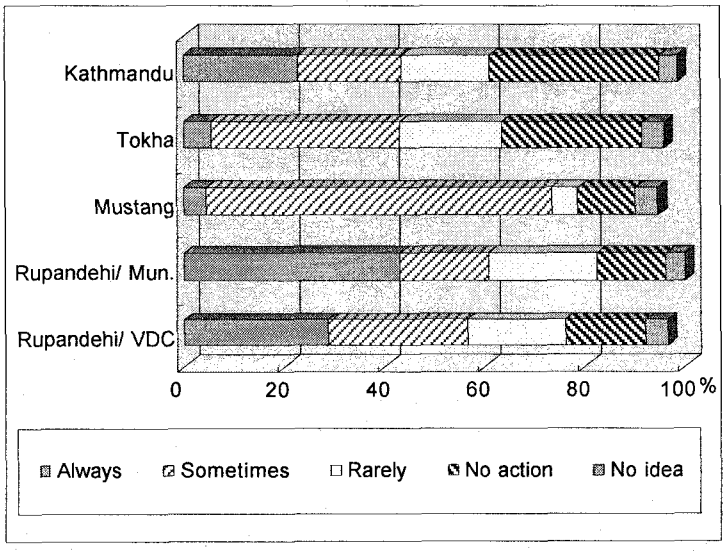

Figure 9. Responses for environmental protection actions.

Tokha and Mustang "Sometimes" was common. In Kathmandu, 34% responded as "No action."

Figure 10 shows the result of response to the priority of importance; economic development or the control of environmental pollution. In Mustang, the majority of the respondents focused on the economic development as the most important issues, while the majority in the other region pointed to the control of pollution as the most important issues. In Rupandehi/Mun, both issues were viewed as important, however the emphasis was placed on pollution control over economic development.

With the exception of Kathmandu, the respondents of all regions were aware of needs for substantial action by the national government. In Kathmandu the most common response was

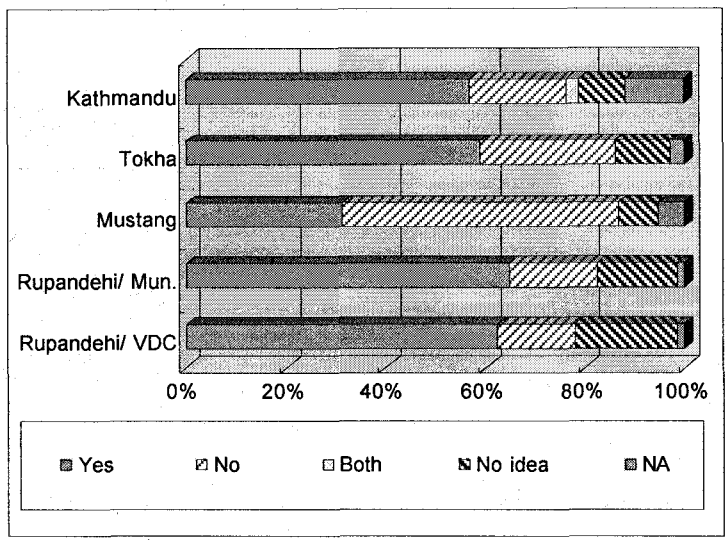

Figure 10. Agreement with the idea that control of the environmental pollution is more important than economic growth.

directed toward a legal regulation of environment. In Mustang, the respondents expressed a need of controls by legislation of new laws and by substantial actions of the national government.

5. Conclusion

The purpose of this study was to examine the relationship between resource use and the perceived environmental problems of the Nepalese, in relation to sustained development. Nepal is a multi-ethnic nation, as reflected by life-styles and economic activities varied from region to region. We have observed regional differences in environmental problems perceived by inhabitants, such as pollution of indoor air and of drinking water. Obtained results are summarized as follows: (1) The environmental concentrations and personal exposure levels of NO_2 and total VOCs differed by regions, reflecting the different type of emission sources. Although the levels were generally lower than the international guideline, the indoor levels of NO_2 and total VOCs were commonly higher in three districts than outdoor levels. (2) Some of the samples from the potable water sources in urban area were contaminated unexpectedly with a high level of nitrate. (3) Analysis of the response to questionnaire indicated marked regional differences in subjects' environmental perception and focus on the major environmental problems.

This study, however, is made as the beginning stage of the project, and does not permit the details of analysis on the interrelationships between these conditions and the underlying factors related to the attitudes of local people toward environmental problems. For example, OECD proposed the framework for environmental indicators based on the pressure-state-response (PSR) model (OECD, 1998). This model will be adopted to our study after systematical analyzing on the relationship between those indicators and inhabitant recognition for social and environmental conditions. In Kathmandu, electric vehicles are being introduced with foreign aid in an effort to improve air

pollution caused by exhaust from many of the automobiles. In the future, the authors plan to investigate further details of such aspects as relevant to alternative measures for improving environmental problems and providing environmental sustainability.

Acknowledgments

The authors acknowledge Dr. Indira Shrestha, Dr. Jeevan B. Sherchand, and Dr. Rajendra R. Wagle at Tribhuvan University, Nepal, for their support our field survey. We also acknowledge Drs. Keiichi Arashidani, Hajime Hori and Toru Ishidao at University of Occupational and Environmental Health, Japan, for providing technical assistance with the chemical analysis. This study was supported by the Grant-in-Aid for Scientific Research of Japanese Ministry of Education, Science, Sports and Culture (#09041174 [1997-98], under the name of research project, Comparative Human Ecology of Resource Use, organized by H. Kashiwazaki).

References

Central Bureau of Statistics (1997): Statistical Year Book of Nepal 1997.

Hori H. *et al.* (1999): NO_2 and Volatile Organic Compound Exposure Level in Nepalese and Japanese, Proc. of the 8th International Conference on Indoor Air Quality & Climate, The International Academy of Indoor Air Sciences.

Nepal South Asian Centre (1998): Nepal Human Development Report 1998.

OECD (1998): Towards Sustainable Development Environmental Indicators, OECD, pp.105-114.

World Resources Institute, United Nations Environmental Programme, United Nations Development Programme, and The World Bank (1998): World Resources 1998-99, Oxford University Press.