State of Environment: Kathmandu Valley, Kathmandu Nepal:

A Special Review

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Introduction to Kathmandu Valley:

Kathmandu is one of the fastest growing cities of the South Asia. It is also one of the populous valleys in the Himalayan belt which also called as a temple valley in the region. With the growth of pollution and socio economic development, infrastructure expansion brings lot of pressure towards environment of the Kathmandu Valley.

Kathmandu Valley lies at 1,300 masl and is located between latitudes 27°32'13" and 27°49'10" north and longitudes 85°11'31" and 85°31'38" east. Its three districts, Kathmandu, Lalitpur, and Bhaktapur, cover an area of 899 square kilometres, whereas the area of the valley as a whole is 665 square kilometres. The valley encloses the entire area of Bhaktapur district, 85% of Kathmandu district and 50% of Lalitpur district.

The valley is bowl shaped and surrounded by the Mahabharat mountain range on all sides. There are four hills acting as forts of the valley, Phulchowki in the South East, Chandragiri/ Champa Devi in the South West, Shivapuri in the North West, and Nagarkot in the North East. The highest altitudes are 2,166m (in Bhaktapur), 2,732m (in Kathmandu), and 2,831m (in Lalitpur).

able 2.1: **Distribution of population by district, 1991–2001**

District	1991	% of total popula-tion	2001	% of total popula-tion	Annual growth rate
Lalitpur	257,086	1.39	337,785	1.46	2.73
Bhaktapur	172,95	0.94	225,461	0.97	2.65
Kathmandu	675,341	3.65	1,081,845	4.67	4.71
KVD*	1,105,379	5.98	1,645,091	7.10	4.06

Source: CBS 2003 b
* Kathmandu Valley districts

Source: ICIMOD Publication 2007

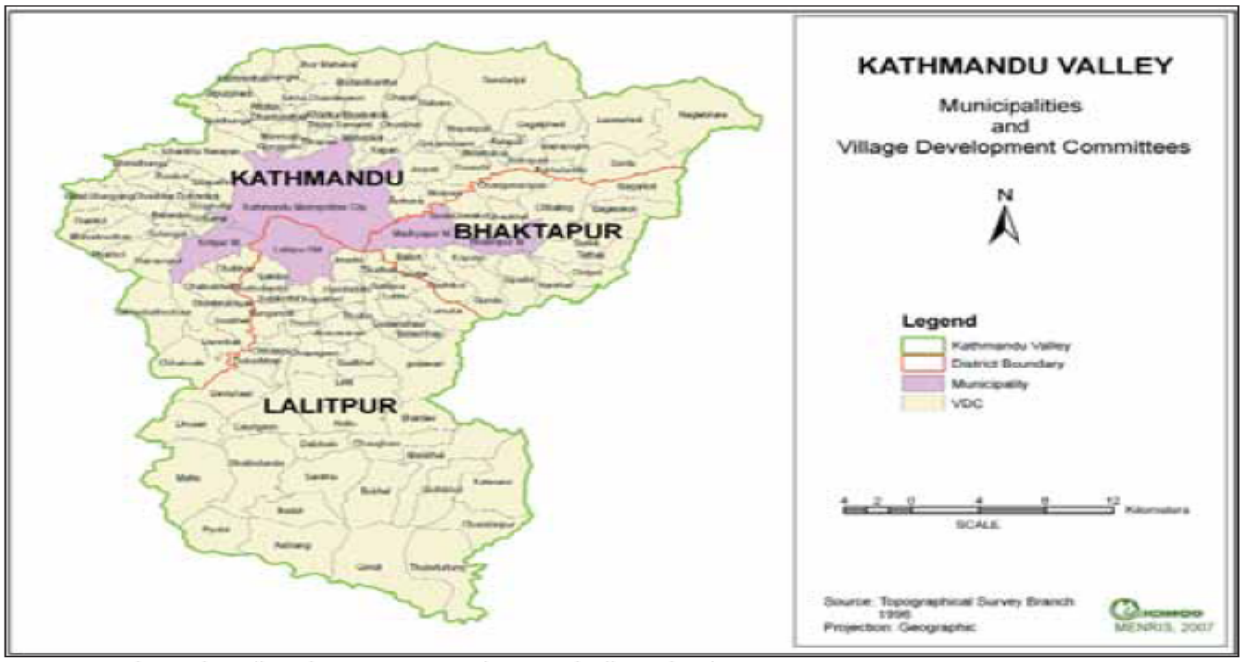


Figure 1: Kathmandu Valley: districts, municipalities, and village development committees (VDCs)

State of Demographic profile of Kathmandu Valley:

The population of the three districts of Kathmandu Valley increased from 1,107,370 in 1991 to 1,647,092 in 2001. The annual population growth rate in Kathmandu district was 4.71%. The population of Kathmandu district was 675,341 in 1991 (3.6% of Nepal's population) and 1,081,845 in 2001 (4.6% of Nepal's population). The population density[1] of Kathmandu district was 1,069 in 1981; 1,710 in 1991, and 2,739 in 2001.

The three districts of Kathmandu Valley consist of five municipalities and 114 VDCs. According to the Local Self Governance Act, 1999, urban areas are classified into Metropolitan Cities, Sub-Metropolitan Cities, and Municipalities. As per this Act, there are three municipalities (Bhaktapur, Madhyapur, and Kirtipur), one sub-metropolitan city (Lalitpur), and one metropolitan city (Kathmandu) in the valley. The population in designated urban areas of Kathmandu Valley has increased considerably (Table 2.4). Urbanization has not been uniform throughout the country. Most urbanized areas are in Kathmandu Valley, which contributes significantly to the overall urbanization status of the country. The urban population density of Kathmandu Valley is 10,265 (the population is 995,966 and the area 97 sq.km.) (CBS 2003b). On the other hand, the rural population is also increasing slowly in the valley. The average annual growth of the rural population is comparatively higher than for Nepal as a whole (Table 2.5).

Table 2.4: Urban growth and urban population growth trend, 1952/54 – 2001[3]

Region	1952/54	1961	1971	1981	1991	2001
Kathmandu Valley	196,777	218,092	249,563	363,507	598,528	995,966
Nepal	238,275	336,222	461,938	956,721	1,695,719	3,227,879
Percentage distribution of urban population						
Kathmandu Valley	82.6	64.9	54.0	38.0	35.3	30.9
Level of urbanisation (in %)						
Kathmandu Valley				47.4	54.1	60.5
Nepal				6.4	9.2	13.9

Source: CBS 2003b

Table 2.5: Average annual growth rates of urban and rural population, 1952/54 – 2001

Region	1952/54		1961 -71		1981		1991		2001	
	U	R	U	R	U	R	U	R	U	R
Kathmandu Valley	1.29	1.53	1.36	4.32	3.83	0.87	5.11	2.32	5.22	2.50
Nepal	4.40	1.56	3.23	2.03	7.55	2.40	5.89	1.79	6.65	1.72

Key: U = urban; R = rural
Source: CBS 2003b

[1] No of person per sq km

Driving Force:

The rapid growth in population is one of the major driving forces for the environmental degradation in Kathmandu Valley. The population growth is due to various pull factors that attract wider population to the valley. The total population of the Kathmandu Valley is the sum of local inhabitants, migrant population[2], and transient population[3].

Nepalese living in rural areas have correspondingly been pushed to move to urban areas by the societal perception that there are better employment prospects, infrastructure, schools, and healthcare facilities, and by their belief that they will enjoy a higher quality of life in the city. While these factors were adequate to explain urbanization and internal migration in the past and a new push factor has become vital at present. The Maoist insurgency, and the corresponding governmental response, is pushing a considerable number of citizens, who fear for their safety and/or lives, to move to the urban areas.

The transient population is distributed sporadically throughout the valley, determined by the objectives of their visits. The main reasons for coming to the valley are higher education, medical check-ups, pilgrimages, bureaucratic formalities, visiting relatives, internal tourism, and official visits.

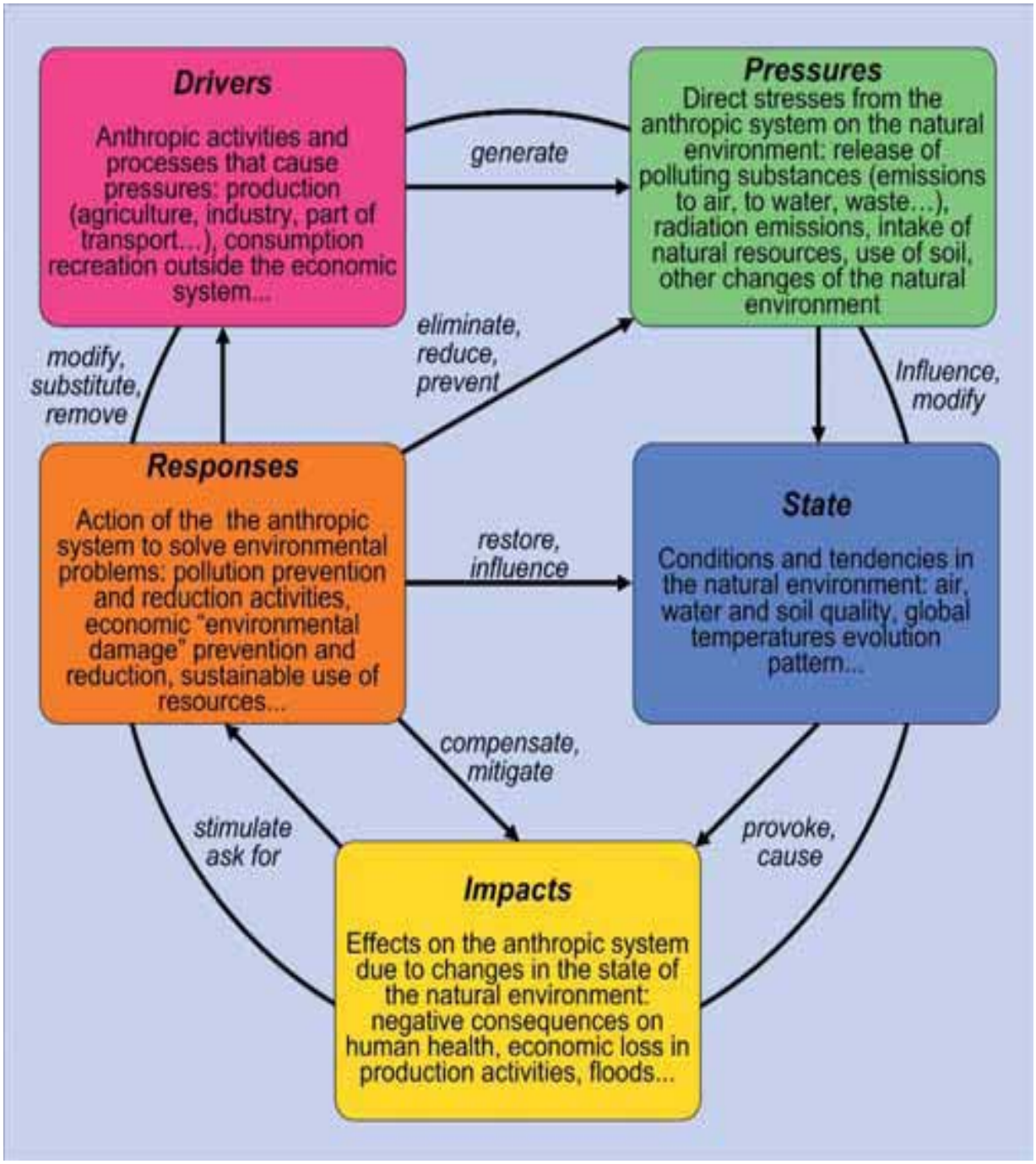
State of Environment in Kathmandu Valley as per OECD framework :

According to the framework developed by Organization for Economic Cooperation and Development (OECD) and other organizations, which has been adopted by the United Nations Environment Programme (UNEP) for the preparation of an integrated environmental assessment report of the Kathmandu Valley's Environment Outlook, the five key environmental issues in the Kathmandu Valley were:

1. Air quality and traffic management
2. Settlement patterns
3. Water resources
4. Waste management
5. Natural disaster preparedness (focused on earthquakes and land subsidence)

[2] Migrant population refers to internal and external migrants
[3] Transient population refers to those who come for temporary purpose

A Driver-Pressure-State-Impact-Response (DPSIR) Framework was used to analyse the five issues in the Kathmandu Valley. The Framework is described below and shown diagrammatic form:



Foresighted State of Environment in Kathmandu Valley:

SN	Issue	Driver	· Pressure	State	· Impact	· Response
1	Air quality and traffic management	Kathmandu-centric development; weak institutional capacities, and increasing affluence and modernization	· Rapid urbanization · Haphazard growth · Unplanned settlements · Vehicular emissions · Increase in number of vehicles · Industrial emissions · Emissions from mismanagement of solid waste	Air quality data from previous years have shown that a high level of suspended particulate matter (SPM) is a major problem in Kathmandu Valley. Among the particles, the smaller particles such as PM10 and PM2.5 are of serious concern because they tend to remain in the air for a long time and can enter deep into the respiratory system causing serious health risks to those exposed. The concentration of NO2 and SO2 are generally within the national standards of 40 and 50 g/m3 respectively. NO2 levels are generally higher in areas with heavy traffic, because vehicles are the main source of NO2. The SO2 levels tend to be higher in Bhaktapur, because of the brick kilns in the area which burn high sulphur coal.	· As the concentration of fine particles in Kathmandu is very high, this is certainly having adverse impacts on public health. Other impacts of air pollution are the economic impacts due to adverse effects on tourism and loss of human productivity because of poor health.	· Several agencies within the government and several other stakeholders are involved in air quality management. Some of the key agencies and their responsibilities are shown in Table 3.9. Over the years, various stakeholders have introduced positive steps to control air pollution in the valley (Table 3.10).
2	Settlement patterns	The population of the valley in 2020 will reach 2.5 million compared to 1.6 million in 2001 (KVTDC 2002). This	· Change in the settlement pattern · Modern development due to expansion of the · industry and	The rural areas of Kathmandu have experienced unprecedented land subdivision and building construction over the past decade. An influx of internally	· River pollution · Air pollution · Dumping of solid waste · Loss of agricultural land	In 2002, the government approved a Long Term Development Concept for

		growth in population includes both natural growth and emigration. At present the population growth for the valley has been estimated at more than four per cent per year. The low density urban sprawl and uncontrolled settlement development in rural areas are the two key issues in urban development.	service sectors	displaced people has suddenly created a demand for housing plots and basic services. Those who cannot afford land in municipal areas prefer to stay on the fringe areas of the cities and in villages. One of the vivid manifestations of unplanned settlement in Kathmandu is the emergence of squatter settlements in different parts of the city.	· Traffic congestion · Land speculation · Loss of cultural heritage · Substandard housing conditions · Gaps in supply of and demand for basic services. · Domination of informal land brokers in the land market	Kathmandu Valley prepared by Kathmandu Valley Town Development Committee.
3	Water resources	· Population growth · Urban growth and expansion · Agricultural development · Tourism · Infrastructural development	· Water quantity · Water quality · Domestic waste · Industrial waste · Increase in the use of agro-chemicals · Change in land-use pattern		·	·
4	Waste management		·		·	·
5	Natural disaster preparedness (focused on earthquakes and land subsidence)		·		·	·

Pressure:

Pressure indicators describe the variables, which directly cause environmental problems. Some of the pressures for environment of KTM Valley:

[a] Lack of employment sectors[b] Unsystematic settlement patterns,[c] Over-consumption of natural recourses.[d] Insufficient public city transport system[e] Solid waste management[f] Polluting industries [g] Improper drainage and sewerage system[h] Large scale deforestation [I] Tourism.[j] Natural Disaster

[a] Lack of Employment Sectors:

People are migrating from rural areas and other urban areas of the state with the hope of getting employment opportunities in different formal sectors. The rate of migration is so high in comparison to the scope of employment in formal sectors is that all cannot get decent employment in the city. So, there is always a lack of employment opportunity. This unemployed mass never go back to their native place. They contribute to the population growth of the city leading to many other correlated environmental problems.

[b] Unsystematic Settlement Pattern:

The settlement pattern of the city is greatly influenced by the rapid growth of population. The settlement pattern in KTM Valley can be classified in to two categories 1. Formal settlements and 2. Informal settlements or, slums, shanty and squatter settlements. There is always a mis-combination of formal and informal settlements in many locations of the city. During the early age of KTM, i.e. in 1950s, KTM had only formal human settlements constructed by the Royal Authorities for its ministers, officers, military staff and workers. But, as the city grew and headed towards more urbanization, more formal settlements were generated by the people along with informal settlements.

[c] Over-Consumption of Natural Resources:

Consumption of natural resources is always directly proportional to the population growth. More uncontrolled population leads to pressure on consumption of the natural resources of Land, water, air, forests etc. As the city grows with population and infrastructures, it destroys the proper land use pattern of the city. The present land use pattern of KTM Valley is as per the following.

From the land use analysis it is observed that the percentage of the vacant land in KTM appreciably high. The city has a good potential for future development on the Western side.

But rapid growth in urban population consumes more of land in an unsystematic manner causing threat to natural land resources. Over consumption of water, air, and forests are also due to the increase in the urban population in KTM Valley. People with low income living in informal

settlements cannot afford to pay to the municipal corporation by taking individual water connections to their houses. So, they depend on the public water tap of the community or, natural water source or tube well of the locality. As they are not paying for consumption of water, they go on misusing. People with low income also pollute air by adopting cheapest means of fuel like fuel wood and coal for cooking purpose. Natural forests are also destroyed to spread the settlements and by collecting wood to use as fuel wood in low-income houses.

[d] **Inefficient Public City Transport system**:

The public city transport system is not that efficient to cater good service to the public. Human settlements are going on increasing in all possible geographical directions. But the network of the public transport system is not increasing accordingly. The city bus service is available in some of the fixed routes, which was there on ten years ago. New routes and connecting routes are not coming up causing inconvenience to the passengers depending on city bus service. Another practical problem the commuters face is that it takes much time to cover even a short distance because the city buses wait for passengers to fill the bus for the initial two to three stops from the starting points. There is no fixed time for the city bus to leave a particular stop. The time depends on either the bus getting filled up with passengers or the next bus reaching the stop from behind and the greatest problem the buses create is that, the whole period of waiting for the passengers is spent with the engines in on position causing a lot of air pollution.

These are the factors that discourage the public to commute by the city buses and encourage using the private vehicle to avoid inconvenience and to consume less time in travel. This increase in private vehicle ownership causes more air pollution of KTM Valley.

[e] **Solid Waste Management:**

Solid waste can be defined as those wastes other than liquid and gas, which do not possess any value for the owners and are discarded. The effect of urban solid wastes is not only confined to one area of the environment, but it has the potentiality to cause ground water, surface water,

Land and air pollution. As such, with rapid growth of population, management of urban solid wastes has become a major concern to the public and is a thrust area of municipal

administration of KTM Valley The quantity of solid waste generated increases with the increase in population and their changing life style and habits.

Solid waste management is one of the important obligatory functions of KTM Valley and Municipal Corporation. This service falls far short of desired levels, resulting in problems of health, sanitation and environmental degradation of the city.

[f] **Polluting Industries**:

KTM Valley is not at all an industrialized area. Still then, there are some patches of industries where we find mostly small to medium scale industries. There are many stone crushers located towards the southern side of the city. The other belts of different types of manufacturing Industries are–Bhaktapur, Lalitpur, Kathmandu Industrial Estates. These Industries put pressure on the air quality of the city. The breaks factory, stone crossing industries, uncontrolled housing are the major contributor for the pollution of the state of environment in the Valley.

[g] **Improper Drainage and Sewerage System**:

Since Kathmandu has undulating ridge and valley topography, the valleys act as natural drains to dispose off the wastewater of the city from the west to the east through the different 'city drains', which ultimately drains in to the river "Baghmati".

The sewerage system of KTM Valley was initially designed to serve a total population of 200,000 people. With rapid pace of urbanization, it is also subsequently added with new Sewerage systems, which is not adequate enough to dispose off the sewers of the city. The congested sewerage system causes overflowing affecting environment adversely.

[h] **Large Scale Deforestation:**

Not long time ago, before the one decade KTM Valley and adjoining regions supported a thick vegetation cover, which was popularly known as Kathmandu Ban/jungle, a part of the Kathmandu dynasty. The forest was moist deciduous type. The biodiversity was remarkably rich. But with the growth of population and expansion of city, large-scale deforestation took place. Concrete jungles disturbing the flora and fauna of the region replaced the natural Jungle. This large-scale deforestation had direct impact on the microclimate of the region.

[I] **Tourism Aspect:**

Kathmandu Valley is known for its ancient art, culture, craftsmanship, and numerous monuments of historic and archaeological importance. One of the popular tourist destination in the South Asia. Its enchanting natural beauty and, temple sculpture and strategic location always attracts millions of tourists and holy devotees to the Kathmandu valley. UNESCO has described Kathmandu as a 'living heritage site'. The valley has a number of temples, palaces, monasteries, and Buddhist stupas that are centuries' old. A unique feature is the religious co-existence of Hindus and Buddhists, as they worship at the same religious sites. There are many interesting sites within a radius of 20 km, and it used to be said that there were as many temples as houses and as many festivals as there are days on the calendar.T here are many popular temples like, Pasupati Temple ,Kathmandu, Rudrayani Temple, Khokana,• Bramhayani Temple, Thaiba,• Bringareshwor Mahadev Temple, Sunakothi • Aadhinath Temple, Chobhar • Chilanchu Mahavihar Temple, Bagh Bhairab Temple, and Umamaheswor Temple in Kirtipur • Bajrabarahi Temple in Chapagaon • Shikara Temple of Rato Machhendranath in Bungamati

Tourists come to Kathmandu Valley throughout the year with heavy flow during the winter season. This tourist population is also sufficient to contribute to the driving force of growing population affecting the environmental state of KTM valley. The majority of the income of the valley comes from the hotel industry, which also put extra burdens in terms of garbage collection and waste disposal.

[J] **Natural Disaster**:

Infrastructural development in the valley facilitates the concentration of population from other parts of the country. Encroachment on land, haphazard construction of buildings, and rapid urbanization lead to rapid population growth No building codes are implemented although they were introduced in 1994; although Lalitpur Sub-Metropolitan City has implemented a Nepal National Building Codes since 16th January, 2003 to make city dwellers aware of the risk of earthquakes. Sky scrapers are being built without taking sub-surface geology into account. Although this is more prevalent in Kathmandu, Lalitpur and Bhaktapur are beginning to follow suit. Population growth trends are shown in Figure 43. The red triangles indicate the occurrence of major earthquakes. According to the figure, the population increased thrice in 50 years. According to Pandey and Molnar (1988), the population and number of houses in Kathmandu Valley in 1920 were 306,909 and 66,440 respectively. According to the 1991 census the population of Kathmandu Valley was 1,105,379 and according to that of 2001 it was 1,653,951.This means the population has increased five times since 1920. Similarly, the urban area of Kathmandu Valley has increased extensively from 1920.

No great earthquake has been reported between the longitude of Kathmandu and Dehradun for 300 years, and that could be a potential area for a big earthquake in future. This location lies between two great earthquake locations (the Nepal-Bihar earthquake of 1934 and the Kangra earthquake of 1905).Geological faults, fragile geological conditions, high intensity rainfall during monsoon, unplanned land use and insufficient fuel leading to deforestation are the forerunners to landslide occurrences. Figure 48 gives the location of landslides in the Kathmandu subsidence.

Table 7.5: **Earthquakes since 1255 which have affected Kathmandu Valley**

Year	Magnitude/ intensity (MMI)	Epicentre	Human		Temples collapsed	Houses	
			Deaths	Injuries		Collapsed	Destroyed
1255	7.0 X (MMI)	NA	1/3rd to 1/4th pop. of the Valley	NA	Many	Many	Many
1408	7.0 X (MMI)	NA	NA	NA	Many	NA	NA
1681	7.0 IX (MMI)	NA	NA	NA	N/A	Many	Many
1810	IX (MMI)	NA	NA	NA	N/A	NA	Some
1833	7.6 VII to X (MMI)	50 km north-east of Kathmandu	414	172	More than 6	Many	4,040
1934	8.3 IX to X (MMI)	Lat 27.45N Lon 87.0E	4,296	NA	19	12,397	43,342
1988*	6.6 V (MMI)	Lat 26.77N Lon 86.60E	8	71		650	1,814

Key: NA = not available; MMI = modified Mercalli intensity
Source: MoHA 1989; Pandey and Molnar 1988; Bilham and Bodin 1995; Chitrakar and Pandey 1986

State of Environment:

State indicators show the current condition of the environment under the influence of different pressure points described earlier. The state of the environment of KTM Valley due to the combined effects of the different pressure heads can be described as follows:

Population growth and distribution, migration and urbanization, inter alias, affect the socio-economic development and settlement process of any country [Fukanuddin, 1990:92]. The population growth of Kathmandu Valley is caused mainly due to migration. All the migrants cannot be offered employment in the formal sectors. So, most of them being unemployed, usually look for the employment in urban informal sectors. They are forced to compromise with lower wages and lower rate of remittances and sub standard living in order to remit some amount for their rural dependants. The physical impact is reflected through high pressure on land and housing, growth of informal settlements of slums, shanty and squatter houses. The slums are located at different locations of Kathmandu Valley along with the formal settlements showing a contrast pattern of human settlement. The growth of the population in Kathmandu Valley has caused overuse, misuse, and illegal encroachment of land resources by constructing

temporary low cost slum houses. Depletion of ground water table is caused by over tapping. The open water bodies are also polluted by over using those. The slum dwellers also pollute the air by adopting cheapest source of fuel to cook their food. Burning of firewood and coal emits lot of CO_2 to pollute the air and also destroy trees and natural forests.

The city transport system cannot provide better service to the increasing population. So, there is always an increasing trend in the number of private vehicle ownership to commute comfortably and timely inside the city. The increasing numbers of vehicles emit different pollutants like-CO_2, CO, Pb, SPM, etc to pollute the clean air of Kathmandu Valley. The table shows the rapid increase in the number of vehicles on the Kathmandu Valley roads.

The increasing number of road traffic and aero planes contribute much towards the noise pollution of the city. Movement of fleet of vehicles, two wheelers, their horn and engine sounds are the major contributors to the higher noise level of the city. As Kathmandu Valley is heading towards more urbanization, the living standard, life style and consuming pattern of the city public is also changing. These changes give rise to generation of more and more solid wastes. The volume of solid waste generated has a positive relation with the growth of population. The solid wastes comprise of paper, cloths, plastics, polythenes, metals, glass, leather, vegetables and organic wastes. The total generation of solid wastes in Kathmandu Valley is approximately 30,000 cft which weigh about 400 tons.

Table 3.8: **Health impacts of PM_{10} in Kathmandu Valley in 1990**

Types of Health Impact	No. of Cases	Value (NRs.)	
		Specific	Total (x 10^3)
Excess Mortality	84	340,000	28,644
Chronic Bronchitis	506	83,000	41,988
Restricted Activity Days	475298	56	26,617
Emergency Room Visit	1945	600	1167
Bronchitis in Children	4847	350	1,697
Asthma Attacks	18,863	600	11,318
Respiratory Symptom Days	1,512,689	50	75,634
Respiratory Hospital Admissions	99	4160	415
Total			**187,480**

Source: Shah and Nagpal 1997

Table 6.5: **Waste generated at the industrial estates in Kathmandu Valley, kg/month**

Waste type		Balaju I.E.	Patan I.E.	Bhaktapur I.E.	Total
Bio-degradable	Food/ kitchen	2,500	500	500	
	Agriculture	10,000	2,000	500	
	Sub-total	*12,500*	*2,500*	*1,000*	*16,000*
	%	26.04	5.0	16.7	15.4
Recyclable (not currently recycled)	Paper	10,000	200	1,000	
	Plastic	5,000	2,300	3,000	
	Tin/ iron/ steel	1,300	2,000		
	Wood	3,000	30,000		
	Milk products	200	-		
	Other			20	
	Sub-total	*19,500*	*34,500*	*4,020*	*58,020*
	%	40.63	69.1	67.0	55.8
Non-recyclable	Rubber/ leather	9,500	-	n.a.	
	Inert material + dust	5,000	12,800	960	
	Sub-total	*14,500*	*12,800*	*960*	*28,260*
	%	30.21	25.6	16.0	27.2
Other waste	Hazardous	500	-	n.a.	
	Medical	500	50	n.a	
	Chemical	500	50	20	
	Liquid waste	-	10		
	Sub-total	*1,500*	*110*	*20*	*1,630*
	%	3.13	0.2	0.3	1.6
	Total	**48,000**	**49,910**	**6,000**	**103,910**

Key : I.E. = industrial estate
Source: Based on Nippon Koei 2005

The generation of solid waste needs proper collection and disposal. In Kathmandu Valley, two clear economic sectors co-exist in the solid waste management system:

1. The formal sector, which has official responsibility for waste collection and disposal. The municipal authority coordinates its activities and it is funded through tax revenues at the municipal and state levels.

2. The informal sector, consisting of the waste picking activities of the waste pickers, municipal collection crews and resident waste pickers, who live and work in the landfill sites. Additionally, itinerant waste brokers travel around place-to-place purchasing and reselling materials from other workers in the informal sector. Both formal and informal sectors play significant role in the waste economy of Kathmandu Valley.

But, the Municipal Corporation of Kathmandu Valley is not able to tackle the solid waste management issue properly. This results in scattered solid waste in some parts of the city causing air pollution emitting bad odor and reducing the aesthetic value of the environment.

There are some industries in the different industrial estate areas, which contribute to air pollution to certain extent. The details of the polluting industries are given below in table.

Table 6.12: **Wastewater treatment plants in Kathmandu Valley**

Plant	Capacity (mld) and type	Status
Dhobighat: receives wastewater from the main urban area of KMC. Constructed in 1978 with IDA funding.	15.4 mld. Oxidation Pond consisting of two primary anaerobic ponds, one secondary facultative pond, and a tertiary aerobic pond. Wastewater requires pumping from Sundarighat pump station.	Not operational, out of operation almost since construction. Problem began with pumping wastewater and conveying through under-river sewer.
Kodku: receives wastewater by gravity from the eastern core areas of Lalitpur. Constructed in 1978 with IDA funding.	1.1 mld. Oxidation pond: consists of two primary/ anaerobic ponds, one secondary/ facultative pond, and one tertiary/ maturation pond.	Partially operational but inefficient. Poor O & M: sludge accumulation and non-functioning flow-control valve, resulting flow short-circuiting (less detention time). Farmers tap raw sewage flowing through sewers for irrigation.
Sallaghari: receives wastewater from some parts of Bhaktapur urban area. Constructed in 1983 with GTZ support.	2.0 mld. Originally designed as an aerated lagoon system using diffused aeration equipment. The plant is now converted to a non-aerated lagoon.	Partially operational. Difficulties related to pumping and operation of mechanical aerators. Farmers tap raw sewage flowing through the sewers for irrigation.
Hanumanghat: serves only a small part of the core area of Bhaktapur. Constructed in 1977 with GTZ support.	0.5 mld. Originally developed as an aerated lagoon.	Partially operating as an oxidation pond/ non-aerated lagoon with low efficiency.
Guheshwori: constructed by the High Power Committee in 1999.	17.3 mld. Activated sludge oxidation ditch.	In operation. High operating costs: in 2005, it was over NRs 10 million (about 65 % of this was for electricity). Foaming in aeration tank is the major technical difficulty. there is also a sludge rise/ flotation problem in the secondary clarifier (Sah 2006).
Teku: constructed by Kathmandu Municipal Cooperation.	Constructed wetland – vertical flow bed	For treating septage (from septic tanks). Not in operation
Madyapur Thimi: constructed with technical support from ENPHO as a pilot demonstration activity of ADB, UN-Habitat, and Water Aid Nepal	Reed Bed Treatment System – horizontal/ vertical flow bed	Serves around 200 households, and receives about 30 m^3/ day of sewage. This has recently come into operation. The municipality looks after the O& M.

Key: mld = million litres per day

Source: Timilsina 2004; Nippon Koei et al. 1999; Metcalf and Eddy 2000; ENPHO leaflet

Apart from these industries, there are some stone crusher industries, which also pollute the surrounding air due to suspended stone dusts in the atmosphere. These stone dusts also destroy the normal vegetation of the locality.

The valley portion of the undulated topography of Kathmandu Valley is getting utilized by constructing residential buildings therein disturbing the drainage system of the city. And over population causes sewerage drains to get overflowed, flooding the city land at many locations. At some locations the sewerage water gets contaminated with the surface water also.

IMPACTS:

The substandard state of environment, due to different environmental pressure, causes adverse impacts on the Environment and ultimately on human health. The impacts may be summarized as:

- Lack of employment opportunity causes mass unemployment resulting in the growth of many informal sectors through out the city.
- Growth of informal settlements like slums, shanty and squatter settlements causes heterogeneity in settlement pattern & loss of heritage. The slum dwellers are deprived of good housing, proper sanitation, clean water and air and other minimum facilities, which endanger the health, safety or morals of the inhabitants. The house of the informal settlements are very much susceptible to natural and man made disasters due to its low quality of construction, closeness of houses and temporary nature which causes threat to life and property all the time.
- Over consumption of natural recourses cause threat towards sustainability of our future generation to come.
- Due to the encroachment of the natural drainage paths for the purpose of constructing buildings and infrastructures, the smooth discharge of runoff water of heavy drown pour is not possible causing city flooding at some specific localities of Kathmandu Valley.
- Increased concentration of pollutants emitted from the running vehicles and industries cause increased number of lungs diseases and respiratory problems of the city dwellers. Children are the worst affected mass of the city.
- Increase in the number of vehicles also cause noise pollution at the city centers. Noise pollution affects the human beings physiologically and psychologically too. Long and continuous exposure to higher level of noise causes irritation and sometimes health problems too.
- Increased number of vehicles also causes traffic congestion.
- Improper solid waste management reduces the aesthetic value of the environment. If not cleared up in regular intervals, i.e. daily, it emits bad odor or, fowl smell causing air pollution of the environment. If proper techniques are not adopted starting from the collections till disposal, it may create health hazards.
- Overcrowding of people due to different factors like Migration, Tourism etc. over use the open water bodies located at different part of the whole old town areas, there by disturbing aquatic eco-system.
- Large scale deforestation and increase in urbanization activities affect the prevalent micro climatic system of Kathmandu Valley. Since last couple of years heat island effect

is very much observed during summer season. There is a very sharp rise in the maximum day temperature even up to the 35 C in the summer, which is uncommon for a urban valley like Kathmandu, located in the mountain slopes. A very big difference in the day's maximum and minimum temperature is observed which causes many health problems.

- Over flow of sewers cause health hazards and also gives foul smell.

Table 6.10: **Summary of water quality in the Bagmati and its tributaries (post-monsoon test November 1999)**

River	Summary of findings
Bagmati River (Sundarijal to Khokana)	TSS increases from about 5 to 70 mg/l; chloride from 1.0 to 24 mg/l; Ammonia from 0.03 to 11 mg/l; BOD form 1.3 to 65 mg/l; and DO decreasing from 8.9 to 1.7 mg/l as the river flows through urban areas. The water quality suddenly deteriorates after joining the Dhobi Khola and becomes worse after joining the Tukucha and Bishnumati. After this, however, the water quality improves: at Khokana, DO value revives to 6.0 mg/l with corresponding decreases in BOD, NH_3, and other pollutant concentrations. Phenol concentration up to 0.07 mg/l in Jorpati and its immediate area (a number of carpet dyeing and washing facilities exist along the riverbanks in this area).
Hanumante River (Khasyang-khusung to Koteshwor)	The water quality first declines as it flows, but improves after other streams join (Manohara, Godavari). For instance, Cl^- increases from 9 to 12 mg/l and then decreases to 10 mg/l; similarly Ammonia from 0.19 to 4 mg/l and then to 2.8 mg/l; BOD from 5 to 12.07 mg/l and then to 7.3 mg, DO decreases from 7.5 to 2.1 mg/l and then increases to 7.8 mg/l. Phenol is detected at 0.002 mg/l.
Manohara River (Sarangchowk to Sankhamul)	Although it also becomes dirtier flowing downstream, the flow also increases from about $1 m^3/s$ to $4 m^3/s$. In comparison to other tributaries of the Bagmati River, the Manohara is much cleaner. For instance, DO values never go below 7.0 mg/l; BOD increases from 1 to 7.3 mg/l; COD from 1 to 21 mg/l, and ammonia from below 0.1 to 18 mg/l. The ammonia value jumped to 18 mg/l from about 0.2 mg/l just before joining the Bagmati.
Dhobi Khola	Upstream from the Kapan area (Lasuntar), water quality is fairly good except for bacteria contamination. Although suspended solids and iron content are fairly high, other parameters are within the drinking water limits. But as the stream flows downstream, it gets rapidly polluted with BOD load increasing from 78 kg/day to 2,132 kg/day and then to 11,919 kg/day (the highest BOD load of all tributaries except the Bishnumati). The causes may be attributed to proliferation of industrial activities, particularly carpet dyeing and washing and rapid urbanisation in the area. Pb, Cd, Cr, Al and Hg are not detected. Phenol concentration is found in one sample of around 0.07mg/l.
Bishnumati River (Tokha to Teku)	Water quality degrades gradually as it flows downstream and flow rate increases from $0.1 m^3/s$ to $2.6 m^3/s$. Cl^- increases from about 2 to 26 mg/l, ammonia from 0.1 to 11 mg/l, BOD from 5 to 85 mg/l and DO decreases from about 7 to 1 mg/l. BOD load increases from 26 kg/day to 18,654 kg/day just before mixing with the Bagmati. The Bishnumati River carries the highest BOD load of all Bagmati tributaries. At the uppermost point near Tokha, the river quality seems to be much better than at downstream points. Cd, Cr, Al and Hg are not detected. But Phenol concentration (0.05 mg/l) and Pb (0.015 mg/l (in one sample) were found.
Nakhu,Godavari, Tukucha, and Balkhu rivers	The water quality of the Nakhu and Godavari kholas are in very good condition except for bacterial contamination. Tukucha is almost sewage with DO near zero and BOD 260 mg/l. Balkhu Khola upstream is good whereas the downstream stretch is a little more contaminated, with BOD increasing from 3 to about 12 mg/l.

Source: MWSP- Project Management Consultant 1999

RESPONCES:

- Some development programmes were taken up, during the last decades by the Nepal Housing Board [NHB] and Kathmandu Metropolitan Development Authority [KMDA] in the support of improving the quality of living of the slum dwellers and for reducing the pressure in the existing slum pockets. Some of the programmes are of direct in nature and others are indirect efforts.

Efforts:

- To regulate the proper land use planning inside the Kathmandu city, KMPDA was formed.
- Unleaded gasoline replaced the leaded one to lower lead content in the air pollutants.
- Opening of vehicular emission test centers at different locations of the city.
- Construction of improved roads and providing other infrastructure facilities for smooth flow of traffic.
- Nepal Pollution Control Board was formed. Among its main objectives, one is to check and control pollution caused by the industries.
- Kathmandu Metropolitan Municipal Corporation is increasing the capacity of the sewerage system in phase wise manner.
- Avenue plantation and roadside plantation is going on from the dept. of Forests.

POLICY GAPS:

1. No policy so far formulated to make rural sides more attractive to reduce rural to urban migration
2. Employment generating schemes not initiated by the government.
3. No policy is thought of to create an intermediate urban center between Kathmandu Valley and the rural areas to reduce pressure on Kathmandu Valley.
4. No clear-cut policy on the slum and squatter settlements has been formulated so far
5. Development of Kathmandu Valley without effectively implementing the existing master plan.
6. Slum up gradation and resettlement programmes fail or don't get materialized as those are dealt without proper understanding peoples' need and affordability.
7. Lack of strict enforcement of Laws.
8. Lack of future estimate by the Govt.
9. Corruption at each level hampers the process of up gradation of the environmental status of Kathmandu Valley.
10. Lack of infrastructural facility and fund.
11. Fund generation process of the municipality not properly implemented.

12. Lack of coordination between different government departments, NGOs and private groups.
13. Lack of peoples' awareness.
14. Inefficient top-down approach in management.
15. Lack of peoples' participation in pollution control programmes.

Recommendations:

- Policy should be formulated and implemented to increase the attractiveness of the rural side to reduce man-drain to the city. Rural areas must be provided with better facilities of good health service, better education and employment opportunity to restrict migration.
- Building Intermediate City to serve as link between Kathmandu Valley and nearby rural areas to check the population growth.
- Various income generating schemes should be introduced with the assistance of the government followed by skill development programmes in specific areas.
- Some clear-cut policy on the slum and squatter settlement should be formulated to regulate the growth of informal settlements.
- Peoples need and affordability must be thoroughly analyzed before formulating any slum up-gradation and resettlement programme.
- The existing master plan of Kathmandu Valley must be reviewed and revised thoroughly by a team of senior experts from different fields and then implemented strictly.
- Proper land use planning must be done.
- Public city transport network should be made efficient to discourage private vehicle ownership and encourage using public transport system to reduce air pollution, noise pollution and traffic congestion during the peak hours.
- Condition of engines of vehicles must be verified periodically by checking the emission. This emission checking process must be made very strict with heavy amount of penalty for the violators.
- Placement of the catalytic converters in the exhaust pipe must be made compulsory for each and every vehicle.
- Availability of better quality of gasoline with high-octane value must be ensured in all petrol pumps.
- Infrastructure developments like construction of more and more improved roads, interchange, intersections and flyovers must be provided to allow smooth flow of traffic. All these facilities along with better traffic management can reduce pollution loads.
- People should be encouraged to buy four-stroke motorbike compared to two stroke bikes to reduce pollution.

- The whole process of solid waste management should be made stream lined.
- Collection bins must be provided at different locations for organized garbage collocation. Different colored bins with clear writings on the sides with local, national and with English languages must be placed together for segregated collection of different types of urban solid waste. These placement patterns should be repeated at every 100 meter distance or, for every 100 people so that, people do not throw garbage here and there.
- The people of the municipal corporation must clean all the collection bins early in the morning hours every day.
- Segregation of the solid wastes is a must. The recyclable wastes like plastics, glass, metals etc must be sent for recycling. The other wastes can be disposed off suitably.
- Creating awareness among the public about solid waste management.
- Encourage 3-R principle i.e. Reduce, Reuse, and Recycle.
- EIA must be made compulsory for every industry or, project.
- Pollution from industries must be controlled by adoption of sophisticated new technology and end of the pipe technology.
- The stone crusher industries causing lot of air pollution should be shifted and relocated sufficiently away from the master plan area boundary of Kathmandu Valley.
- Production of noise from all sources expecting emergency requirements should be banned between 9.00 pm to 6.00am.
- Pneumatic horns of the vehicles should be banned altogether.
- City sewerage system must be made updated by redesigning, considering future growth.
- Urban sprawling in the vicinity of the natural drainage channels not only creates unhealthy situation but also frequent urban flooding caused due to heavy rain. Extra attention should be given at the time of granting planning permission.
- Hazardous waste generated must be disposed off properly irrespective of their quantity.
- Large-scale avenue plantation must be encouraged.
- The developmental activities should be always interdisciplinary.
- Green agenda, Brown agenda and White agenda must be emphasized.
- Government must find means to generate funds for environmental protection.
- Improved techniques like GIS should be followed in town planning.
- Strict enforcement of laws.
- Awareness and capacity building among the public along with stakeholders consultation.
- Develop public-private-partnership [P.P.P] in protecting the environment of Kathmandu Valley.

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