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Transportation and Environmental Issues: A Case Study of Nepal

Shobhakar Dhakal
Urban Engineering Department, Graduate School of Engineering,
The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113

1. INTRODUCTION

Environmental issues in transportation sector of Nepal emerge from two principal directions. The first is ever increasing and concentrated economic activities in urban settlements with narrow roads which have created high concentration of pollutants due to congestion in the urban atmosphere. The effect is multiplied due to lack of policy initiatives in environmental quality, controlled urbanization, and coordinated effort in the planning process, and this have been the major reasons for transport induced environmental problems in the past. A second dimension of environmental problems persists in *out of the urban settlements* due to deforestation, soil erosion and loss of bio-diversity in roads and nearby areas. However, this report intends to focus on the environmental issues of urban settlements in more detail.

The major sources of transport induced air pollutant problem in the urban settlements have been energy consumption by automobiles. For developing country like Nepal, the motivation for energy concern stems from the viewpoint of reducing air pollutants and to cope with energy security issues. Lack of vehicle maintenance and fuel in-efficiency due to wear and tier have contributed much to worsen the situation in Nepal. Therefore, policy options being tried are import-restriction on old vehicles, encouraging vehicle maintenance, promoting alternative fuel vehicles and so on.

This report presents a holistic view of the state-of-art Nepalese transport sector in the beginning. The energy and environmental issues of an urban settlement is then analyzed and the future of motorization and their implication is tried to en-vision. The motivation for focussing on capital city, Kathmandu is multi-fold which will be clear after going through subsequent texts.

2. COUNTRY PROFILE

1.1 Geographical and Economic Profile

Geography: Nepal is a tiny land-locked Himalayan kingdom sand-witched between People's Republic of China to its north and India to its other three sides. The country has a population of 18.5 millions(1991) and an area of 147,181 square kilometers. It is roughly the shape of rectangle with 885 kilometers in length and 145 to 241 kilometers in width. Within the very short span of width, the terrain ranges from 65 meters above sea level to the highest peak in the world, Mount Everest(8,848 m). Topographically, Nepal can be divided distinctly into three regions from north to south: the mountainous region, the hilly region and the flat plains, known as Terai. The mountainous area ranges from 4,877 to 8,848 meters and the hilly region lies in the middle part of the country with altitude from 610 to 4,877 meters above sea level. Terai, the extension of Gengetic plains of India, forms a low flatland along the southern border. About eighty percent of total land area is covered by mountains and high hills whereas the flat Terai region, suitable for cultivation, covers the rest. Officially Nepal is divided into five development regions i.e. western, mid-western, far-western, central and eastern development regions(CBS, 1996). Table 1 shows the land use pattern and population of the country.

Table 1 Land Use Pattern and Population, Nepal (1991)

Land use	Area in sq.m	Percentage
Agriculture	26,533	18.0
Forest	55,334	37.6
Snow	22,463	15.3
Pasture	19,785	13.4
Water	4,000	2.7
Settlements and Roads	1,033	0.7
Others	18,033	12.3
Total	147,181	100

Population	
Male	9.2 million
Female	9.3 million
Density	126 persons/sq.km
Growth rate	2.1% (1981-91)
Urban	10%
Rural	90%
Total	18.5 million

Source: CBS(1996)

Economy: Nepal is one of the least developed countries in the world with per capita Gross National Product of US$210(UNDP, 1998). Majority of it's population depend on agriculture with very small land holding. Despite planned development effort of 40 years, more than half of the population are living below the poverty line. The real GDP in 1996/97 was 82119 million Rs. at 1984/85 price and its growth has been hovering around 5 percent since 1980(MOF,1998). The share of agriculture sector is 40 percent, industry sector is 18 percent and service sector is 42 percent in GDP. The country has to import not only fuel and capital goods but also primary and consumption goods. Disadvantages generated by geography and other factors make it difficult in maintaining international competitiveness and hence an edge in the export market due to high transportation cost. Economic policies related to labor, trade, interest rate, pricing and exchange rate could not have been independent due to long open border with India.

1.2 Transportation Sector

Transport Modes: Nepalese transport sector is dominated by road transportation due to country's land-locked geographical position. Apart from roads, air transport is the only modern transportation means to reach many remote destinations of the kingdom where road network does not exist. High current and high slope have made water transportation impossible in the existing rivers. Trains virtually do not exist in the country except 52 km steam engine in a district bordering with India. Horse and walking is the only mode of transportation in hilly areas whereas Sheep and, a hybrid offspring of horse and donkey, are common mode of goods transportation in high mountains. Therefore Government's policies have long been directed to mobilize resources so as to make every district headquarters accessible by road at least.

Road Transportation: Varieties of non-motorized road transportation modes have been observed in the country. In the flat plain areas bordering with India, bicycles, manually propelled(tri-cycle type or animal driven) three wheeled *Rickshaw* and ox-driven wooden carts have been popular, the latter in rural households. Small towns are flooded with *Rickshaws* since the town is small in area and bus network supports only inter-town commuters and goods. Varieties of automobiles form the part of the motorized sector. Poorly maintained bus network connects all the major cities in the country that are accessible by roads, and typically all these cities are connected to the capital city, Kathmandu. Taxies are operational only in few major cities in Nepal such as Kathmandu Valley, Pokhara and Biratnagar. Bicycles and two wheelers(commonly called motor cycles) are therefore popular mode of inter-city transportation all over the country where road network exists.

Road Statistics: As of mid-April 1997 Nepal has 11,456 km road lengths out of which the shares of black topped, graveled and fair-weather road are 32%, 25% and 43% respectively(UNDP, 1998). Similarly, the shares of national highway, major feeder road, district road and urban road have been 26%, 15%, 45% and 14% respectively(DOR, 1997). Appendix 1 shows the distribution of total road

length by region, road classification and road type. Regional disparity is huge in road distribution in the kingdom. It is seen that out of the total urban roads in the country, central region occupies almost half, which basically represents the urban road in Kathmandu Valley.

The east-west highway is the most strategic highway integrating the country from east to west and has been under construction since last 36 years. In the southern belt of the country, major district headquarters are connected via major feeder roads or other highways to the east-west highway. This highway is yet to complete and 22 bridges are remaining to be completed in western side.

Vehicle Population: Table 2 shows the vehicle population by type and region. The statistics shows that the two-wheelers i.e. motorcycles, constitute more than half of the total vehicles in the country and Bagmati zone alone constitutes 65 percent of motorcycles in the country. More than 65% of car/jeep/van in the country is concentrated in Bagmati Zone which roughly represents Kathmandu valley in terms of transportation. Even though buses/trucks and other vehicles are registered at other regions, the majority of these vehicles operate to and from Kathmandu.

Table 2 Vehicle Population by Type and Zones, Nepal(July, 1998)

Zones	Bus	Minibus	Truck/ Tanker	Car/ Jeep	Tempo	Motorcycle	Tractor	Others	Total
Bagmati	1471	1562	5042	31124	3978	71047	1672	3278	119174
Narayani	3666	342	8187	6689	774	10452	4899	49	35058
Lumbini	955	167	1323	1642	240	6582	3081	20	14010
Koshi	302	179	1219	2473	265	7931	1308	154	13831
Gandaki	517	202	671	2793	-	5397	585	13	10178
Janakpur	182	18	379	436	34	2420	1239	70	4778
Bheri	187	32	465	499	132	2436	807	14	4572
Mechi	236	35	397	441	18	1513	318	2	2960
Sagarmatha	93	16	234	346	9	1137	480	3	2318
Seti	95	5	316	159	37	564	815	2	1993
Mahakali	150	6	174	154	29	388	231	-	1132
Rapti	123	6	97	163	9	445	244	6	1093
Total	7977	2570	18504	46919	5525	110312	15679	3611	211097

Source: DOTM(1998)

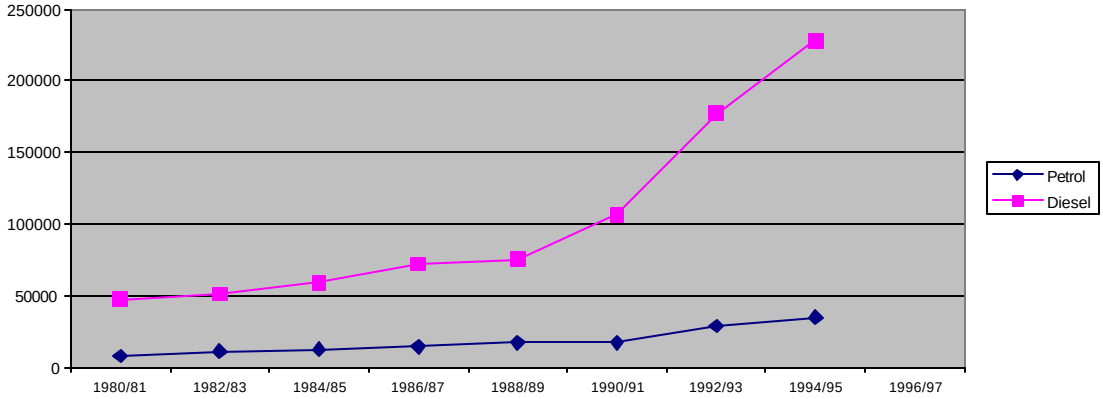
Above discussions clearly show the importance of Kathmandu valley in overall transport sector of the country. Kathmandu valley holds nearly half of the urban road and more than 70% of light vehicles in the country.

Table 3 Vehicle Population Growth since 1995, Nepal

Year	Bus	Minibus	Truck/ Tanker	Car/ Jeep	Tempo	Motorcycle	Tractor	Others	Total
1995 July	6180	2210	15256	35746	4922	75999	11497	3437	155251
1996 July	6470	2260	16006	39787	4996	85373	13157	3324	171559
1997 July	7078	2440	16913	42780	5181	98006	14414	3593	190672

Source: DOTM(1998)

Energy Consumption in Transport Sector: Transport and industry sectors of Nepal rely on supply of imported hydrocarbons from Arab countries through India. Demand for imported petroleum is reported to be grown at about 7% per annum over 1980-93(WECS, 1993) but recently steep growth have been observed(MOF, 1998). The demand of petroleum products in road transportation is depicted in figure 1.



Source: MOF(1998)
Figure 1 Demand of Petroleum Products in Road Transportation, in Kiloliters

3. ENERGY-ENVIRONMENTAL ISSUES IN KATHMANDU VALLEY

Kathmandu valley constitutes three districts including the capital city, Kathmandu. It has been the heart of "modernity" in Nepal which is political, economical and transportation center. The population of the valley grew from 700,000 in 1981 to over a million in 1991 constituting almost five percent of the country's population(CBS, 1996). Recent studies have indicated that Kathmandu Valley suffers from serious air pollution and vehicle exhaust is the most prominent source(Shrestha and Malla,1996; KVVECP,1994; NILU-URBAIR,1995). It is estimated that transport sector is the largest source of emission among different sectors contributing 59 percent in 1993/94. Bowl like topography has created a process called *temperature inversion* which has caused the pollutants to settle near the surface rather than escaping out of the valley. Apart from human health and material damage, tourist influx has also been affected since tourism is a major source of foreign currency in the Nepalese economy. Lots of interest in electric vehicles(hereafter EVs) have been generated recently in the valley and few converted electric three wheelers (popularly called 'tempo' which are blamed for being noisy and polluting) have been operating since 1995. Private investors and donor agencies have shown considerable interest for electric vehicle development in the valley and two such companies have already been established. Government, donor agencies and local authorities are encouraging EVs that are reflected in their import, sales and income tax policies.

3.1 Environmental Implication Analysis

An attempt is made to calculate the tailpipe pollutants in the Kathmandu Valley mainly, CO, HC, NOx, SOx, Particulate Matters(PM) and lead(Pb).
The exhaust emission by vehicle type i for pollutant type j in year t is expressed as,
$P_{ij}(t) = N_j(t) * VKT_i(t) * EF_{ij}(t)$
Where,
$N_j(t)$ = Number of vehicles in operation of type j in year t
$VKT_i(t)$ = Average vehicle KM traveled by vehicle type j in year t
$EF_{ij}(t)$ = Emission factor of pollutant type i of vehicle type j in year t
Since the selection of emission factors is crucial for estimation of pollutants, data compiled in a recent study for different vehicle types in the context of Kathmandu valley are used in this analysis(Appendix 2).

Current Pollutants mix: It is found that CO constitutes the largest share(67%) in the emission of total pollutants in 1996 followed by HC(25.7%) and NOx(5.4%). At the same time PM, SOx and lead emissions contribute small shares(1.5%, 0.5% and 0.02% respectively) in the total emission. Share of CO is the largest because CO is the major pollutant emitted by gasoline vehicles such as cars and motorcycles, whose population shares are 21% and 57% respectively. The effect of these pollutants on people would be amplified due to the congestion and low average speed of the vehicles which cause high pollutant concentration inside the core city area. Table 4 shows the pollutant mix by pollutant as well as by vehicle types. The estimate suggests that gasoline vehicles were responsible for almost 91% of total pollutants in comparison with 9% by diesel vehicles. Further calculation show that the pollutants will increase by three folds in the year 2011 if unchecked as in the past.

Table 4 Pollutant Emissions in 1996, in Tons

Type	PM	CO	HC	Nox	Sox	Pb	Total
Bus	66	264	81	286	39		736
Minibus	65	97	54	56	17		794
Truck	168	673	208	72	98		1876
Car	72	22368	2994	97	47	7	26463
Jeep	157	541	227	24	66		1236
3 Wh.(MS)	14	1517	947	13	3	1	2496
3 Wh.(HSD)	28	42	24	242	7		343
Motorcycle	268	12846	10170	38	11	2	23333
Tractor	9	22	12	14	4		60
Total	847	38370	14717	3102	292	10	57337

MS is Motor Spirit; HSD is High Speed Diesel

3.2 Attractiveness of Electric Vehicles

Apart from environmental benefits, there are other factors favorable to EVs in Kathmandu valley. In the context of lack of indigenous petroleum resources, foreign dependence on oil can be reduced drastically since transport is major (44.3%) petroleum consuming sector in the country and Kathmandu valley accommodates nearly 60% of total vehicles in Nepal. The indirect and unaccounted benefits of energy security and fuel substitution will be high for land-locked economy like Nepal. Nepalese electric system is predominantly hydro and EV battery charging could use surplus off-peak hour energy provided by run-of-river hydro plants. If electric rates are properly designed, EVs would help improving the load and capacity utilization factors of the power system. The major technical limitations of EVs such as short travel distance per charge and low top speed are not expected to hinder EVs in Kathmandu valley, since the average daily travel requirement and speed of vehicles are reported to be below 100 kilometers per day and 25 kilometers per hours respectively(JICA, 1992).

3.3. Avoided Pollutant Emissions by EVs

Possible role of EVs in reducing pollutant emissions is studied with different scenarios of EV penetration to the Kathmandu's transportation system. Scenarios are defined as below. Vehicle population forecast is adopted from a previous study(JICA, 1992).
Base Case Scenario is without electric vehicles in the urban system of Kathmandu. Five scenarios are considered for EV penetration. The first three scenarios overestimate the capability of EVs to meet the travel requirement in the valley however last two scenarios are more realistic which can be met by current state-of-art electric vehicles. These scenarios differ in terms of total number and types of vehicles, daily kilometers traveled and yearly EV penetration rates.

EV Scenario 1: All Government Vehicles to be Electric(EV-1): One important method to facilitate the introduction of EVs to overcome initial market barriers is the practical demonstration of the technology through government and public utility adoption. Many researchers have proclaimed that positive externalities associated with EVs will be captured neither by producers nor by users of EVs in absence of initial incentives and facilitation(Ford, 1995; Dabels, 1992 and OECD, 1992). Therefore, in this scenario, all government vehicles will be electric by the year 2003. In initial years the penetration is assumed low(% of total stock) and higher after the year 2000.
EV Scenario 2 (EV-2): This scenario is directed towards the use of EVs in commercial sectors. It is assumed that all taxies, buses/minibuses and light trucks operating inside the valley will be electric by the year 2011. The penetration rates considered are 10% by 2003 and 100% by 2011.
EV Penetration 3 (EV-3): This is rather optimistic scenario and incorporates scenario 1 and 2 to some extent. All government vehicles together with 50% of all commercial vehicles are assumed to be electric by the year 2011.
EV Scenario 4 (EV-4): This is realistic scenario in which only 50% of total government and private cars are considered to be electric by the year 2011. Taxies are excluded since they may seek high driving requirement. EV penetration is assumed from the year 2000(2 and 3% respectively in private and government car stock) which follow S-shaped penetration curve.
EV Scenario 5 (EV-5): This scenario is similar to EV-4 except 30% maximum penetration level is set in private and government car stocks in the year 2011.

The control technologies considered in this analysis are unleaded gasoline, low sulfur fuel, catalytic converter and particulate trap for diesel vehicles and resulting emission factor are adopted from existing literature(Anderson, 1992). Table 5 shows that the percentage of pollutant reductions that would be achieved by EV introduction is slightly greater than the Internal Combustion Engine Vehicles(hereafter ICEVs) with pollution control technologies. The reason for this small difference is that, the percentage abatement is high in CO and HC due to efficient emission control technologies. Environmental benefits of EVs would be relatively less if efficient emission control technologies are used in all ICEVs in future. However the cost of such system is not analyzed here. It was found that reduction in HCs by EVs is less in all the scenarios. This is mainly due to the motorcycle induced HCs which have highest share(due to their population) but not considered for EV replacement. NOx and SOx emissions are avoided very significantly.

Table 5 Percentage Reduction of Pollutants in Year 2011, Kathmandu Valley.

Scenario	PM	CO	HC	Nox	Sox	Pb	Total
EV-1 no emission control	13.8	13.3	6.6	17.8	18.9	15.5	12.2
EV-2 no emission control	38.9	28.2	14.1	60.8	54.4	31.8	27.1
EV-3 no emission control	43.7	22.5	12	57.8	61.6	24.2	22.9
All vehicles with emission controlled(EV-3)	15.8	22.5	14.4	71	32	0	30
No EVs but same no. of ICEVs with emission control technologies each year (EV-3)	39.7	21.3	11.2	41.1	55	24.2	20.6
EV4 no emission control	3.7	21.9	9.7	12.9	6.2	21.2	18.5
EV-5 no emission control	2.2	13.1	5.8	7.8	3.7	12.7	11.1

3.4 Issues of Electric Vehicles

Technical/infrastructure problems: Low maintenance cost, reliable, environmentally friendly and energy security are positive attributes associated with electric vehicles but at the some time low performance, problems associated with battery, heavy and bulky and high cost are negative sides.

Batteries have been major hindrance to EVs since the beginning of twentieth century. Till today state-of-art Lead-acid type is used although efforts are underway to enhance other types such as sodium sulfur, metal-ion, metal-hydride, nickel-cadmium and metal-air batteries. However, high performing batteries would raise the EV cost. A latest electric car, EV-1, from General Motors uses maintenance free advanced Pb-acid batteries with 800 cycle life, 80% depth of discharge(DOD), peak storage of 16.3 KWh and 53 amps./hr (312volts) which can drive at maximum 125 km per charge depending on slope, air-conditioning use and regenerative braking. The reported peak speed is 80 mph (129 km/h) and charging time is 3 to 15 hours depending on charger types. Widespread charging infrastructure is needed to develop which can either recharge or exchange batteries to the empty ones. Since Nepal cannot be expected to influence the technology side, the planning process is expected to face uncertainties in technology and economics that are prevailing in present EV market. Institutional cost in developing charging infrastructure is crucial factor at present and for future too. Surrounded by these problems, the consumers would hesitate to choose EVs except in case of fixed route taxies or three wheelers.

Economic constraints: EVs are expected to have high cost and without any financial mechanisms EV market would be difficult to create. Clear role of stakeholders, such as public authorities, producers and suppliers of vehicle and infrastructure, and consumer are necessary. The popular mechanisms that are adopted in other countries are subsidy programs such as easy loan, import duty, income/corporate tax benefits to stakeholders. Electric utility is expected to take active role since a new market of electricity would establish. The result of the analysis done for Nepalese National Power Grid show that the average cost of electricity production can be reduced considerably by electric vehicle with load management(Dhakal, 1996). Therefore utility can take active part in EVs as done by others such as, Pacific Gas and Electric(PG&E) and Southern California Edison(SCE) in USA, and TEPCO in Japan.

Are EVs clean? Electric vehicles might not be clean as expected. EVs would just shift pollutants from vehicle tailpipes in urban areas to remote locations where power would be generated. Therefore, if the contribution of nuclear or hydro is much higher in total electricity generation then only EVs would be environmentally friendly. Many studies done in the past reported that the amount of pollutants, acid rain and CO_2 would increase by EV use if power is generated by coal. Nepalese electric system is suitable for electric vehicles since Hydro- power capacity is huge in Nepal. The issue of lead pollution also arises since state-of-art lead acid batteries are expected to dominate at least till first quarter of 21st century. A preliminary analysis done for Kathmandu Valley with 80% recycling rate and 2% recycling emission for a typical Pb-acid battery suggested that electric cars emit 25 to 27 times more lead than conventional cars on per car basis. However, control of lead pollution can be monitored since it is emitted from stationary and limited sources.

3.5 Alternative Fuels Vehicles

Apart from electric vehicles, other alternative fuel vehicles are possible to combat air pollution in the valley. Alternative fuels that could be of interest in the valley are LPG, CNG and methanol. Commercial vehicles are viewed as a more promising market for alternative fuel vehicles than the private ones due to several reasons. In high annual mileage applications, LPG and CNG vehicles are likely to be cheaper despite higher vehicle purchasing costs. The additional conversion cost for LPG is estimated at 800-1000$ and for CNG at 2000-3000$ for light and heavy-duty vehicles(Dhakal, 1996). CNG will have more constraints and limited market than the LPG vehicles due to their high conversion cost, filling station problems, working with high pressure, large storage tanks and short range between refueling. An analysis to compare electric and LPG car suggests that by converting all cars to LPG, 11.5 percent of total transport induced pollutants can be avoided in the year 2011 in Kathmandu valley. This figure is close to the amount avoided by electric i.e. 15 percent(Dhakal, 1996). However, other operational constraints are less in LPG vehicles as compared to electric vehicles.

4. NATIONAL TRANSPORTATION ISSUES

4.2 Financial Mechanism

The most important national transportation issue Nepal is facing is the lack of adequate road network in the country. Road construction in the high hills is technically difficult and capital intensive. Even Kathmandu, the capital city, has only one access road to connect it to the rest of the kingdom. Few tunnel roads have been proposed but it could not be worked out yet due to financial problems. Financial constraints are not only in road construction but also in maintenance and operation. The far-eastern region has few roads even though regional disparity have been tried to eliminate. The major sources of funding are the grants and loans from multilateral banks and donor agencies. Therefore, when the national interests and donor interests do not match, it occasionally causes severe setbacks to the long term planning. People's participation in road construction has been the past tradition in the country but with the touch of "modernity" the tradition has vanished. Private investment in road construction and concept of toll-road is not yet realized in the country.

4.3 Technical and Socio-economic Factors in Transport Induced Environmental Problems

One of the major reasons for increasing vehicle population, particularly light vehicles in the urban area, is the lack of adequate public transportation system. This is also the reason for the difficulties being faced to scrap out noisy and polluting three wheelers off the street. Other reason is the societal perspective on a car, which has been a symbol of social pride and social status rather than travel need.
In response to the worldwide attention for environmental protection, the Environmental Protection Council was established in Nepal in 1992 chaired by the Prime Minister. Environmental Protection Act was passed for the first time in 1997 and emission standard for vehicles were fixed. For gasoline driven vehicles, it is set 3% CO by volume and for diesel vehicles it is 65 HSU. Many of the vehicles are decade-old and due to reconditioned vehicle import, it requires heavy investment to bring them to tolerate emission standards. Apart from vehicle conditions, the fuel used in Nepal is of low octanic, high carbon residue and high lead content. Therefore, the emission standards are not being followed strictly except in some core city areas. The country still lacks reliable study and information on overall impact of pollution and solutions.
Uncontrolled urban settlement without basic necessities is another reason for related problems. Narrow roads, vehicle concentration and resulting congestion have aggravated environmental problems. Therefore, the solution to the environmental problem cannot be solved until overall urban perspective is not considered and strong committed policy and operational effort is not initiated soon.

4.4 Institutional Problems

Various Government agencies are responsible for transport related activities. Department of Roads, Department of Transportation Management, Traffic Police, Municipality, local bodies, and fleet operators are the major stakeholders. However, lack of co-ordination among these agencies has been observed at implementing the policies that are already formulated.

5. CONCLUDING REMARKS: CHALLENGE FOR 21ST CENTURY

Kuznet's inverted-U curve suggests that the increase in economic activities would cause the environmental degradation till a point of inflexion from where environmental degradation started decreasing. This notion assumes that the economic activities requires high travel demand and accelerate urban metabolism. The dilemma of urban city like Kathmandu is what will happen in the future since the present itself, with slow economic growth and inadequate transport infrastructure, has

so much environmental problems. A new paradigm in environmental understanding is thus required. The creation of core urban center should be avoided and non-motorized transportation should be encouraged as much as possible. Population, travel demand and economic activities are expected to increase in the Kathmandu Valley and other major cities in the country in future and sustained development would require the shift of major economic activities to the suburban areas, in the satellite towns, without intervening existing system. Cities other than Kathmandu have not worsened yet so that sustainable transportation system could be developed in these cities with less effort. Environmental awareness is required to be stimulated within the society and, commitment and will of the policy makers are most important in it.

It is seen that the huge amount of pollutants from conventional vehicles can be abated just by technical-control mechanisms. These control mechanisms should be tied with the economic and fiscal benefit to attract people to use it. Command-and-control mechanisms in the form of rules and regulations need to be tightened slowly and fuel substitution should be sought for the long term.

Need for integrated urban and transportation planning is very evident which is hardly done in Nepal seriously. Even in those areas that are planned, the implementation part is poor due to socio-political reasons. Investment generation from private sector is to be encouraged in infrastructure development. Regional equity in development has to be given careful thought.

Twenty-first century seeks all to learn lessons from the problems of twentieth century and to plan effectively for the next century maintaining inter-generation equity.

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APPENDIX 1 Length of Roads with Classification and Type in Nepal, kilometer

Classification	Development Region	Black-topped	Graveled	Earthen	Total
National Highway	Eastern	453	157	41	651
	Central	648	59	10	717
	Western	479	0	0	479
	Mid-western	261	94	181	536
	Far-western	245	0	203	448
	Total	2086	310	435	2831
Feeder Road (Major)	Eastern	103	56	26	185
	Central	246	147	48	441
	Western	165	84	147	396
	Mid-western	11	135	182	328
	Far-western	0	22	141	163
	Total	525	444	544	1513
Feeder Road (Minor)	Eastern	0	0	0	0
	Central	102	12	1	115
	Western	0	23	5	28
	Mid-western	0	0	23	23
	Far-western	0	0	0	0
	Total	102	35	29	166
District Road	Eastern	37	407	909	1353
	Central	110	665	1081	1856
	Western	22	150	563	735
	Mid-western	18	115	380	513
	Far-western	1	92	249	342
	Total	188	1429	3182	4799
Urban Road	Eastern	113	108	113	334
	Central	332	235	135	702
	Western	161	43	85	289
	Mid-western	15	38	3	56
	Far-western	11	20	3	34
	Total	632	444	339	1415
Total		3533	2662	4529	10724

APPENDIX 2 Emission Factors by Vehicle Types in Kathmandu Valley, grams per kilometer

Type	Fuel	PM	CO	HC	Nox	Sox	Pb
Bus	HSD	3.00	12.00	3.70	13.00	1.75	-
Minibus	HSD	1.50	2.25	1.26	13.00	0.39	-
Truck	HSD	3.00	12.00	3.70	13.00	1.75	-
Car	MS	0.20	62.00	8.30	2.70	0.13	0.02
Jeep	HSD	0.90	3.10	1.30	1.40	0.38	-
3 Wheelers	MS	0.21	22.64	14.13	0.20	0.05	0.02
	HSD	1.50	2.25	1.26	13.00	0.39	-
Motorcycle	MS	0.50	24.00	19.00	0.07	0.02	0.003
Tractor	HSD	0.90	2.25	1.26	1.40	0.39	-

MS is Motor Spirit; HSD is High Speed Diesel

Source: Shrestha and Malla (1996); Dhakal(1996)