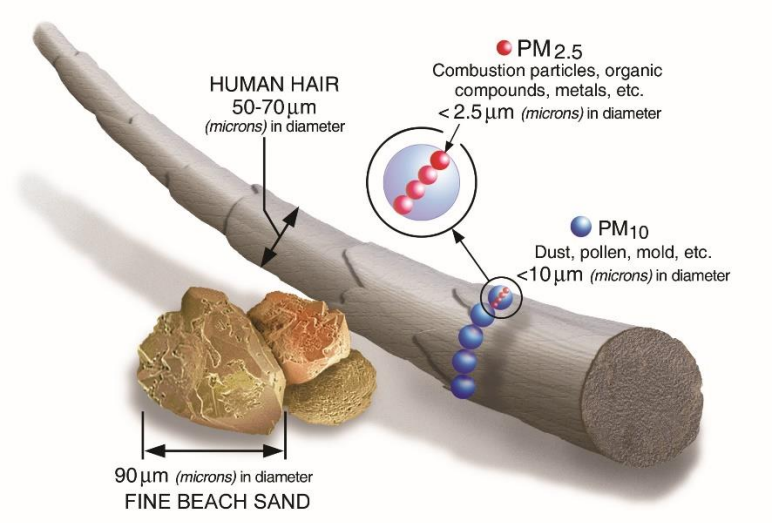
Policy Brief on Air Quality and Health in Kathmandu Valley

Introduction

Air pollution is a major public health risk in Kathmandu Valley where the annual average concentration of PM2.5 is about five times higher than WHO guidelines (WHO, 2018). Realizing this, the Ministry of Health and Population together with the World Health Organization (WHO) is implementing the Urban Health Initiative (UHI) in Kathmandu Valley to build evidence on the health impacts of air pollution, enhance the capacity of the health sector and raise awareness on this issue. This policy brief on air pollution and health is part of a series on different sources of air pollution in Kathmandu Valley and its linkage to health.

WHO estimates that more than 90 percent of the people worldwide are forced to breathe polluted air that exceeded the WHO Air Quality Guideline of 10 µg/m^3 annual average $PM_{2.5}$ concentrations in 2016 (WHO, 2018). $PM_{2.5}$ concentration is a measure of tiny particles that are less than 2.5 microns in diameter or about 30 times smaller than the thickness of human hair, in the air we breathe. These particles, which are often produced by combustion processes and can have harmful particles attached to them, can go deep into the human body through the respiratory system and cause significant health impacts.

Figure 1: Size comparison of $PM_{2.5}$

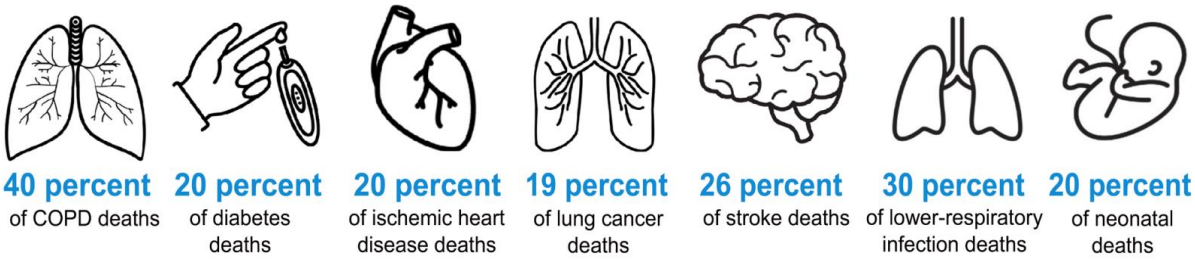


Source: USEPA

In 2019, air pollution moved up from the 5th to 4th leading risk factor for early death globally and resulted in 6.67 million deaths, which is nearly 12 percent of deaths globally (HEI, 2020). This large burden of disease is due to the fact that long-term exposures to air pollution contributes substantially to chronic non-communicable disease such as Ischemic heart disease, chronic obstructive pulmonary disease (COPD) and stroke (Figure 2). Besides these diseases, women who are chronically exposed to air pollution are more likely to have babies born with low birth weight or preterm birth. In 2019, air pollution caused nearly half a million neonatal death among infants less than one month old. Of the infant deaths attributable to

air pollution, two thirds are related to household air pollution, which is a major concern in Nepal as about two thirds of the households cook using traditional stoves that use solid biomass such as firewood or dung cakes as fuel (HEI, 2020).

Figure 2: Percentage of global deaths from specific causes attributable to air pollution



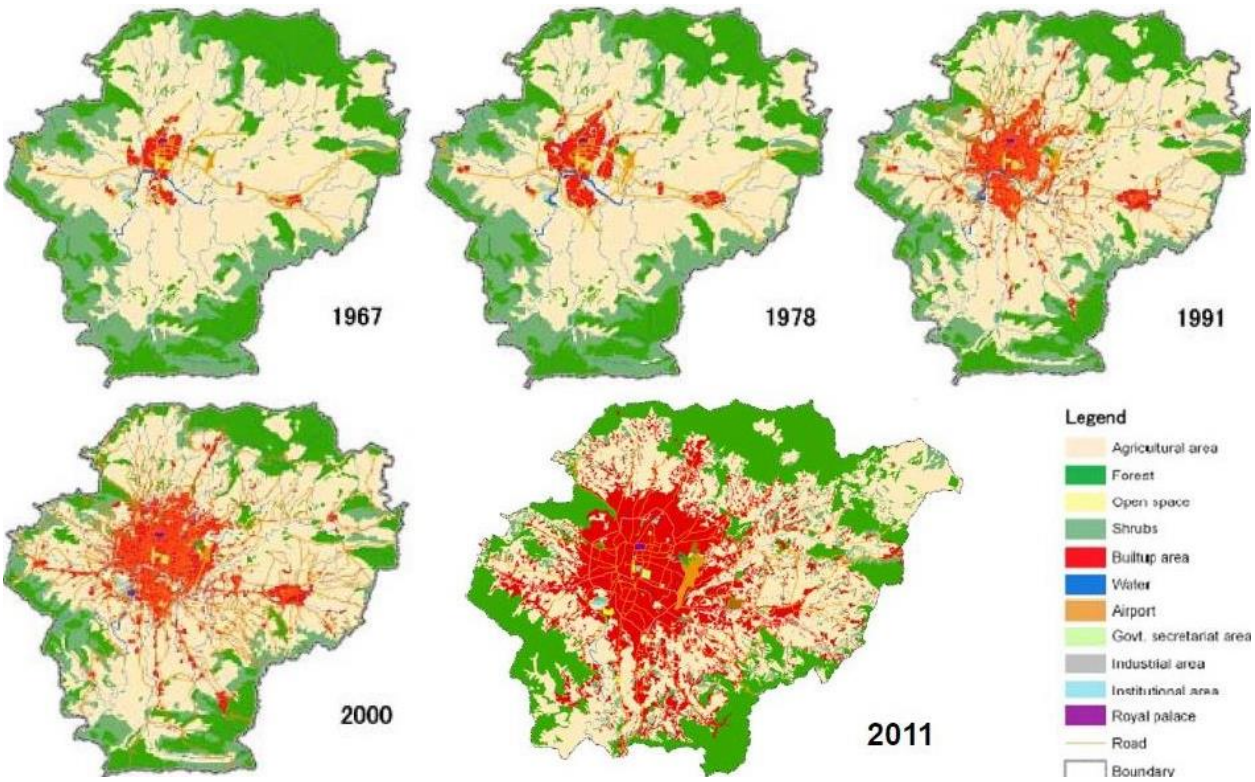
Source: HEI (2020)

Link between COVID-19 & Air Pollution
One of the immediate effects of COVID-19 was an improvement in air quality across cities around the world, including Kathmandu, due to lockdowns and reduced sources of pollution. The need for social distancing during the pandemic has also resulted in promotion of cleaner mobility options such as walking and cycling in many cities. However, people with long-term exposure to high levels of air pollution are more vulnerable to COVID-19 because (i) air pollution leads to many of the health conditions associated with increased vulnerability to COVID-19, such as diabetes, cardiovascular disease, and chronic obstructive lung disease, and (ii) air pollution affects the body's immune defense, increasing susceptibility to respiratory and other infections. Studies show that areas with higher air pollution levels experience higher rates of infection or of case fatalities due to COVID-19 (HEI, 2020).

Kathmandu's Air Quality

Kathmandu Valley, which includes the capital city Kathmandu and 17 other municipalities, is especially vulnerable to air pollution due to its natural conditions, such as bowl shaped topography, limited wind flow and long dry season, as well as rapid and haphazard urbanization. The population of Kathmandu Valley grew from 766,345 in 1981 to 2.5 million in 2011 (CBS, 2011). Between 2001 and 2011, the average annual population growth rate was 4.3 percent. The population is expected to reach 3.8 million in 2021 and 5.7 million in 2031 (KU/WHO, 2020). Along with population growth, the land use within the Valley has also changed significantly over the past few decades with agricultural land shrinking as built up area expands rapidly (Figure 3).

Figure 3: Land Use Change in Kathmandu Valley (1967-2011)



Source: DoR/JICA, 2012

Ministry of Forests and Environment (MoFE) has been monitoring Kathmandu's air regularly since 2016, with air quality monitoring stations at Ratna Park, Pulchowk, Bhaisepati, Shankha Park, Kirtipur and Bhaktapur. In addition, the US Embassy also has monitoring stations at Phora Durbar and its embassy complex in Maharajgunj. Air quality monitoring data from Ratna Park, located at the centre of Kathmandu, indicates that the annual average $PM_{2.5}$ in 2017 was 42 μg/m^3 and the PM2.5 concentration at Ratna Park exceeded the national standard of 40 μg/m^3 on 37.4% of the days, when valid data was available (MoFE, 2020).

The average of air quality data collected by MoFE and US Embassy, Nepal from 2016 to 2018 shows the annual average concentration of $PM_{2.5}$ in Kathmandu Valley was 50.25 μg/m^3 in 2016, 43.83 μg/m^3 in 2017, and 45.26 μg/m^3 in 2018. The highest mean $PM_{2.5}$ concentration was recorded at the traffic-congested site of Phora Durbar (52.42 μg/m^3) followed by Ratna Park (45.89 μg/m^3). The $PM_{2.5}$ levels were highest in January and February which is the peak of the winter season and was found lowest in the peak of the monsoon season (KU, 2020).

The high concentration of $PM_{2.5}$ in the winter season is mainly due to natural reasons such as thermal inversion and lack of rain, as well as man-made causes such as operation of the brick kilns, which do not operate during the monsoon, and people burning fires for warmth and managing waste.

Besides seasonal variation, the $PM_{2.5}$ concentration in the Valley also shows fluctuations during the day with two distinct peaks in the morning, between 8 and 10 am and in the evening between 8 and 10 pm,

with the morning peak being higher than the evening peak. The $PM_{2.5}$ concentration is found to be at its minimum in the afternoon between 1 to 3 pm. The diurnal variation of pollution levels in Kathmandu Valley is mainly due to meteorological conditions. The morning peak is mainly caused by the recirculation of pollutants emitted the night before, while the dip in pollution in the afternoon is caused by westerly winds which enter the Valley in the late morning or early afternoon from the western passes and blow the pollutants out of the valley. In the evening pollutants tend to accumulate in the city before they are lifted up late at night due to convergence of cleaner colder air from the valley rims (Panday and Prinn, 2009).

Air pollution data also shows the impact of holidays as $PM_{2.5}$ concentrations were observed to be significantly lower in long weekends (KU, 2020). This indicates the high contribution of vehicles on pollution levels.

Sources of Air Pollution

Various studies have shown that the transport sector is the main source of air pollution in Kathmandu. Other sources include construction activities, waste burning, use of solid biomass fuel for cooking and industries, particularly brick kilns. DoE (2017) estimated that construction activities result in 53% of the PM10 emissions in Kathmandu Valley, while transport contribute 30%, brick kilns 9%, household energy 5% and waste burning contributes 1%.

Kim et al., (2015) analyzed PM_{10} filter samples during two intensive campaign between December 2012 and February 2013 and attributed 95 percent of the average PM_{10} concentration to local primary sources – motor vehicles (31%), soil dust (26%), biomass/garbage burning (23%), and brick kilns (15%), while only 5 percent was attributed to a secondary source.

Although local sources are the main contributors to Kathmandu's air pollution, studies have also shown that pollutants also enter the Valley, primarily from the south and west. Part of this is from forest fires and combustion of household energy in rural Nepal while part of it is pollution coming from the Gangetic plains (Panday and Prinn, 2009).

As part of the UHI, Kathmandu University (2020) estimated the air pollution in 2030 from four different sources – transport, waste management, brick kilns and household energy – under different scenarios. The changes in emissions in two of these scenarios – 'business as usual' and 'aggressively positive' – as shown in Table 1 indicates that aggressive policies can have a significant impact in reducing emissions.

Table 1: Change in Emission in 2030 from Four Sources in under Two Scenarios

	Scenarios		
	Business as Usual	Aggressively Progressive	Percentage Change
Solid Waste			
$PM_{2.5}$ emission (tons/year)	486	83	-82.9%

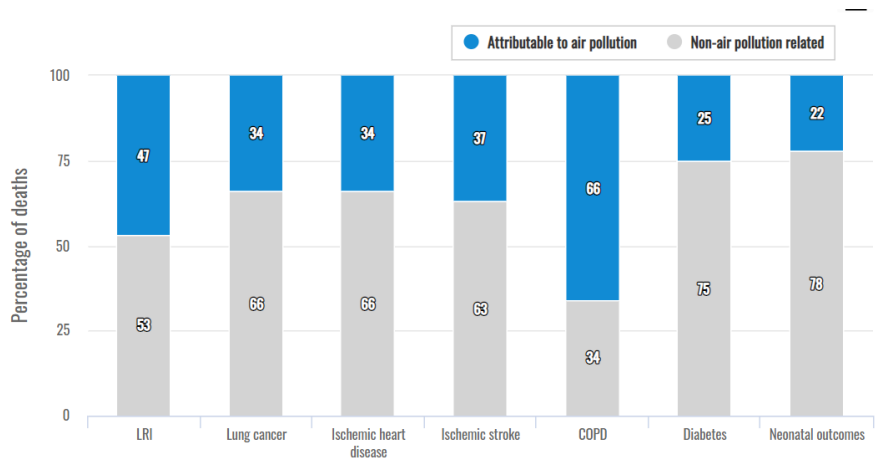
$PM_{2.5}$ Concentration (µg/m^3)	1.54	0.26	-83.1%
CO_{2e} (metric tons in 2030)	574,828	290,002	-49.5%
Brick Kilns			
$PM_{2.5}$ emission (tons/year)	229.16	43.93	-809.8%
$PM_{2.5}$ Concentration (µg/m^3)	0.73	0.14	-80.8%
Transport			
Total Atmospheric Emission (saved metric tons in 2030)	2024.95	4530.50	53.3%
Household Energy			
$PM_{2.5}$ Concentration (µg/m^3)	92	54	-41.3%

Source: KU/WHO (2020)

Health Impacts of Kathmandu's Air Pollution

Health impacts are usually measured as excess mortality and morbidity, which is often measured in disability adjusted life years (DALYs), attributed to a certain risk factor. It is estimated that Nepal lost 42,100 lives and over 1.2 million DALYs due to air pollution in 2019. Of these, 17,900 deaths were caused by ambient particle pollution or $PM_{2.5}$ while 6,030 was attributed to ozone pollution and 21,600 were attributed to household air pollution from solid fuels (HEI, 2020). In Nepal, 66% of the deaths caused by COPD, 47% of the deaths caused by lower respiratory infections, 37% of the deaths caused by ischemic stroke, 34% of the deaths caused by ischemic heart disease and 25% of the deaths caused by diabetes can be attributed to air pollution (Figure: 4). These figures are higher than global averages (Figure: 2).

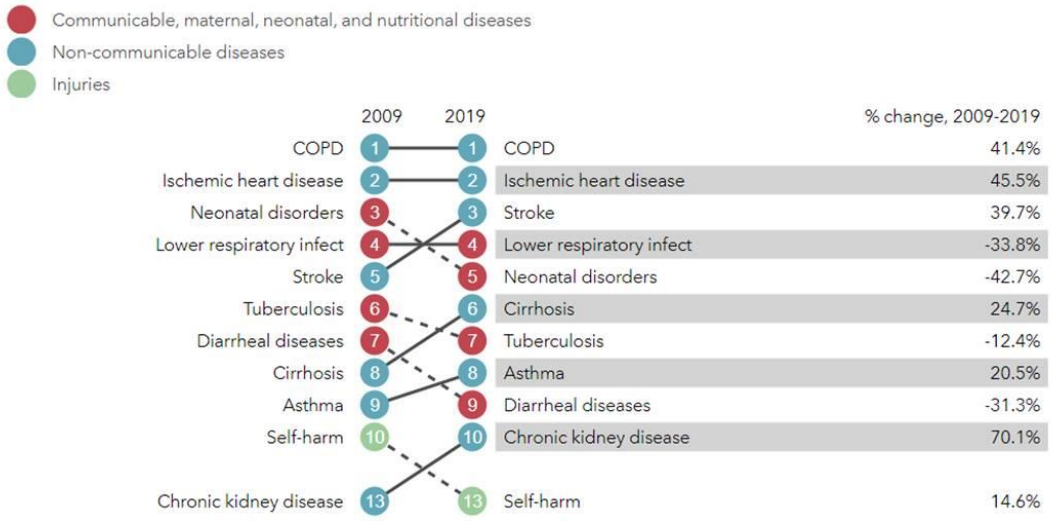
Figure 4: Percentage of deaths from various causes attributed to air pollution in Nepal



Source: HEI, 2020

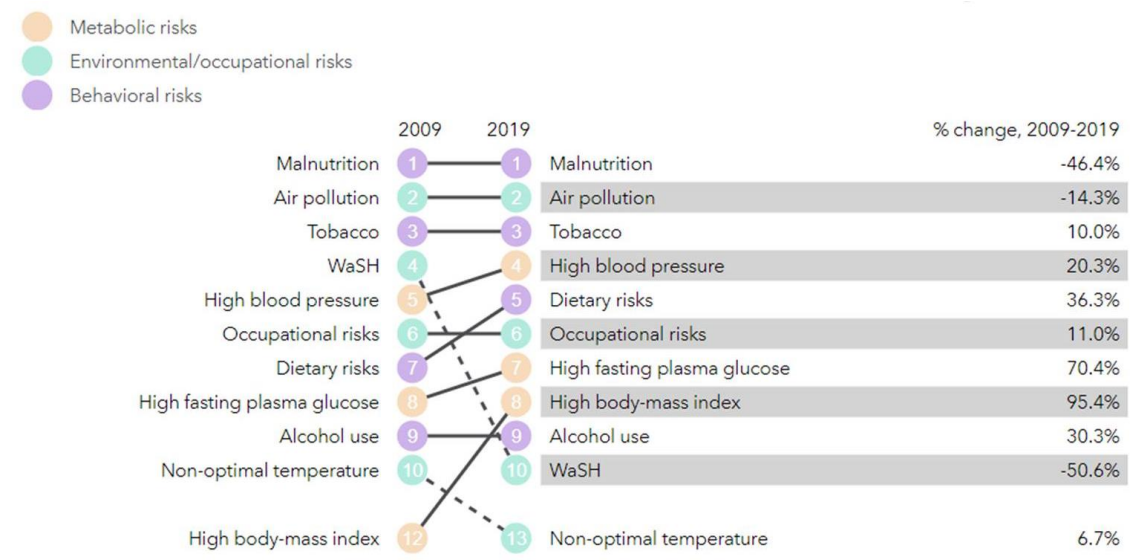
COPD, ischemic heart diseases and stroke are also the top three causes of death in Nepal and air pollution is recognized as the second major risk factor for mortality and morbidity in Nepal, after malnutrition (IHME, 2020).

Figure 5: Main Causes of Death in Nepal in 2009 and 2019



Source: IHME, 2020 **http://www.healthdata.org/nepal**

Figure 6: Main Risk Factors Causing Morbidity and Mortality in Nepal 2009-2019



Source: IHME, 2020 **http://www.healthdata.org/nepal**

Although long-term epidemiological studies to assess health impacts of air pollution have not been conducted in Kathmandu, a few studies have conducted preliminary medical examination of a group of exposed population, analyzed hospital records, and used dose-response relationships that have been developed elsewhere to estimate health impacts. These studies indicate that the health impacts of

Kathmandu's air pollution are quite alarming. World Bank estimated that PM10 levels in Kathmandu Valley in 1990 resulted in 84 cases of excess mortality, 506 cases of chronic bronchitis, 4,847 cases of bronchitis in children and 18,863 asthma attacks per year (Shah and Nagpal, 1997).

An analysis of the records of 369 chronic obstructive pulmonary disease (COPD) patients and 315 control patients admitted to Patan Hospital from April 1992 to April 1994 showed that the odds of having COPD are 1.96 times higher for Kathmandu Valley residents compared to outside valley residents. The study also stated that over the past decade the proportion of COPD patients had increased by more than four folds and that COPD was the number one killer of adult patients in the hospital. An analysis of hospital records from three major hospitals in Kathmandu indicated that the number of COPD patients admitted to hospitals, as well as the percent of COPD patients as a percentage of total medical patients, had increased significantly in the ten years between 1992 and 2002. Hospital records also indicate that the number of COPD patients is highest in the dry winter months, which is also when air pollution in Kathmandu is at its peak (CEN/ENPHO, 2003).

The study done by Nepal Health Research Council shows that among the considered diseases, COPD (39.4%), pneumonia (29.1%), and acute respiratory illness (25.3%) excluding pneumonia were the leading respiratory diseases in the hospitals of Kathmandu Valley followed by asthma (4.8%), bronchitis (4.8%) and pleural effusion (1.9%). The comparative assessment between different age groups shows that children (age 0-9 years) and aged persons (age 50+ years) are the most vulnerable groups in the valley concerning respiratory illnesses (Karki, et al., 2016).

In fiscal years 2015/16, the percent of mortality and morbidity caused by different air pollution related diseases among hospital patients in Kathmandu Valley was reported to be 17.39% and 11.82% out of all the diseases among inpatients, while 24.20% and 13.06% was reported for fiscal year 2016/17 respectively. Pneumonia, COPD and Acute Respiratory diseases are leading airborne diseases among inpatients in the area, contributing to relatively high total morbidity caused by air pollution diseases (KU, 2020).

Findings of a study on health impacts of air pollution in 2030 from four different sources – transport, waste management, brick kilns and household energy – under different scenarios indicate that thousands of deaths and DALYs can be averted by implementing aggressive policies to reduce pollution (Table 2). The health impacts are particularly high for policies related to the transport sector (KU, 2020).

Table 2: Health impacts of Changes in Emission under Different Scenarios

		Scenarios	
Sectors	**Averted deaths due to changes in emissions**	**Business as usual**	**Aggressively Progressive**
Transport	All-cause mortality	13,680	50,213
	Cause-specific mortality	3,091	14,511
Industry	All-cause mortality	15	44
	Cause-specific mortality	4	12

Household	All-cause mortality	N/A	N/A
	Cause-specific mortality	1020	3745
Solid waste	All-cause mortality	0	43
	Cause-specific mortality	0	50
Total	**All-cause mortality**	**13,695**	**50,300**

Source: KU/WHO (2020)

Policy and Institutional Framework for Clean Air

A conducive policy framework, which consists of national, provincial and municipal policies, legislation, standards, guidelines, plans and programmes, is essential for air quality management. Nepal has several polices related to air quality management (Table 3) but there are still gaps and implementation of the policies is a major challenge. Furthermore, many of the policies consist of broad statements without goals, targets, and defined time frames.

Table 3: Policies for Clean Air

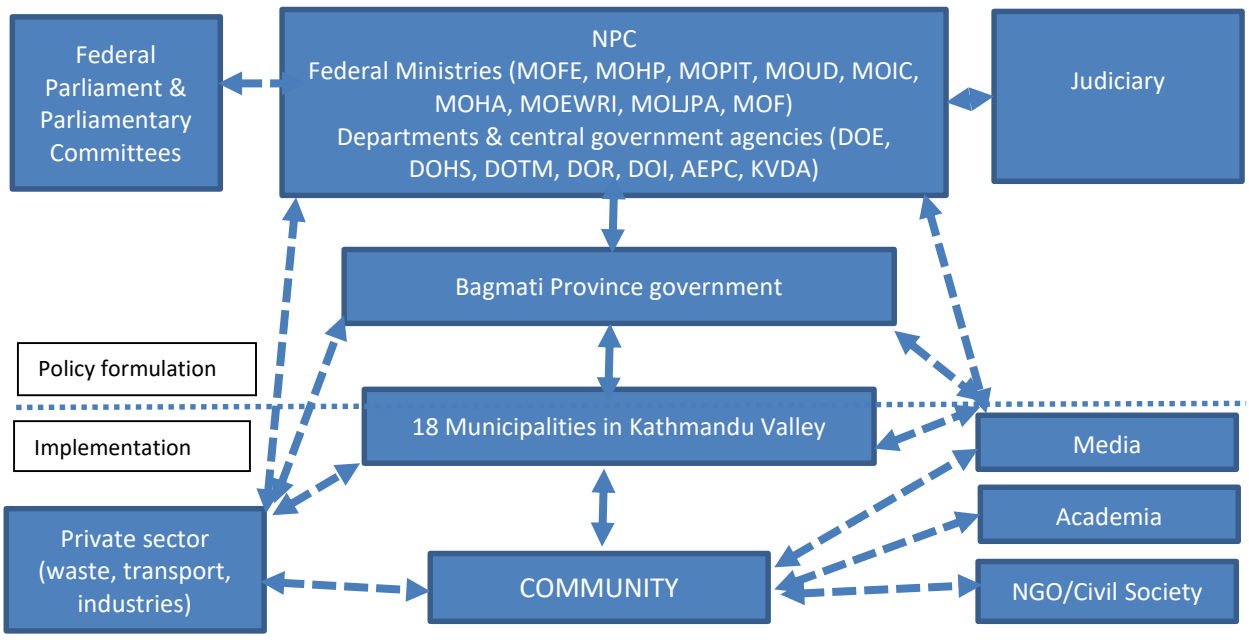
POLICY	DESCRIPTION
GENERAL POLICIES RELATED TO AIR POLLUTION	
Constitution of Nepal, 2015	Part 3 Section 30 of the constitution mentions 'right to clean and healthy environment' as a fundamental right of every Nepali citizen.
15th plan (2019/20 – 2023/24)	One of the three objectives of the plan is, "Quality education and health, healthy and balanced environment. The plan also mentions a target of reducing the mean $PM_{2.5}$ level from 53 µg/m^3 to 40 µg/m^3 by 2023/24.
POLICIES RELATED TO ENVIRONMENT AND CLIMATE	
National Environment Policy, 2019	The goal of this policy is to control pollution, manage waste and promote greenery to ensure all citizens can enjoy their rights to a clean and healthy environment. The policy has 10 objectives, one of which is to minimize and control all sources of pollution.
National Climate Change Policy, 2019	One of the seven objectives of this policy is to promote green economy by reducing carbon emissions. The policy also lists eight themes, which include rural and urban settlements; industry, transport and physical infrastructure; and tourism and nature/cultural heritage.
Kathmandu Valley Air Quality Management Action Plan (KVAQMAP), 2020	This plan has eight objectives, 11 strategic areas, and has proposed 135 different actions. The Action Plan has also proposed a Coordination Committee, chaired by the Minister MoFE and an Implementation Committee, chaired by the Secretary of MoFE. The Plan also has provisions to declare Public Health Emergency if the Air Quality Index exceeds 300.
Second Nationally Determined Contributions, 2020	This includes several targets for electric mobility such as increasing market share for private electric vehicles to reach 25% by 2025 and 90% by 2030, and for public electric vehicles to reach 20% by 2025 and 60% by 2030. It also envisions that by 2030, 25% of households will use electric cook stoves as their primary mode of cooking.

National Ambient Air Quality Standards	The standard for 24 hour average $PM_{2.5}$ concentration is 40 µg/m^3 and this can be exceeded only 18 days per year.
Pollution Tax	The government charges Rs. 1.50 per litre of diesel and petrol sold in Nepal as pollution tax. The collected funds, however, have not yet been utilized.
POLICIES RELATED TO HEALTH	
National Health Policy, 2019	National Health Policy, 2019 mentions the need for Multi-sectoral Action Plan and Package of essential NCDs and that an Integrated Urban Health System will be developed which could include measures such as regular monitoring of air quality, conducting assessments of health effects of air pollution and raising awareness to reduce air pollution.
Urban Health Policy 2015	The policy has "to ensure safety from the factors that adversely affects the health of the people residing in urban areas" as its vision but it does not have any programmes related to air pollution control.
POLICIES RELATED TO TRANSPORTATION	
National Transport Policy 2007	The policy aims to develop a reliable, cost-effective, safe facility-oriented and sustainable transport system. Need for effective public transport service is highlighted and the policy focuses on transport sustainability through gas and electric mobility solutions.
Transport Management Act, 1991 and Vehicles and Transport Management Rules, 1996	This legislation authorizes DoTM to regulate public transport by issuing route permits and issuing standards. It, however, restricts the modifications of vehicles once imported. As a result, it has not allowed petroleum vehicles to be converted to electric, although several companies want to do so.
Environment Friendly Vehicle and Transport Policy, 2014	The policy calls for increasing the share of "environment friendly vehicles" to a minimum of 20% of the total vehicle fleet by 2020; encouraging manufacturing of environment friendly vehicles; encouraging private sector to invest in construction and management of electric vehicle parking stations and service centers and improving the possibility of local assembly by improving access to required vehicle parts, including batteries.
Road, Rail and Transport Development for Prosperous Nepal – Five Year Strategic Plan (2073-2078)	The plan mentions 'discourage private vehicles and promote public vehicles as well as walking to provide safe, convenient, environment friendly and affordable transport services to the public' as one if it's a basic principle. It also states that roads will be expanded to make space for environment friendly mass transit, urban roads will be made pedestrian-friendly and disable friendly, and cycle lanes will be promoted in urban and peri-urban streets.
National Action Plan for Electric Mobility, 2018	The Action Plan proposes three priority actions: (i) establish unit for electric mobility (ii) national program for electric mobility, and (iii) financing mechanism for electric mobility to promote electric mobility.
POLICIES RELATED TO WASTE MANAGEMENT	
Solid Waste Management Act, 2011 and Rules, 2013	The Act and Regulations make source separation of waste mandatory and promotes recycling of waste. However, it does not specifically mention that waste burning is not allowed.

Annual Plans and Programmes of Municipalities	The Annual Plans and Programmes prepared by the 18 municipalities in Kathmandu Valley have various programmes on waste management, but not much on air pollution control.
POLICIES RELATED TO INDUSTRIES	
Industrial Policy 2011	This policy calls for the promotion of environment friendly production processes in industries. It also mentions the need to provide financial and technical support to proactive industries on adopting environment friendly and energy saving technologies and propose.
Industrial Enterprises Act, 2020	It makes industries responsible to control pollution and requires them to go through EIA procedures before obtaining license. It also mentions that the Industrial Promotion Board has the authority to restrict registration of industries in urban areas including Kathmandu Valley.
POLICIES RELATED TO HOUSEHOLD ENERGY	
Biomass Energy Strategy 2017	The strategy aims to "make indoor air pollution Nepal by 2022 through the promotion of clean cooking technologies in all households; and by 2030 ensure the availability of modern clean energy in all households using solid biomass.
Ministry of Energy, Water Resources and Irrigation White Paper ,2018	The White Paper mentions "Electric Stove in Every House" program to promote electricity as a cooking fuel and also mentions that the Ministry will prepare and implement a work plan to introduce appropriate policies and charging stations to increase the use of electric vehicles so that within the next five years half of vehicles imported in the country is electric.

With many stakeholders, ranging from municipalities to central government ministries, private sector and NGOs, involved in various aspects of air quality management, coordination is essential to avoid gaps in policies and activities. The government is a key player as it formulates polices, invests in programmes and monitors progress. However, the responsibility of air quality management is divided among several government agencies, as well as the parliament and the judiciary. Besides government, private sector organizations such as transport entrepreneurs, industries and waste management companies, NGOs, media and academia also play an important role. Some of the main agencies involved in air quality management in Kathmandu Valley are shown in Figure 7.

Figure 7: Main Stakeholders Involved in Air Quality Management



Way Ahead

There are many solutions to Kathmandu's air pollution and many of these solutions can be adopted immediately with existing resources. The government, particularly MoFE and municipalities, need to lead this effort in partnership with private sector and civil society. As the Cabinet has endorsed KVAQMAP, which is a comprehensive action plan with timelines and names of responsible agencies, this should be the road map to control Kathmandu's air pollution and should be implemented immediately. The Action Plan also has provisions for a Coordination Committee and an Implementation Committee, which will help in coordinating efforts and ensuring timely and effective implementation of the plan. In addition, the effective implementation of the plan and other initiatives help to comply with national standards as well as WHO air quality guidelines in protecting people from adverse health impacts of air pollution.

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