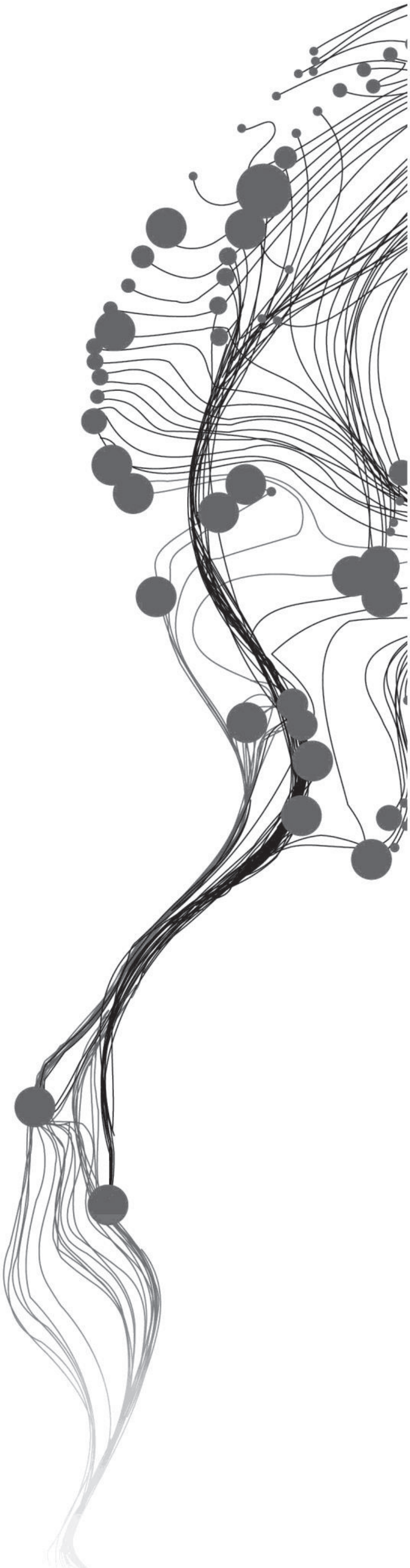
DEVELOPMENT OF ENVIRONMENTAL AND HEALTH INDICATORS RELATED TO INEQUALITIES AND ASSESSING ENVIRONMENTAL JUSTICE IN KATHMANDU, NEPAL

BASUNDHARA MAHARJAN

February, 2014

SUPERVISORS:

Dr., J. F., Johannes Flacke
Dr., J. M., Javier Martinez



DEVELOPMENT OF ENVIRONMENTAL AND HEALTH INDICATORS RELATED TO INEQUALITIES AND ASSESSING ENVIRONMENTAL JUSTICE IN KATHMANDU, NEPAL

BASUNDHARA MAHARJAN
Enschede, The Netherlands, February, 2014

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Urban Planning and Management

SUPERVISORS:
Dr. Johannes Flacke
Dr. Javier Martinez

THESIS ASSESSMENT BOARD:
Prof. Dr. Ing. P.Y. Georgiadou (Chair)
Dr. Heike Kockler (External Examiner, TU Dortmund)
Dr. Johannes Flacke (First Supervisor)
Dr. Javier Martinez (Second Supervisor)

ABSTRACT

Environmental justice in context of urban areas in developing countries is understudied. The aim of this study was to develop a set of indicators related to environment and health inequalities and to assess environmental justice in Kathmandu. The integrated study of environmental inequalities, health inequalities in socio-economic context is necessary to assess environmental justice. DPSEEA framework was used for indicator development to show association between environmental exposure and health effects. Set of indicators has been proposed to evaluate inequalities through consultation with environmental experts. For the empirical study, household survey was done in six neighbourhoods of Kathmandu. With the aid of social, environmental and health indicators, the inequalities were assessed. Cluster analysis was performed to classify the households into different socio-economic groups using income, education, occupation etc. Initially, assessment between neighbourhoods showed that households in some of the neighbourhoods are having adverse health effects due to environmental pollution. So, further analysis is done to check whether certain socio-economic class are having disproportionate burden within the neighbourhood and the whole study area. Chi-square test was used to check significant relationship between socio-economic class and health effects. It is found that lower socio-economic class households are facing more health effects even with similar exposure to environmental pollution. In some cases, the proximity to pollution source affects the health status rather than socio-economic condition alone (for example: noise effects). Hence, the disproportionately adverse health effects in some neighbourhoods suggest that environmental injustice prevails in the area. Also the higher burden to lower socio-economic class households illustrates environmental injustice in the study area.

Key words: Environmental justice, Indicators, health inequalities, Nepal,

ACKNOWLEDGEMENTS

I am very much grateful to the Government of Netherlands for providing me with the NFP scholarships to pursue my further education at ITC, University of Twente. I would also like to share my gratitude to ITC for providing me an opportunity to gain knowledge on Geo-Information Science for Urban Management.

I would like to express my sincere thanks to Dr. Johannes Flake, first supervisor and Dr. Javier Martinez, second supervisor for their undying support, valuable guidance, time and encouragement in accomplishing my dissertation. They have always been my source of inspiration during my works to overcome all the circumstances.

I should definitely not forget all the UPM staffs in ITC for helping me to sort out my problems and for whatever you have done for me during my stay at ITC.

I would also like to express my gratitude for the experts in Environmental Justice in Nepal Mr. Narayan Belbase and Dr. Jagannath Adhikari for their insight into the subject matter with enthusiasm. For providing me with the emission map, I would also like to thank ICIMOD, for providing emission map.

My acknowledgment also goes to all my colleagues and friends in UPM at ITC for their valuable company and pleasure at ITC.

I would also like to acknowledge all member of Nepali society in ITC for the company. I would definitely like to take this opportunity to express their gratefulness, my intimate friends Tanushree paudyal and Nilima Thapa Shrestha to be a part of my life and helping me through every hard times in The Netherlands. I would also like to express thanks to Rehana Shrestha for guiding in initial stage of my thesis. I would also like to thank my friend Shahriar Rahman for motivation throughout my study period.

My acknowledgment is also there for the people and neighbourhoods for their contributions and making this study happen. I would also like to express my gratefulness to different associations and organization regarding this study.

Last but not the least; I would like to thank my husband for his support and care. For bearing all the hard time in my absence, I am very proud of my families and thanks for all your unconditional support every when.

Basundhara Maharjan
February 2014

TABLE OF CONTENTS

1. Introduction ... 1
   - 1.1. Background ... 1
   - 1.2. Problem Justification ... 1
   - 1.3. Research Problem ... 2
   - 1.4. Research objectives ... 3
   - 1.5. Research Questions ... 3
   - 1.6. Conceptual Framework ... 4
   - 1.7. Structure of Thesis ... 5
2. Literature Review ... 6
   - 2.1. Environmental Justice ... 6
   - 2.2. Environment Justice in Nepal ... 7
   - 2.3. Assessing Environmental Justice ... 7
   - 2.4. Scale and unit of analysis ... 8
   - 2.5. Indicators for Environmental Justice ... 8
   - 2.6. Indicators Framework ... 9
   - 2.7. Conclusion ... 10
3. Study Area: Kathmandu Metropolitan city ... 12
   - 3.1. Introduction ... 12
   - 3.2. Kathmandu Metropolitan city (KMC) ... 13
   - 3.3. Selection of wards and Neighbourhoods ... 13
4. Research methodology ... 16
   - 4.1. Research Design ... 16
   - 4.2. Research Matrix ... 17
   - 4.3. Primary Data Collection ... 18
   - 4.4. Secondary Data Collection ... 19
   - 4.5. Post Fieldwork ... 20
   - 4.6. Data Analysis ... 20
5. Development of Indicators ... 22
   - 5.1. Major Environmental and Health Issues in Nepal ... 22
   - 5.2. Indicator Development ... 25
   - 5.3. Subset of Indicators for Household Survey ... 31
6. Results ... 33
   - 6.1. Socio-economic context ... 33
   - 6.2. Assessing Inequalities between Neighbourhoods ... 38
   - 6.3. Assessing Inequalities within Neighbourhoods ... 41
   - 6.4. Assessing Inequalities between Socio-economic Classes ... 42
   - 6.5. Multiple Effects ... 48
   - 6.6. Effects on Children and Elderly ... 50
7. Discussions ... 51
   - 7.1. Assessing inequalities between neighbourhoods ... 51
   - 7.2. Assessing inequalities within neighbourhoods ... 52
   - 7.3. Assessing inequalities between socio-economic classes ... 54
   - 7.4. Conclusion ... 56
8. Conclusions and recommendations ... 57
   - 8.1. Conclusions ... 57
   - 8.2. Recommendations ... 57

List of references ... 59

9. Annex 64
9.1. Descriptions and Rationales of Indicators 64
9.2. Interview Questions to Experts 70
9.3. Household Survey Questionnaire 71
9.4. Charts, Tables and Figures 74

LIST OF FIGURES

Figure 1: Conceptual Framework....4
Figure 2: The modified DPSEEA model 10
Figure 3: Kathmandu Valley Districts and Local Governments.... 12
Figure 4: Ward boundary map of KMC, showing location of selected neighbourhoods 14
Figure 5: Research Design.... 16
Figure 6: Showing the random sample points created in ArcGIS over the satellite image 19
Figure 7: Graphical representation of analysis steps.... 21
Figure 8: Public opinion on main environmental problems in urban areas.... 22
Figure 9: Indicators widely used for socio-economic context.... 25
Figure 10: Map of PM10 emission in Kathmandu (tonnes/year/grid) 27
Figure 11: Distribution of Household Income range in sampled data 33
Figure 12: Household with highest education level 33
Figure 13: Household income range distribution across socio-economic classes.... 36
Figure 14: Age distribution among socio-economic classes 37
Figure 15: Ownership of house among socio-economic classes 37
Figure 16: Distribution of different socio-economic class in neighbourhoods.... 37
Figure 17: Map showing distribution of Socio-economic classes of households in different neighbourhood 37
Figure 18: Perception of bad odour in environment in different neighbourhoods.... 38
Figure 19: Box plot showing average value of air pollutants in Sampled Neighbourhoods. 39
Figure 20: Health effects in Neighbourhoods 40
Figure 21: Health effects in different socio-economic clusters within selected neighbourhoods.... 42
Figure 22: Perception of bad smell by different socio-economic classes 43
Figure 23: Socio-economic classes with proximity to bad odour sources.... 43
Figure 24: Perception of Bad smell in neighbourhood 43
Figure 25: Distribution of average value of PM_{10}, SO_2, NO_x and CO across different socio-economic classes 44
Figure 26: Emission of PM_{10} ton/year/grid and spatial pattern of households in 3 socio-economic classes 45
Figure 27: Sources of drinking water used by socio-economic groups.... 45
Figure 28: Morbidity due to Water-borne Disease.... 46
Figure 29: Morbidity due to Respiratory Disease 46
Figure 30: Effects due to polluted Air.... 48
Figure 31: Effects due to noise pollution 48
Figure 32: Distribution of houses with reported polluted air effects.... 49
Figure 33: Reported noise effects and its proximity to major noise source (Transportation in roads)........ 49
Figure 34: Location of households of three socio-economic classes and road (main source of pollution). 47
Figure 35: Spatial patterns of household with response to respiratory illness.... 47
Figure 36: Households with no effects and all four effects in different socio-economic class.... 49
Figure 37: Summary of percent of reported effects in 6 neighbourhoods.... 52
Figure 38: Radar chart of 3 Neighbourhoods on reported health effects with respect to socio-economic class 53
Figure 40: Radar chart showing Health effects in three socio-economic classes.... 55
Figure 41: Major drinking water source in Neighbourhood based on multiple responses.... 74

LIST OF TABLES

Table 1: Research Questions....3
Table 2: Demographic information of selected wards 14
Table 3: Selected neighbourhoods 15
Table 4: Research Matrix 17
Table 5: Summary of major environmental problems according to different authors.... 23
Table 6: Domain for indicators, their marking value and respective count of indicators.... 23
Table 7: Indicators related to air pollution 28
Table 8: Indicators related to noise pollution 29
Table 9: Indicators related to water pollution 30
Table 10: Selected indicators for socio-economic context.... 31
Table 11: Selected indicators for environment exposure and health effects.... 32
Table 12: Characteristics of clusters 35
Table 13: Average values of emission of selected pollutants in Neighbourhoods based on emission grid. 39
Table 14: Summary of health effects in neighbourhoods 41
Table 15: Average value of environment pollutants exposed 44
Table 16: Types of diseases mentioned by different socio-economic groups 46
Table 17: Types of respiratory diseases mentioned by different socio-economic groups 47
Table 18: Proportion of households with multiple effects in neighbourhoods 49
Table 19: Age group reported for respiratory illness and waterborne disease.... 50
Table 20: Waterborne disease reported in Neighbourhoods.... 74
Table 21: Health effects in each Neighbourhood across different socio-economic class 74

ACRONYMS

ARI	Acute Respiratory Infection
CBS	Central Bureau of Statistics
CEN	Clean Energy Nepal
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Disease
DUDBC	Department of Urban Development and Building Construction
ENPHO	Environment and Public Health Organization
GIS	Geographic Information System
GoN	Government of Nepal
HSEC	Higher Socio-economic Class
ICIMOD	International Centre for Integrated Mountain Development
KMC	Kathmandu Metropolitan City
LSEC	Lower Socio-economic Class
MoSTE	Ministry of Science, Technology and Environment
MSEC	Middle Socio-economic Class
NHRC	Nepal Health and Research Council
NO_x	Nitrogen oxides
PM_{10}	Particulate matter with a diameter of 10 µm or less
$PM_{2.5}$	Particulate matter with a diameter of 2.5 µm or less
RUA	Rapid Urban Assessment
SO_2	Sulphur dioxide
US-EPA	United States- Environment Protection Agency
VDC	Village Development Committee
WHO	World Health Organization

1. INTRODUCTION

1.1. Background

Environmental justice is a concept that promotes the equitable treatment of people of all races, incomes and cultures with respect to environmental laws, regulations, policies and decisions (Todd & Zografos, 2005). According to Cha (2007) it aims in ensuring the marginalized and weaker members of a community not forced to bear the main burden of environmental hazards or harm. environmental justice has now increasingly become part of the language of environmental activism, political debate, academic research and policy making around the world (Walker, 2009). Ghimire (2003) argues that most of the cases of injustices in environmental matters emerge from the roots of any social structure as it's clearly seen, being reflected through the social disparity. Therefore caste, class, gender, unawareness, and political power have been the main causes of environmental justice (Adhikari & Ghimire, 2002)

There is an increasing interest in unequal socio-spatial distribution of environmental 'goods' and 'bads' and the associated implications of geographical inequalities in health (Pearce et. al., 2011). Evans and Kantrowitz (2002) also consider inequalities in health status as implications of unequal environmental exposure that potentially harm or promote health and wellbeing. A keen interest on health inequalities and other distributional aspects of health status and service draw cities over the years (Gwatkin, 2002). A report by WHO (2012) mentioned that the inequalities in health are major challenge for both development and overall progress in countries.

1.2. Problem Justification

The cities in developing countries are facing rapid population growth and urbanisation. Cities are considered as power-house of national economic growth containing most skilled, best educated and economically productive people. However, they are facing the problems related to good governance, basic infrastructure like provision of water, sanitation and housing as well as emergence of severe inequalities in income, wealth and health (Weeks, Hill, & Stoler, 2013). The environment is deteriorating day by day however; there are inequalities in sharing burden or benefits of environment. With the issues of inequalities that had been raised in the late nineteenth and twentieth century in Europe and America, developing countries are still struggling to find equitable solutions.

The environmental justice approach was pioneered in the USA by civil right activists and is now receiving increased attention in Europe, due to the rights embodied in the 1998 Aarhus Convention, (Walker, 2003). The concept of environmental justice is relatively new and only few studies have been conducted in Nepal so far (Ghimire, 2003). Disproportionate sharing of ecological benefits and hazards in society to the unequal access to resources, unhealthy environment, decision making, information and other civil rights etc. are some of the issues related to environmental injustice in Nepal (Ghimire, 2003). Most of the injustice issues in urban area root in the management of solid waste, for example, dumping of waste material near the slum and marginal neighbourhoods without giving adequate information regarding its hazardous consequences (A. Shrestha, 1993). Similarly polluting rivers by disposal of sewerage, lacking access to clean drinking water, air pollution, and contamination of food items are other common issues of environmental problems.

Lots of studies had been done in health inequalities in Europe. Recent report by WHO (2012) indicates that environmental health inequalities exist in all sub regions and in all countries of WHO European Region, even though countries may have different patterns of exposure and risk. The inequalities can be assessed in global, national, regional or local scale. At the local level there may be considerable variability from one part of the city to another. These inequalities in health are expected to be starkest and most visible in cities of developing countries (Weeks et al., 2013).

In Nepal, studies on public health are done regularly, for example Annual report by Department of Health Services (DoHS, 2012), Nepal demographic and health survey (MOHP, New ERA, & ICF International Inc., 2012) conducted every 5 years. These studies are aimed for reviewing the performance of different programs and to provide up-to date data for guidance in planning, implementing, monitoring, and evaluating health programs in Nepal. Although, these studies show the health inequalities between rural and urban areas or between the districts, while the intra urban health inequalities are out of its scope. The cities being the centre of attraction for all, inviting migrants from different parts of the country, lots of variations exist in socio-economic condition as well as health condition. However, the inequalities that exist within the cities among different groups of community or places are hardly considered in the studies. There is a strong need to show the existing intra urban inequalities with the aid of appropriate indicators to consider it in future planning process.

There is a considerable volume of studies regarding the nature of health disparities and nature of environmental inequalities throughout the world; however the role of exposures to environmental inequalities on community health is nearly absent (Brulle & Pellow, 2006). In addition, Cohen and Schuchter (2013) emphasizes that the co-existence of inequalities in urban environment and health also needs to be examined. They also portray that within neighbourhoods, it is often the same people who bear the cumulative brunt of these inequities. Brulle and Pellow (2006) say that there is a critical need to integrate research on the impacts of environmental inequality and exposure to environment pollution into existing studies of community health and health disparities.

Different indicators sets had been developed by different organizations to measure health and environment aspects. For example, US-EPA (2004) developed indicators to measure environmental justice in USA, WHO developed Environmental Health Indicators (Briggs, 1999), WHO (2012) developed indicators to measure Environmental Health Inequalities in Europe, National Institute for Public Health and Environment developed Public Health Indicators for the European Union in 2005 (Kramers & ECHI team, 2005). However, for the study of a specific city, due to contextual variations, finding the relevant set of indicators are necessary as suggested by Todd and Zografos (2005).

There is a lack of suitable indicator for measuring and monitoring the health and environment conditions in developing countries including Nepal. Some attempts had been made to figure out the key environmental issues for Kathmandu Valley and develop indicators for measuring them by ICIMOD (2007), Nest (P) Ltd. (2013). However, the indicators which show the environmental and health inequalities within the cities are not considered in the studies. Moreover, assessing environmental conditions in environmental justice perspective are nearly absent in present studies.

1.3. Research Problem

Kathmandu, the capital city, is the most densely populated and largest city in Nepal. Like other cities in developing countries, Kathmandu is also urbanizing very rapidly. According to Census 2011, urban areas in Kathmandu Valley have a population density of 14,355 person/sq. km. with 3.92% average annual population growth in the past 10 years (CBS, 2012a).

Kathmandu is facing several environmental problems which are affecting the health of the residents. Air pollution due to heavy traffic in the city centres (CEN & ENPHO, 2003; R. M. Shrestha & Malla, 1996) is the major environmental problem in the city. Asthma and other respiratory diseases (Saraf, 2005), frequent occurrence of water borne diseases etc. are some of the major environmental health problems in the city. However, there is a spatial variation on degree of problem depending upon socio-economic factors and level of exposure to environmental conditions within the city. ICIMOD (2007) studied environment status of Kathmandu Valley where urban and sub-urban areas of three district Kathmandu, Lalitpur and Bhaktapur were considered, but they fail to show the variation exists within these big cities. On the other hand, the separate studies on health assessment or environmental assessment have been done but studies on the impact of unequal environment exposure and burden in health outcomes are nearly absent. In addition, how a health and environment effect varies with sub-population (e.g. socio-economic status, age, education, caste) has also been overlooked (Gurung & Bell, 2013). Therefore, whether the environmental inequalities and health inequalities exist within a city and whether some group of people are facing disproportionately high burden of environmental externalities creating the issue of Environmental Injustice in Kathmandu are yet unknown.

To measure the inequalities of different areas in Kathmandu, a relevant and contextual set of indicators can be very useful. This research intends to provide a set of health and environment indicators that analyse spatial inequalities to analyse the situation of environment justice in Kathmandu. The approach of developing indicators and the developed set of indicator will be helpful for assessing environmental justice in other cities of developing countries with similar context.

1.4. Research objectives

The main objective of this research is to develop indicators related to inequalities in health and environment and to assess environmental justice in Kathmandu, Nepal. The sub-objectives and research questions are given below:

1. To find out the major environmental and environmental health issues in Kathmandu
2. To develop suitable indicators to measure spatial inequality in environment and health in Kathmandu
3. To assess inequalities in environment and health and analyse if there is situation of environment injustice in study area

1.5. Research Questions

Research questions to fulfil 3 sub-objectives of research are shown in the Table 1.

Table 1: Research Questions

S.N.	Sub objectives	Research Questions
1	To find out the major environmental and health issues in Kathmandu	1. What are the most important environmental burdens and benefits in Kathmandu? 2. What are the main environmental health issues in Kathmandu? 3. In what ways those health and environment issues are inter related?
2	To develop suitable indicators to measure inequality in environment and health in Kathmandu	4. How environmental justice aspects can be framed in suitable indicator framework? 5. What are the indicators to measure the social aspects related to environment and health inequalities? 6. What are the indicators to measure the environmental inequalities? 7. What are suitable indicators to measure health outcomes relating with environmental exposure?

3	To assess inequalities in environment and health and analyse if there is situation of environment injustice in study area.	8. Are there inequalites existing between neighbourhoods in environment and health in study area? 9. Are certain groups suffering disproportionately from adverse health or environmental effects in study area? 10. What is the situation of environment justice or injustice in study area?

1.6. Conceptual Framework

Socio-economic conditions, Environment conditions and Health outcomes are the major components for assessing environmental justice. Therefore, the indicator framework to study environmental justice will consider the indicators showing all three components. Through the indicators, existing spatial inequalities in the cities on environment and health can be shown, from which the situation of environmental justice or Injustice can be assessed as shown in Figure 1.

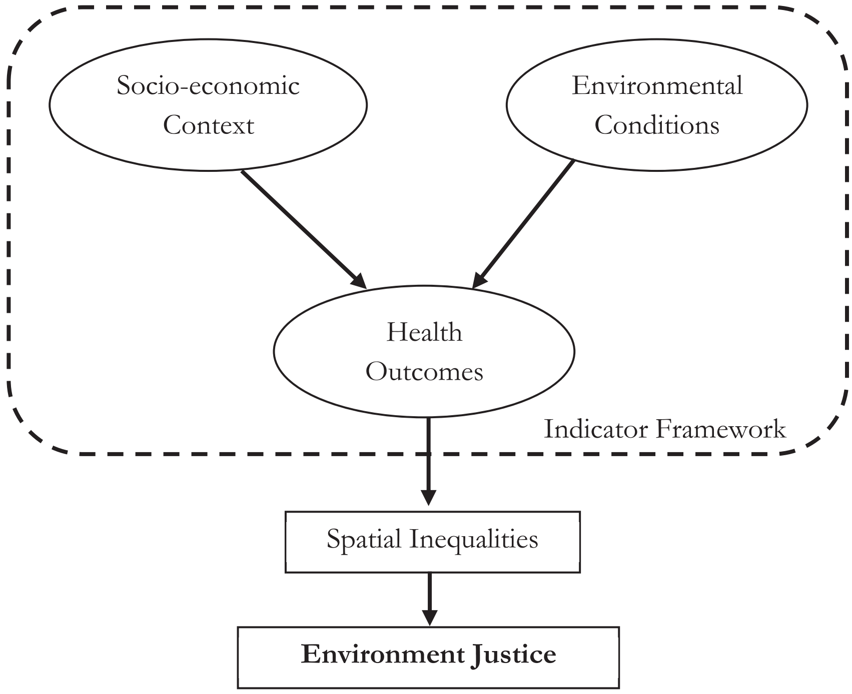


Figure 1: Conceptual Framework

Socio-economic contexts like poverty and education play great role in the level of exposure to the environmental benefits and burden. The general pattern at current depicts the deprived populations, not always more exposed; experience greater harmful pollution effects because of vulnerability factors (Deguen & Zmirou-Navier, 2010). More importantly the relationship between health and socio-economic deprivation is well documented (Shortt, Richardson, Pearce, & Mitchell, 2012). In other words, health inequalities cannot be understood in isolation from the social context within which they are found and the people who are affected (Smyth, 2008). For example, in the UK, inequalities in health appear to be more marked in deprived areas than in more affluent ones (Norman et al., 2005).

Furthermore, there is an ample evidence linking various health outcomes to components of the physical environment, for example, air pollution and green space (Jerrett et al., 2001). Exposure to environmental risk varies strongly by a range of socio-demographic determinants and thus causes inequalities in exposure to - and potentially in disease resulting from environmental conditions. (WHO, 2012). J. R. Pearce, Richardson, Mitchell, and Shortt (2010) suggested that the future research on environmental justice and Health should simultaneously consider the 'triple jeopardy' of social, health and environmental inequalities. Even, US-EPA (2004), has adapted the OECD's framework "Economic/ Environment/ Social Indicators" for assessing the overall health of a community and identifying conditions of environmental injustice.

1.7. Structure of Thesis

Chapter 1: Introduction

This chapter gives brief introduction on essential issues of the study including background and justification, research problems, objectives, questions and conceptual framework.

Chapter 2: Literature Review

This chapter consists of literatures in environmental justice, indicator frameworks and indicators.

Chapter 3: Study Area

As the study is carried out in a specific geographic location, the study area is described in this chapter along with the justification for selecting the areas and their characteristics.

Chapter 4: Methodology

This chapter presents research design and methods of data collection to achieve the objectives, including primary and secondary data collection.

Chapter 5: Development of Indicators

This chapter consist of indicator development by finding of major problems in the study area through available literature, published and unpublished and interviews with stakeholders. Then the set of socio-economic indicators and environment and health indicators are proposed to assess the inequalities if exist.

Chapter 6: Analysis and Findings

This chapter presents results of case study using household survey. Socio-economic context is presented initially. The analysis of inequalities is done in different levels of study. First- assessing inequalities between Neighbourhoods, Second- assessing inequalities within neighbourhood and finally assessing inequalities between different socio-economic classes in terms of environmental exposure and health effects across the study areas to find out if there is any condition of injustice.

Chapter 7: Discussions

This chapter presents the analytical discussions on the result obtained addressing the sub-objectives of this study. Major findings of case study are discussed.

Chapter 8: Conclusion

This chapter contains the summary of research findings with respect to research objectives as well as recommendations and future research directions.

2. LITERATURE REVIEW

This chapter provides relevant literature on Environment justice, spatial unit of analysis, indicators, and indicator framework for development of indicators.

2.1. Environmental Justice

Environmental justice is the goal to be achieved for all communities so that people of all races, colours, and income levels are treated fairly with respect to the development and enforcement of protective environmental laws, regulations, and policies; and potentially affected community residents are meaningfully involved in the decisions that will affect their environment and/or their health (US-EPA, 2004). Walker (2003) have defined Environment Injustice as "disproportionate exposure of poor communities to pollution, and its associated effects on health and environment, as well as the unequal environmental protection and environmental quality provided through laws, regulations, governmental programs, enforcement" whereas US-EPA (2004) states Environmental Injustice as the situations where communities believe that the goal has not been achieved because of their belief that there is disproportionate exposure to environmental harms and risks. These environmental harms and risks often include, for example, multiple sources of air pollution (indoor and outdoor), water quality concerns, and the cumulative impacts associated with living in some urban and rural areas.

Paavola and Adger (2002) put forward an analysis of justice by looking at distributive justice and procedural justice. Distributive justice deals with distribution of environmental goods and bads, with equity and fairness whereas procedural justice is concerned with meaningful involvement in decision process related to distribution of environmental benefits or burden.

Although researchers have considered the implication of multiple environmental risk factors (Evans & Kantrowitz, 2002) for inequalities in health status, the research fields of environmental justice and health inequalities are largely separate realms (J. R. Pearce et al., 2010). Brulle and Pellow (2006) suggested to integrate research on the impacts of environmental inequality and health disparities. According to Maantay (2002), environmental injustices and resulting health effects needs to be shown, it is important to show disproportionate effects of pollution rather than just the fact that disproportionate distribution of pollution sources exists.

Ako (2013) presented in his book "Environmental Justice in Developing Countries" that the definition of environmental justice is the fluidity of concept to cover a wide range of issues that is peculiar to societal challenges; in USA racial factors, in UK socio-economic disparity is the focal challenge while in developing countries, access to environmental resources is a major challenge. In South Asian context, the major concern is towards factors leading to marginalization including religion, class and ethnic background to address environmental justice (Cha, 2007).

Asia pacific environmental network defines environmental justice as the 'right to a clean and healthy environment in which communities can live, work learn, play and thrive (APEN, 2002). Deteriorating qualities of life in urban areas of developing countries due to environmental pollution is the major concern in urban areas of developing countries. According to Adhikari (2003), long term solutions to the environmental problems urge analysis of the problems in terms of environmental justice. The main root of environmental problem and its respective impacts should be analysed properly in which social aspects are essentially considered for avoiding social and political conflicts.

2.2. Environment Justice in Nepal

The right to live in a clean environment for every individual has been included in the interim constitution of Nepal promulgated on January 2007 which has been repealed in the Constitution of the Kingdom of Nepal 1990 (Cha, 2007). This emerging concept is considered important in improving environmental quality and enabling the sustainable use of resources and their protection, empowerment of the marginalized and improved livelihood security (Adhikari & Ghimire, 2002). Narayan Belbase, an environment lawyer states in interview with Down to Earth (2012),

> "environmental justice entails right to live in a healthy and clean environment; right to equitable access to environmental resources, goods and services, sustainable use of those resources and equitable sharing of benefits arising from the utilisation of these resources, goods and services. It also includes right to environmental information; participation in the environmental decision-making processes as well as full compensation to the victims of environmental degradation and pollution"

As an emerging concept of Environmental Justice, the literatures in Nepal reveals various discriminations existing in Nepali society with respect to proper management and utility of natural resources (Adhikari & Ghimire, 2002). Moreover, the prevalent discriminations are rooted in the existing social structure according to class, caste, gender and political power (Adhikari & Ghimire, 2002, p. 3) . Environmental burden ranges from polluted air and water to diminished access to natural resources in Asia. Cha (2007) explains how environmental burden can disproportionately affect marginal communities; either they may be exposed to more toxins than mainstream communities or same environment burden may affect them more.

In urban context, very few studies have been done. Adhikari (2003) puts forward as the major issue concerned to the increasing slum and squatter settlements, problems of solid waste management, air pollution, water pollution, declination of public open spaces and drinking water scarcity in urban areas; highlighting marginalized groups, lower caste and poor encountering the burden of these environmental problems fiercely. He further argues that children, women and elderly are mostly affected by air pollution. Similarly, indoor air pollution specially affects women and children. On the other hand, industrial areas and the road sides are the most polluted spaces where mostly poor people live. Jha (2006, p. 41) also has mentioned that the burden of pollution is more on poor, minorities, women, children and elderly and that the effects of pollution are not distributed equally.

2.3. Assessing Environmental Justice

Although there are differences in issues such as hazardous waste or access to environmental resources, the major goal of environmental justice is to protect from disproportionate sharing of benefits or burdens. Barzyk et al. (2011, p. 171) defines the term "disproportionate" as "the magnitude of health and environmental impacts is greater for a given community or population as compared to a reference counterpart, such as a comparable community or the area surrounding the target community." According to Department of Justice (1994) in Department of Justice Guidance Concerning environmental justice, there are a number of factors that should be considered in determining whether any individual situation does raise such an issue:"(i) Whether individuals, certain neighbourhoods, or federally recognized tribes suffer disproportionately adverse health or environmental effects from pollution or other environmental hazards; (ii)Whether individuals, certain neighbourhoods, or federally recognized tribes suffer disproportionate risks or exposure to environmental hazards, or suffer disproportionately from the effects of past under enforcement of state or federal health or environmental laws; (iii) Whether individuals, certain neighbourhoods, or federally recognized tribes have been denied an opportunity for meaningful involvement, as provided by law, in governmental decision making relating to the distribution of environmental benefits or burdens." However, to evaluate the magnitude of the disproportionality has been identified as major challenge for environment justice assessment by Barzyk et al. (2011).

US-EPA (2004) adopts assessment of potential for "adverse" environmental and human health effects and assessment of potential for "disproportionately high and adverse" effects at two level :screening and refined. Disproportionate risk is examined by comparison of impact between affected community and reference community. The statistically significant differences between two groups in one or more measures of risk are assessed. Therefore, this method is very helpful for initial screening if there is any injustice and performs a more detail study if screening level assessment shows injustice situation.

Environmental justice assessment in urban context of developing countries where issues are not siting toxic facilities but the people are facing adverse health effects due to excessive pollution had not been studied yet. It is not known that whether there is disproportionate burden to certain group of people or in certain neighbourhoods or not. Lack of comprehensive hazard database, inadequate exposure indices and health assessment data, realistic geographic extent of exposure and characteristics of affected population are limitations sorted out by Maantay (2002) in mapping environmental and health equity are applicable in context of developing countries.

2.4. Scale and unit of analysis

Environmental justice analysis depends largely on geographical scale and unit of analysis. Cutter, Holm, and Clark (1996) tested association between presence of hazardous facilities and socio-economic characteristics of places at three different spatial scales: counties, census tracts and census block groups and found conflicting results as aggregation at regional scale masks both interstate and intrastate variations. Similarly, Baden, Noonan, and Turaga (2007) also showed that the evidence of environmental injustice is sensitive to researcher's scale and scope choice. These discrepancies are due to modifiable areal unit problem (MAUP) (Openshaw, 1984). According to Maantay (2002), most of the environmental health and equity studies had been conducted at the national, state-wide, regional or city level of analysis but with coarser resolution which cannot pinpoint accurate spatial patterns suggesting that neighbourhood or community level analysis will be more feasible and useful than studies of large geographic extent. Cutter et al. (1996) also suggested tracts and block groups are the most appropriates spatial scale for assessing inequalities because of wide intra-county and intra-zip code variation.

The benefit of neighbourhood scale analysis has been discussed in Maantay (2002) as incorporation of local knowledge bases, less complexity in aggregating exposure from multiple and varied source, direct involvement of the affected people and the intimate knowledge of their surroundings.

2.5. Indicators for Environmental Justice

Indicators are the data used for assessment, measurement and communication of any phenomena. US-EPA (2004) developed "environmental justice Indicators" as tools that can be used to assess environmental decisions, and then provides a systematic approach for using these tools to assess a potential environmental injustice situation. About the development of indicators, Todd and Zografos (2005) states ".... in order to focus on the specific properties of the environmental injustices in a geographical area and with a defined community or group of stakeholders, the indicators which rise from these attributes should be measured and weighted to reflect the problems of that area. This would reflect the environmental justice's localised nature".

Similarly, criteria like policy relevance, analytical soundness and measurability had been discussed in US-EPA (2004) and OECD (1993). US-EPA (2004) suggested that evaluation of more than one indicator for the same endpoint can provide more clear picture.

However, the selection of right indicator is very important as this is the means to inform the current situation and basis for future planning. The use of indicator allows the comparison between various geographical units of analyses, which shows the inequalities in the geographical units. Spatially explicit indicators can help in identification of hot spots for actions (Briggs, 1999; Kockler & Flacke, 2013)

Subjective Indicators

Self-reported (subjective) health indicators are widely used in health studies as it provides true picture of how people perceive their own health. However, it also has limitations. Ploubidis and Grundy (2011, p. 700) listed limitations of self-reported health referring to different literatures: response bias such as social desirability; the information people use to assess their own health derived from combination of information about specific health problems, general physical functioning, health behaviours, mental health and general social experience. Dowd and Zajacova (2007) found individuals with different education, or income levels assess their health differently.

In environmental justice studies, fewer studies have used subjective indicators. Riedel, Scheiner, Müller, and Köckler (2013) evaluated the relation between objective and subjective indicators of residential exposure to road traffic noise as an issue of environmental justice and found that objective noise exposure predicts effects like noise annoyance insufficiently. The factors like socio-demographic, economic, health related and noise related attitudinal factors influence perception on noise.

Therefore, the measurement of subjective indicators in addition to objective indicators might provide more effective evidence in environmental justice assessment.

2.6. Indicators Framework

Various indicator frameworks have been developed in the areas of environment, health and environmental health. The main role of framework is to organize the concepts, ideas, and notions of a subject meaningfully (Health Council, 2002). T. Hambling, Weinstein, and Slaney (2011) have provided the groundwork for the future development of Environmental health indicators, as a multidisciplinary approach to link existing environmental and epidemiological data and networks. They found Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) as best suited for developing environment health indicator as it provides systematic approach to aid interpretation of the complex interactions by demonstrating links between environment and health.

Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) Framework was developed in the early 1990s by WHO. T. Hambling et al. (2011, p. 12) states about framework:

> "The framework describes the environmental health chain through the following components: Driving force (anthropogenic)-factors that motivate and push the environmental process involved. Pressure (on the environment)-are normally expressed through human occupation or exploitation of the environment. State (of the environment)-status of the environment. Exposure (of humans i.e., interaction between the environment and humans)-take place when humans are exposed to environmental conditions. Effect (in humans)-health effects from exposure to the environmental hazard. Action-policies or interventions aimed at reducing or avoiding health effects, they can be aimed at any point in the framework."

The framework describes the cause-to-effect chain and provides a framework for analysing interrelated factors that impact on the human health (WHO Europe, 2004). Carneiro et al. (2006) found that this framework is useful for the analysis of complex environmental health issues as it addresses all the complex levels from economic, social dynamics to environmental responses, and human health. Moreover, further advantage of this framework is its flexibility and applicability (Waheed, Khan, & Veitch, 2009). DPSIR framework developed earlier does not describe exposure route i.e. link between cause and effect (T. Hambling et al., 2011), exposure component added in DPSEEA refers to the intersection between people and hazards inherent in the environment; when people are exposed to environmental hazards, then risk to health may occur (Briggs, 1999).

DPSEEA framework was further developed for the use in context of children's environmental health as Multiple Exposures-Multiple Effects (MEME) Framework which recognizes exposures and health outcomes may be affected by more remote, contextual factors, such as social conditions, demographics and economic development that influence the susceptibility of the population to environmental health effects (Briggs, 2003). Morris, Beck, Hanlon, and Robertson (2006) also emphasize on context and added "contextual bubble" in DPSEEA framework surrounding exposure and effect to include social, demographic, economic and behavioural factors. By integrating socio-economic and demographic context in epidemiological studies through context bubble, it opens the door for including social inequality in this model (Kockler & Flacke, 2013).

This study focuses on the association between environment exposure and health as well as socio-economic factors. So, DPSEEA is the most suitable framework with socio-economic context added to it. The indicators are developed for Environmental exposure, Health effects and socio-economic context as these components are prime focus on this study to assess inequalities.

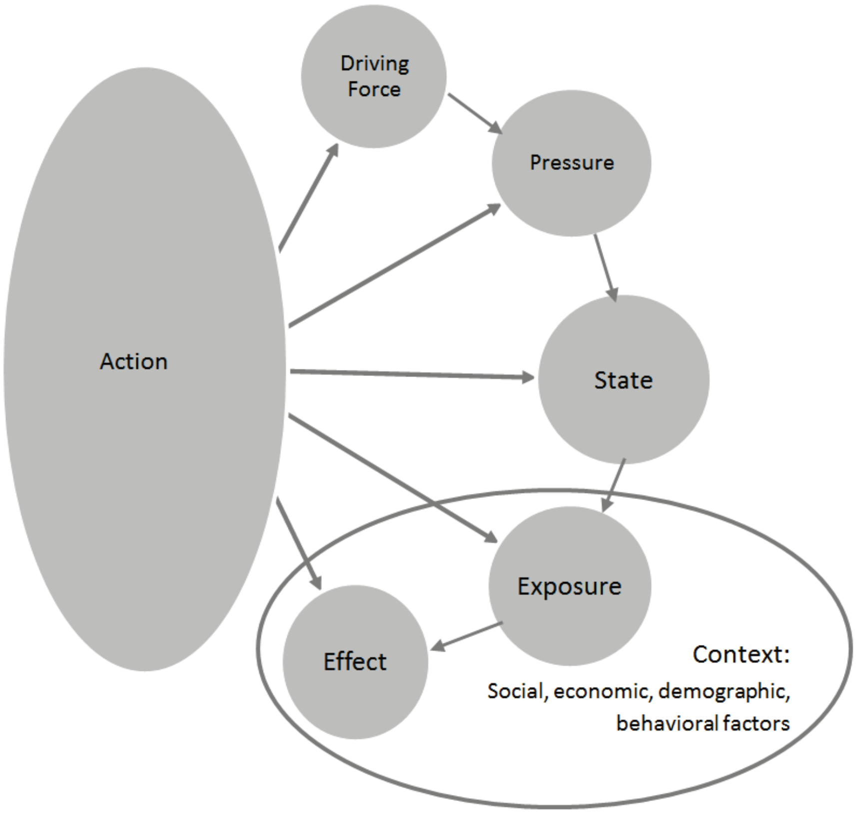


Figure 2: The modified DPSEEA model

Source: (Morris et al., 2006)

2.7. Conclusion

Environmental justice concept is relatively new in developing countries like Nepal. Having said that major environmental concerns like polluted air and water etc. have more burdens on poor, minorities, empirical studies have not been done yet. To find the long term solutions to environmental problems, environmentalists urge to analyse them in environmental justice perspective. Disproportionately high and adverse health effects to certain neighbourhood or certain groups of people due to adverse environmental exposure need to be assessed.

The scale and unit of analysis is very important in environmental justice analysis as the results might be sensitive to it. To pin point accurate spatial patterns, smaller units of analysis is recommended. Neighbourhood scale analysis can have benefit of incorporation of local knowledge and direct involvement of the affected people.

The indicators to measure environmental justice should be have focus on specific geographical area and group of stakeholders. Spatially explicit indicators are needed to show inequalities between geographical areas. In addition to objective indicators, subjective indicators should be included not to miss environmentally unjust situation, which objective indicators may not show.

The indicators needed to be framed in a suitable framework. DPSEEA framework describes cause and effect relation of exposure and health effects. Therefore inequalities in environment as exposure and health as effect can be better explained by DPSEEA framework. As socio-economic context plays an important role in exposure and health outcomes, the context should also be incorporated.

3. STUDY AREA: KATHMANDU METROPOLITAN CITY

3.1. Introduction

Nepal, located in South Asia with an area of 147,181 square kilometres with population of 26.6 million with population growth rate of 1.4% (CBS, 2012a). Nepal is divided into 5 development regions with 14 administrative zones and 75 districts. Kathmandu valley at the central development region consist of three districts- Kathmandu, Lalitpur and Bhaktapur. Figure 3 shows 5 municipalities in Kathmandu Valley including Kathmandu Metropolitan City (KMC).

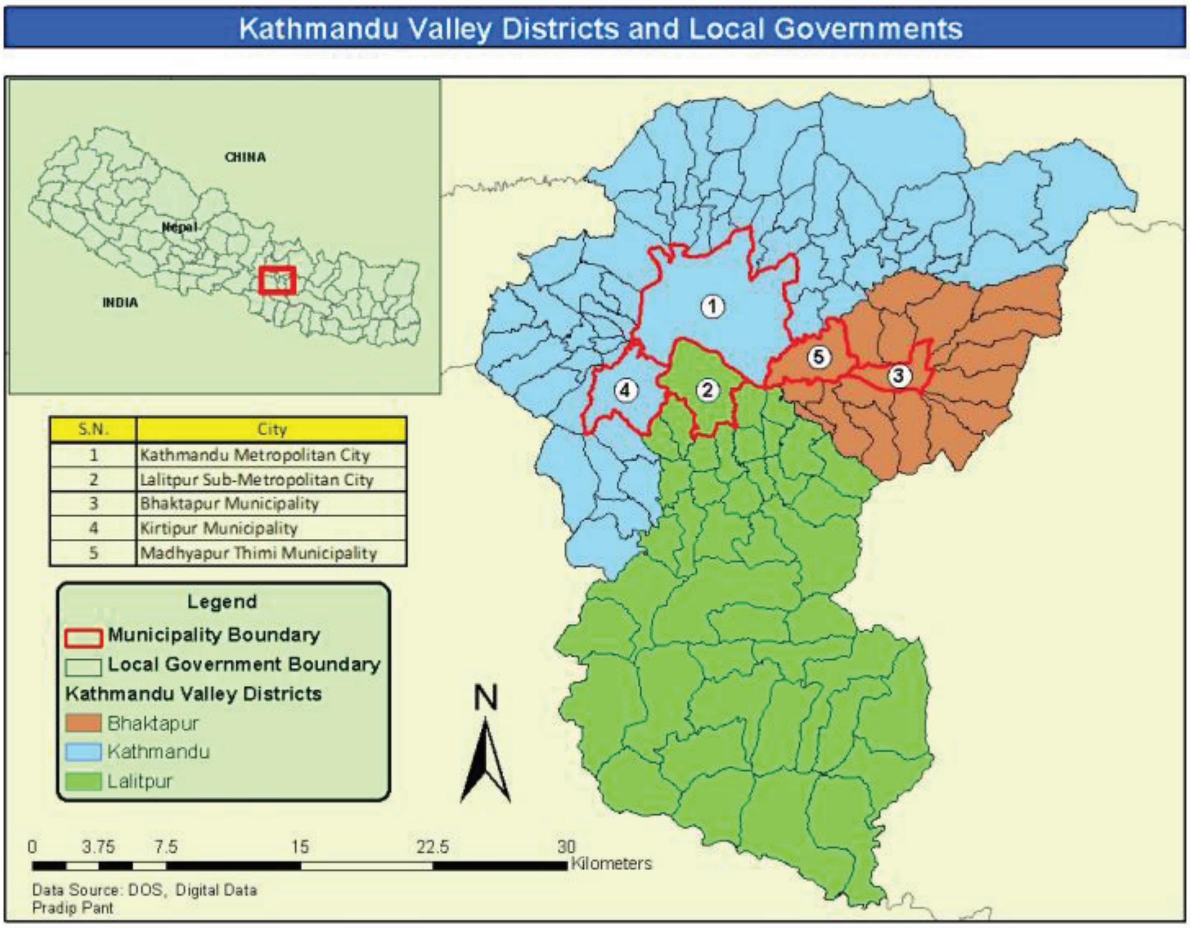


Figure 3: Kathmandu Valley Districts and Local Governments
Source: Pant and Dongol (2009)

Kathmandu being the capital of country and major economic activity centre, there is an excessive migration and inflow of people from other part of the country (ICIMOD, 2007) resulting in the highest population growth rate in Nepal. Basic amenities like water supplies, electricity, gas, telecommunications, roads, sanitation, education, security, and transportation are well developed in Kathmandu in comparison to the rest of Nepal. Kathmandu is a centre for all types of health services as well. Most of the well-equipped and specialized healthcare facilities are located here. There are three industrial districts in Kathmandu Valley. The main polluting industries in the valley are only small scale, and these include brick kilns; wool dyeing and carpet washing; textile dyeing; pottery; polyurethane and rubber foam; beaten rice; dairy products; metal casting; metal craft industries and gold plating; and alcoholic and non-alcoholic beverages (ICIMOD, 2007).

An increase in the population density places great strain on existing water supply and sewerage systems, open spaces and other facilities. Unplanned urbanization and haphazard development of industrial units, has generated a range of environmental problems affecting human health and welfare (Thapa, Murayama, & Ale, 2008). Similarly, an increase in vehicle numbers creates noise, smell, dust and smoke pollution, and increased risk of traffic hazards. Air pollution is the most significant problem in urban areas of Nepal including Kathmandu Valley. Emission of dust due to smoky motor vehicles and construction works, and the release of particulate matters (PM) by small-scale industries such as brick kilns are major sources of air pollution (Dhakal, 2006). Noise pollution is also increasing, due principally to aircraft noise, because of the international airport's close proximity to the city core, to out-dated vehicle engines, and industries located near residential areas (Adhikary, 1995).

3.2. Kathmandu Metropolitan city (KMC)

Kathmandu Metropolitan city (KMC), the only metropolitan city in Nepal lies in Kathmandu District with an area of 50.67 square kilometres and comprises of 35 wards. The current population is 1,006,656 (CBS, 2012a) which is almost increased by double in 10 years which was 671,846 in 2001. The population density of wards varies from 3,233 to 13,983 per square kilometres according to census 2001.

The indicators for environment and health inequalities are specially developed focusing on major issues in KMC, however, it will be applicable to other urban areas with similar characteristics. For the empirical study, 3 wards were selected and from three wards total 6 neighbourhoods were selected.

3.3. Selection of wards and Neighbourhoods

The study was conducted in neighbourhood level (smaller than ward). Though ward is the smallest administrative level in Nepal, area covered by a single ward is not homogeneous in socio-economic character as well as in terms of area occupied. As this study is primarily based on assessing inequalities between different neighbourhoods or socio-economic groups, stratified sampling was done for the selection of neighbourhoods. The strategies were:

- Neighbourhoods with similar environmental condition and different socio-economic conditions
- Neighbourhoods with similar socio-economic condition and different environmental conditions

Environmental conditions mainly focussing on major transport roads (relating air pollution and noise pollution), river (water pollution) etc. are considered. Though variations in population density, housing patterns and conditions for ward are available, economic data are not available. It is assumed that there are variations in socio-economic conditions within the wards, yet the environment conditions will be similar. Adjacent neighbourhood clusters with similarities and differences in terms socio-economic conditions and environmental conditions with specific characters are selected as shown in Table 3. Selected neighbourhoods from 3 wards 12, 13 and 14 are shown in Figure 4.

Table 2 shows the demographic information and area of selected wards. Major characteristics of selected wards are given below:

Ward No. 12 comprises of the traditional core area with lots of sacred shrines and pilgrimage sites, as well as waste transfer station in the southwest, and hospital area Sukra Raj tropical hospital and Nepal Public Health Laboratory at southeast. Population is 13262 inhabited in 3173 household with population density of 26738 per square kilometer. The ward has an area of 51 hectares surrounded by Bishnumati River in the west and Bagmati River in the south, two major rivers of Kathmandu. Due to the composition of different type of landuse within the ward, the characteristics of ward are heterogeneous. More than 50% of the buildings are of clay mortar and more than 15% of buildings are in poor condition. Out of the total household, 56% of household are staying in rent. The settlement pattern is different in north and south, north part containing very dense traditional settlement with narrow roads, whereas south part is of low density, dispersed housing also comprises of institutional land use.

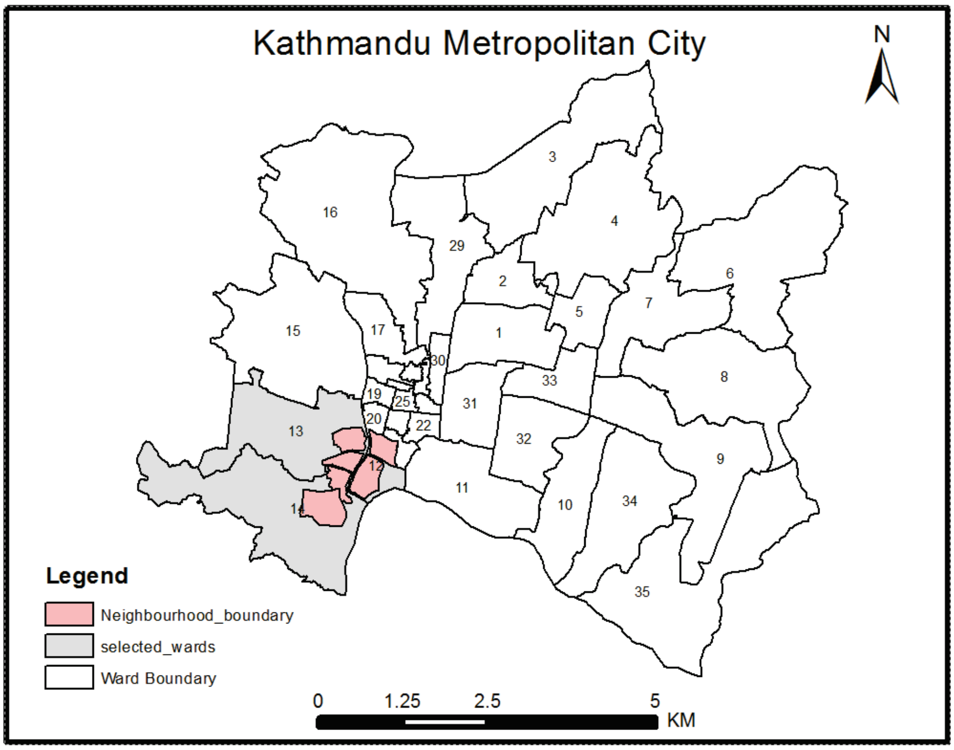


Figure 4: Ward boundary map of KMC, showing location of selected neighbourhoods

Table 2: Demographic information of selected wards

Ward No.	Household	Total Population	Area (sq.km.)	Pop. Density	Housing Density
12	3173	13262	0.496	26737.90	6397.18
13	10207	40456	2.288	17681.82	4461.10
14	15472	58495	3.466	16876.80	4463.94

Source: CBS, 2012

Ward 13 comprises 213.3 hectares with Bishnumati River in the east. Almost the entire ward is made up of residential and commercial areas. Kathmandu's famed vegetable and fruit market is situated here. This ward also comprises of the large establishments like Telecommunication corporation, National museum etc. Total Population is 40456 inhabited in household 10207, population density 17681/square kilometre of area. 25% of buildings are made of clay mortar and around 30% of buildings are in poor condition. Out of the total household, 65% are staying in rent. The ward is very heterogeneous with mixture of planned and unplanned housing area including old commercial area.

Ward 14 is covering an area of 302.9 hectares with Bagmati River in the east. Kuleshwor Housing Project, the first such effort by His Majesty's Government, is situated in this ward. Total population of ward is 58495 in 15472 household with population density of 16876 per square kilometre of area. Out of the total household, 62% are staying in rent. Around 25% houses are made of clay mortar of which more than 30% are in poor condition. The ward consists of part of major road joining Kathmandu Valley with other parts of Nepal.

Table 3: Selected neighbourhoods

Ward No.	Neighbourhood	Area (sq.km.)	Approx. Household	No. of Samples	% of sample	Specific Characteristics
14	Neighbourhood 1	0.29	840	78	9	Housing project, residential area designed for GoN staff
14	Neighbourhood 2	0.11	490	67	14	Along the busy road, residential and commercial mixed area
13	Neighbourhood 3	0.11	450	69	15	Compact settlement, comprising two major roads, residential and commercial mixed
13	Neighbourhood 4	0.15	620	66	11	Compact settlement, comprising of old Vegetable market
12	Neighbourhood 5	0.14	1200	68	6	Traditional core area, compact and dense settlement
12	Neighbourhood 6	0.20	400	60	15	Medium density settlement, nearby waste transfer station

4. RESEARCH METHODOLOGY

This chapter presents research design and methods of data collection to achieve the objectives, including primary and secondary data collection. Method data analysis is also presented.

4.1. Research Design

Phase I: Pre-Field work

Conceptualization: The first phase comprised of gaining theoretical concept on environmental justice, spatial inequalities, Indicator frameworks, and current situations of Kathmandu etc. which relies largely on literature review.

Field Work Preparation: Preparation for interview questions for semi structured interviews with experts in Health and Environment were done. Preliminary survey questionnaires for household survey were prepared and the sources of required data were sorted out in this phase. Sampling strategy, sample size, survey location and survey design were also determined during this phase.

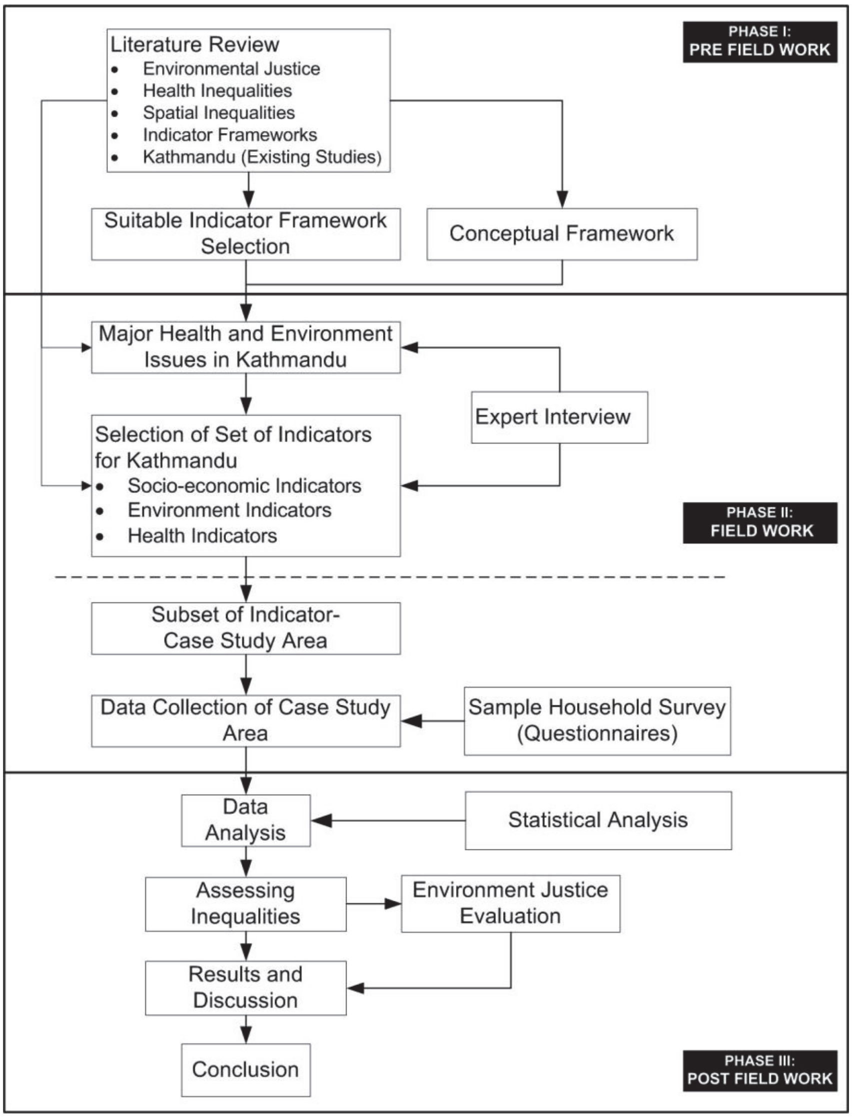


Figure 5: Research Design

Phase II: Field Work

Interviews and Indicator Development: During field work, data was collected from the government offices such as Ministry of Science, Technology and Environment (MoSTE), Ministry of Health and Population, Kathmandu Metropolitan City Office, Environment and Public Health Organization, Central Bureau of Statistics etc. On the other hand, semi structured interview with experts in environment on environmental issues were done. The major domains to include for the study were discussed. Few possible indicators were discussed as well. Depending on the interviews and literatures, the list of indicators was prepared.

Household Survey: After development of indicator set, few indicators were selected which best can demonstrate spatial inequalities in environment and health if exists, which further helps in evaluating the environmental justice condition in the case study area. Six neighbourhoods were selected for primary data collection. Sample household survey was carried out in the selected neighbourhoods to find out social, demographic, economic data as well as the health conditions data for the selected indicators.

Phase III: Post Fieldwork

Analysis and Conclusion: The data obtained from the household survey was then analysed using statistical analysis methods. Inequalities in environmental and health were assessed and further analysed in terms of environmental justice. The results and findings are communicated and conclusion is driven with further research directions.

4.2. Research Matrix

Table 4: Research Matrix

Sub objectives	Research Questions	Data Required	Data sources	Methods
To find out the major health and environmental issues in Kathmandu	1. What are the most important environmental burdens and benefits in Kathmandu?	Secondary data	Government documents	Expert Interview & Literature
	2. What are the main environment related health issues in Kathmandu?	Secondary data	Government documents, Hospital Records	Expert Interview & Literature
	3. In what ways those health and environment issues inter related?			Expert Interview & Literature
To develop suitable indicators to measure inequality in environment and health in Kathmandu	4. How these aspects can be framed in suitable indicator framework?			Literature
	5. What are the indicators to measure the social aspects related to environment and health inequalities?			Literature
	6. What are the indicators to measure the environmental inequalities?			Literature
	7. What are suitable indicators to measure health outcomes relating with environmental exposure?			Literature

Sub objectives	Research Questions	Data Required	Data sources	Methods
To map inequalities in environment and health and analyse if there is situation of environment injustice in Case Study Area	8. Are there inequalities exist between neighbourhoods in environment and health in case study area ?	Primary data on Environmental, Socio-economic and health	Household Survey + Secondary data	Cluster Analysis, Cross tabs
	9. Are certain groups suffering disproportionately form adverse health or environmental effects in case study area?	Primary data on Environmental, Socio-economic and health	Household Survey + Secondary data	Cross tabs, Chi-square test
	10. What is the situation of Environment Justice or Injustice in case study area?	Primary data on Environmental, Socio-economic and health	Household Survey + Secondary data	Exploration and Comparison

4.3. Primary Data Collection

4.3.1. Interviews and Discussion

To meet the first and second objective, semi-structured interviews were conducted with the concerned people. Environment lawyer, environmentalist, engineers in environment section from KMC and DUDBC were interviewed to find out the major environmental problems of Kathmandu and major health issues related with it. Interviewees were selected based on the literatures published as well as their knowledge and their positions on the respective organisations.

4.3.2. Development of Indicator

Major domains for development of indicators were discussed in interviews. Environmental justice issues were discussed. Few suggestions on indicators were obtained by interviewees. However, relevant set of indicator was developed from extensive literature review.

4.3.3. Subset of indicators for empirical study

For the empirical study, indicators from the set of indicators, most related to the site were short listed after field observations which were possible to collect through household survey.

4.3.4. Household Survey

Stratified random sampling was done for selection of households for the survey in selected neighbourhoods. Depending on time constraints, total sample size for this study was determined around 400 households with 60-75 households from each selected neighbourhood which is about 6-15% of total households in the neighbourhood (Table 3). Due to unavailability of household database, available satellite image of year 2006 was used as the base map (Figure 6). Digitization in ArcGIS was done to define neighbourhoods excluding pockets of major road, open/vacant spaces as far as possible. The numbers of required random points are generated using ArcGIS tool 'Random Points'.

4.3.4.1. Questionnaire

The survey questionnaire mainly focused on the three groups of variables: socio-economic characteristics, perceived environmental conditions and self-reported health conditions. Structured questionnaire was used with simple terminologies for better understanding by general people. Most of the questions are set with possible options for uniform answers. In case of income, four ranges of income are used as people hesitate to say exact income.

For the household survey, 6 survey assistants helped in collecting data in local language. The survey assistants were trained on the first day on how to collect the questionnaires. They were also trained to read map overlaid with satellite image, in order to find the spotted houses on the imagery. A pilot survey was conducted in two neighbourhoods to check the order of questions, peoples' reactions as well as to confirm that the survey assistants understand the question.

The criteria for household survey are:

- The respondent should be preferably head of household. In case of absence, respondent should be at least of age 18, who should be able to give detail information about the whole household members and who can represent the perception of all other household members.
- In case of unavailability or unwillingness of respondent in the spotted house, the nearest house on the right side of the spotted house is selected and it is marked on the map.

After the pilot survey, some modifications were done in the questionnaire such as changing the order of questions, adding and removing of alternative answers etc. Then with revised questionnaire, all 6 neighbourhoods were surveyed.

The design of questionnaire intends to collect socio-economic condition which will have effect on the handling environmental burdens and change in health behaviour.

Figure 6: Showing the random sample points created in ArcGIS over the satellite image

4.4. Secondary Data Collection

The secondary data mostly consists of spatial data in GIS format, reports published by concerned organizations and policies and acts. Following are list of secondary data collected:

1. Kathmandu Valley Administrative boundaries, land use map and road network map from KVTDC, 2006 in GIS format
2. Emission grid map for air pollutants, 2012 in GIS format from ICIMOD by B. B. Pradhan, Dangol, Bhaunju, and Pradhan (2012)
3. Census Data from CBS (only for selected social indicators), 2012 in Excel format which has not been published yet

4. Hospital Record of last six month in Sukraraj Tropical and Infectious Diseases Hospital, Teku, Kathmandu
5. Urban Indicators for Municipalities, 2012 from DUDBC by Nest (P) Ltd. (2013)
6. Environment Protection Act and Regulation, 1996
7. Urban Environmental Guidelines (UEG), 2010
8. Publications from Martin Chautari and Forum for Justice related to environmental justice in Nepal
9. Reports from Environment and Public Health Organization (ENPHO, 2007), Nepal Health and Research Council (NHRC, 2009), ICIMOD (B. B. Pradhan et al., 2012) etc.

4.5. Post Fieldwork

Data collected from primary source, questionnaire and interview were checked for consistency. Questionnaires collected from fieldwork were entered in digital format (SPSS) for further analysis. Overall summary on all the variables (for example frequency table, sum, mean) are produced for general overview of collected data. Other secondary GIS data are processed to match similar projection system and spatial referencing was done due to inconsistency between different sources of data. Maps produced by ICIMOD (B. B. Pradhan et al., 2012) for assessing urban air quality have been used which provides the data of total emission of air pollutants (PM_{10}, NO_x, SO_2 and CO etc.) per 100 mx 100m grid. This grid map has been intersected with neighbourhood to get average value of air pollutant in the neighbourhoods. Similarly, each household point is assigned air pollutant value from the grid map for calculating level of exposure that households are facing.

4.6. Data Analysis

4.6.1. Socio-economic Condition

Cluster analysis was done as the neighbourhoods were very heterogeneous in terms of different socio-economic characteristics. Major indicator for economic condition which was range of household monthly income was biased with 59% of household were in 13000-30000 income range and very low in <13000 and <60000. Similarly, other characteristics are also not found homogeneous within each neighbourhood except in few.

Cluster analysis groups together similar observation to reduce ‘n’ original observations into ‘g’ groups, where, $1 \leq g \leq n$. A general goal of reduction of observation to minimize within group variation and maximize between group variation (Rogerson, 2001) is necessary to find out different classes of socio-economic conditions of the sampled households. Different categorical variables like household income, education, occupation, car ownership and continuous variables like number of motorbike owned are used as input in two step cluster analysis in SPSS 21. Ratios of sizes, predictor importance, silhouette measure of cohesion and separation are checked. Cluster can be characterized based on descriptive statistics provided for each input variable.

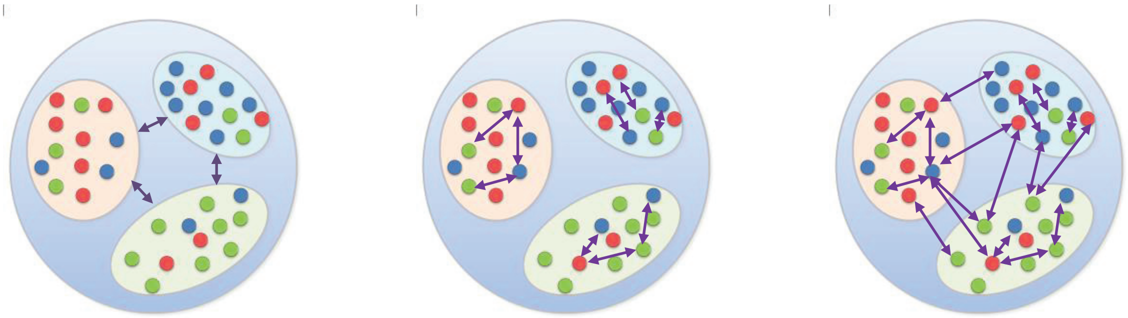
4.6.2. Assessing inequalities

From primary data and available secondary data, analysis is done to assess inequalities. This study uses exploratory approach to identify the existence of inequalities. It is done in three steps as shown in Figure 7. In every step, environmental condition and health effects are checked with respect to unit of analysis.

4.6.2.1. Assessing inequalities between Neighbourhoods

As most of the variables are categorical data, contingency tables were created using cross tabulations to check the relation between two variables. Perceived environmental conditions and reported health effects are checked with respect to neighbourhoods to find out if some neighbourhoods have higher or lower effects compared to other neighbourhoods.

First Step **Second Step** **Third Step**



Analysis is done between neighbourhoods

Analysis is done within neighbourhoods of different socio-economic class

Analysis is done between socio-economic classes across the whole study area

Figure 7: Graphical representation of analysis steps

4.6.2.2. Assessing inequalities within neighbourhoods

The households in each neighbouhood are classified according to cluster analysis. Within each neighbourhood, the association between socio-economic class and environmental condition and health effects are analysed. Contingency table and Pearson's chi square test (Field, 2009) are used to find out whether the association is staistically significant, to find out whether certain socio-economic class are disproportionately burdened by environment and health effects within neighbourhoods.

4.6.2.3. Assessing inequalities between socio-economic classes

In this stage, all households in study area classified in 3 different socio-economic classes were checked for their relationship with environmental condition and health effects. Contingency table and Pearson's chi square test was performed to check significant relationship between socio-economic classes and environmental conditions and effects.

5. DEVELOPMENT OF INDICATORS

This chapter consists three sections. First section consists of findings of major environmental and health issues in Nepal mainly through literature and expert interviews. Second section consists of development of indicators on major issues find out in first section. The set of socio-economic indicators and environment and health indicators are proposed to assess the inequalities if exists. Final section is the subset of indicators selected for empirical study of selected case study area in Kathmandu.

5.1. Major Environmental and Health Issues in Nepal

For the development of indicators related to inequalities in environment and health, major environmental and health issues in Kathmandu are sorted out through literatures and reports published or unpublished and interview with experts in environment. Environmental problems had been hot issues of discussion especially in urban areas due to deteriorating quality of life from excessive environmental pollution. However, the studies linking environmental pollution with health effects are very few. The major environmental issues and environmental health issues are described in the following sections.

5.1.1. Major Environmental Issues

According to survey done by CBS in 1996, most urban residents feel that solid waste management is the most problematic environment issue (Figure 8) followed by sewerage, air pollution and water pollution (ENPHO, 2007). It assumed that in last ten years from the publication date, these figures have not changed because very little work has been done to improve the urban environment. But there is absence of recent studies on what issues people in urban area feel more problematic in the present context.

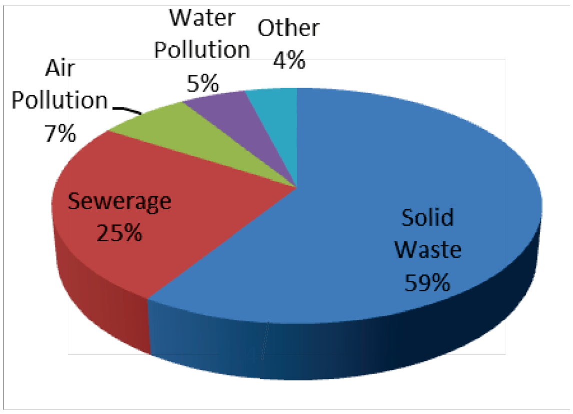


Figure 8: Public opinion on main environmental problems in urban areas
Source: CBS (1997) cited in ENPHO (2007)

The publication by ICIMOD (2007) provides a detailed account of the status of the Kathmandu Valley environment. The report highlights the five key environmental issues of Air quality, Settlement pattern, Drinking water resources, Waste management and Natural disaster preparedness. The study done by Nepal Health Research Council (NHRC) presents Air pollution, Water pollution, Solid waste management and Climate changed as key environmental problems (NHRC, 2009). Major problems indicated by different literatures are summarized in Table 5.

Most recent report on Urban Environmental Indicators by Nest (P) Ltd. (2013) identified and proposed key urban environment indicators and their measurement methods, on the selected variables. The national standard for each indicator had also been proposed wherever feasible. The major environmental problems are summarized in Table 6 which also shows their importance given as marking value for each domain ranging from maximum of 130 to minimum 15. The report was prepared with extensive consultation with key stakeholders and the main purpose was to evalute environmental conditon of municipalites with the aid of developed indicators. However, the indicators were not based on any specific framework may be because it intends to show only the current situation. Solid waste management is considered as one of the biggest environmental problem in most of the literatures. In contrast, an engineer from environment section of KMC argues that it to be not applicable for the case of residents in Kathmandu since there is a frequent collection mechanism through office itself or through private sectors. Similarly, the highest marking values has been given for drainage and sewerage. The areas where municipality is mostly responsible for management seem to be given high priority in the report. The indicators proposed are mainly focused on environment state, so exposure of population to the environment condition has not been considered in indicators.

Table 5: Summary of major environmental problems according to different authors

Sources	Solid Waste	Air Quality	Water quality /supply	Drainage & Sewerage	River Pollution	Noise
CBS 1997	√	√	√	√		
Adhikari & Ghimire (2002)	√	√	√	√	√	
ICIMOD (2007)	√	√	√			
NHRC (2009)	√	√	√			
Nest (P.) Ltd. (2013)	√	√	√	√	√	√
Pant and Dongol (2009)	√	√			√	
Interview		√	√			√

Table 6: Domain for indicators, their marking value and respective count of indicators

Domain	Marking Value	Domain	Marking Value
1. Solid Waste Management	100	12. Housing	50
2. Air Quality	50	13. Road	
3. Noise Level	50	14. Transportation	60
4. Water Supply	100	15. Risk Management	50
5. Sanitation	20	16. Heritage Conservation	25
6. Drainage & Sewerage	130	17. Visual Pollution	25
7. Water bodies	50	18. Urban Agriculture	15
8. River Streams	50	19. Urban Forest	25
9. Green areas and open spaces	50	20. Energy	50
10. Land use	25	21. Urban Environment Management	25
11.Population Density	50		

Source: Nest (P) Ltd. (2013)

Regarding the views of expert on major environmental problems in Kathmandu, an environmental lawyer and an enronmentalist both stated water scarcity, water quality and air pollution as the most problematic environmetal pollution in context of Kathmandu. Noise pollution is also considered as one of the major arising issue due to increasing number of vehicles in the city.

Along with the problems arising the issues of environmental justice i.e. solid waste management, water pollution, air pollution and chemical pollution(Adhikari & Ghimire, 2002); Adhikari and Ghimire (2003) also put forward the slum and squatter, river pollution, drainage, drinking water shortage in additional challenges in the urban environment.

Furthermore, an environment lawyer focuses on inequalities between different class of people (rich and poor) regarding the environmental inequalities issues as rich people have their own built environment or they can cope better with bad environmental consequences. Another environmentalist stated that there are surely disproportionate sharing of the burden of environment burdens in Kathmandu, especially children, women and poor people suffer most. These view complies with the publications (Adhikari, 2003; Jha, 2006) related to environment justice in Nepal. Despite of the fact that these views from interviewees comply with most of the publications related to environmental justice in Nepal, their empirical studies have always been overshadowed.

5.1.2. Major Environmental Health Issues

Health is determined by several factors like personal behaviours, access to quality health care, general external environment (such as the quality of air, water, and housing conditions) and genetic inheritance (National Academy of Sciences, 2006). Health related with natural and built environment is termed as environmental health. In Nepal, the health effects due to exposure with environment are given less priority than primary health care. Therefore, environmental health has been studied by only few organizations including NHRC and ENPHO.

Annual Report by Department of Health Service, Ministry of Health and Population says that the top ten causes of morbidity observed in outpatient visits in the country's health institutions are pyrexia of unknown origin, headaches/migraines, gastritis, ARI/lower respiratory tract infections, upper respiratory tract infections, intestinal worm infestations, impetigo/boils/furunculosis, presumed non-infectious diarrhoea, and amoebic dysentery, fall/injuries and fractures in 2010/11 (DoHS, 2012). It is seen that most of the diseases are related with environmental factors such as air pollution and water pollution.

The most discussed issues on impact of environment is the impact of air pollution in human health, for example, ICIMOD (2007), CEN and ENPHO (2003), Saraf (2005). The most common health effect of air pollution is damage to the respiratory system as inhalation is the means to enter the pollutant into the human body. Exposure to air pollutants can overload or break the natural defence system in the body, contributing to respiratory diseases such as lung cancer, asthma, chronic bronchitis and emphysema (CEN & ENPHO, 2003).

In National Academy of Medical Science (Bir Hospital- one of the major hospitals in Nepal), COPD and Pneumonia are major causes for mortality whereas they are major causes of morbidity after fractures and injuries. In Kanti Children's Hospital, respiratory disease is major cause of mortality of children after Neonatal Sepsis in year 2010/11 (DoHS, 2012). According to Health Magazine (2013), pneumonia is one of the major causes of child mortality with around 5600 mortality per year under the age of five which is around 16% of total child mortality. Yearly, around 285,000 children are suffered from Pneumonia and other respiratory disease in Nepal. Chest infection due to air pollution (emission and dust particles) is the major cause of pneumonia and the rate of its occurrence is increasing due to increase in air pollution according to Dr. Dhan Raj Aryal as quoted in Health Magazine (2013).

Water borne diseases such as diarrhoea, dysentery, cholera and skin diseases are due to deteriorating quality of water (ICIMOD, 2007) and has been one of the most serious public health issues in Kathmandu Valley. According to NLSS III (CBS, 2011a), diarrhoea accounts for 15.5% of total illness in Nepal, whereas in urban areas of Kathmandu Valley its 19.1% which is higher than national average. In addition, gastritis, intestinal worm infestations etc. in the list of top-ten causes of morbidity shows the severity of water pollution problem.

Hence, air pollution and water pollution being the most problematic environmental issues and inequalities in burden are noticed, and so are selected for the development of indicators. In addition, though the effect is not seen prominently, noise pollution is also selected for indicator development assuming inequalities may exist within urban areas.

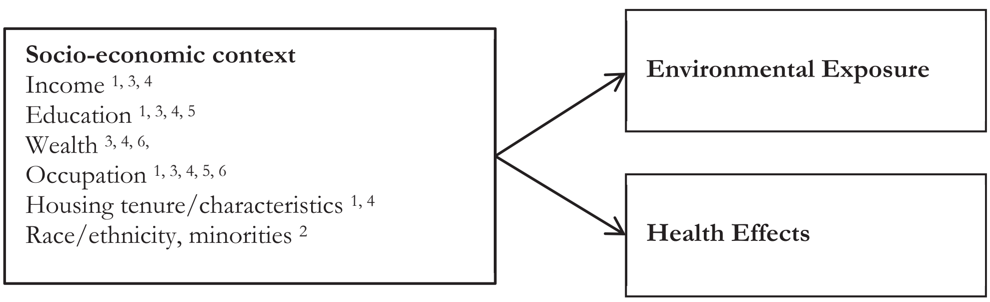
5.2. Indicator Development

The indicators for the major environmental problems are developed. To show the association between environment exposure and health, DPSEEA framework is used. Socio-economic context is added as social conditions, demographics and economic development that influence the susceptibility of the population to environmental health effects (as discussed in literature review on Indicators Framework). Since, this study is focused on indicators related to inequalities, major problems which might have different exposure and effect on public health and livelihood are in concern. Indicators for socio-economic context, which might have impact on exposure and health effects, are developed. Air pollution, water pollution and noise pollution are the major domain considered. For each domain, indicators for environmental exposure and health effects are developed with reference to international literatures, published and unpublished reports by different organizations in Nepal. Experts suggested indicators are also included; however, only general indicators were suggested.

5.2.1. Socio-economic Indicators

As socio-economic context plays important role in exposure and health of people, the indicators that show socio-economic differences are required. A graded relation has been established between socio-economic class and health; increase in level of socio-economic status, rate of morbidity and mortality is decreased (Adler et al., 1994). Evans and Kantrowitz (2002) presented differential environmental exposure as explanation for socio-economic status-health gradient and documented evidence of inverse relations between income and other indices of SES with hazardous waste, air pollution, water quality, ambient noise, residential crowding, housing quality, work environments etc.

The most commonly used indicators of socio-economic status are income, education and occupation (Liberators, Link, & Kelsey, 1988). Education is more stable indicator of socio-economic status and it can contribute both occupational and income attainment (Ostrove, Feldman, & Adler, 1999). Daly, Duncan, McDonogh, and Williams (2002) found that wealth and recent family income as most strongly associated with mortality. Indicators associated with wealth, such as, car ownership (Smith, Shipley, & Rose, 1990) also employed and housing tenure, housing conditions and household amenities are proposed by Galobardes, Shaw, Lawlor, and Smith (2006). Race and ethnicity are also most discussed indicators in the field of health and environment research. Figure 9 summarizes widely used socio-economic indicators.



The indicators have been used in following studies: [1]Barzyk et al. (2011); [2]Buzzelli and Jerrett (2004); [3]Daly et al. (2002); [4]Galobardes et al. (2006); [5]Kramers and ECHI team (2005); [6]Smith et al. (1990)

Figure 9: Indicators widely used for socio-economic context

Socio-economic Indicators in context of Nepal and Kathmandu

National Population and Housing Census 2011 (CBS, 2012a, 2012b), Nepal Living Standard Survey, 2010/11 (CBS, 2011a), Nepal demographic and health survey 2011 (MOHP et al., 2012) are major surveys and publications of socio-demographic context in Nepal. Nepal demographic and health survey 2011 uses household population, including information on housing facilities and characteristics, household assets, wealth status, education, and food security as a basis for understanding the socio-economic status of households. Lowest spatial unit of analysis of these indicators are by sub-regions (greater than district), as they are national level survey. The major indicators of socio-economic context which plays major role in health conditions are described below in context of Nepal.

Household Income/Poverty

Income plays significant role in health condition as it provides the resources needed to maintain good health. In general, higher income is associated with higher social status with better education. However, income being sensitive matter, data on income is not published, instead poverty line is used. Poverty estimation in Nepal follows the Cost of Basic Need approach (CBN) according to which, the poverty line is defined as the expenditure value required by an individual to fulfil his/her basic needs in terms of food and non-food items. The poverty line in Nepal for average 2010-11 prices has been estimated at NRs. 19261, the food poverty line is NRs. 11,929 and the non-food poverty line is 7,332. However for Kathmandu, food poverty line is 14610 while non-food is 26323 with overall poverty line at 40933. According to this, Kathmandu has 11.47% incidence of poverty which accounts for 5.7% of total poverty in Nepal (CBS, 2011b). Therefore, poverty can be used as one of the socio-economic indicator. However, data availability at required spatial unit might be a restriction. The data can be obtained from CBS, Nepal.

Education

Literacy and education attainment are important determinants of individual and household welfare as literacy has a positive impact on health and nutritional status with overall wellbeing of the individual and the society and educational attainment is directly related to the economic status of individual as well as the household (CBS, 2011a). Literacy has been defined as the ability to read and write simple statements in any language in his/her daily life and the rate has been calculated considering the population aged 6 years and above. About 61% of population are literate in Nepal whereas in urban areas in Kathmandu Valley 84.3% are literate. Education also has shown relation with poverty in study (CBS, 2011b). Poverty is substantially lower for higher levels of head's education. Households with an illiterate head are more than 4.5 times more likely to be poor than households with a head that has completed 11 or higher.

Occupation

Occupation though does not affect directly on health outcome, occupation related to polluting industries may have impact on health. Occupation can also be linked with social status and poverty. Households with head as professional wage-worker have least poverty rate and head with wage agriculture have highest poverty rate while household head involved in trade and services, manufacturing etc. has medium level of poverty compared to others (CBS, 2011b).

Housing characteristics

Housing characteristics are one of most used measures for socio-economic position as well as health outcomes. Ownership, construction materials, dwelling size and access to utilities and amenities such as electricity, piped water, cooking fuel etc. are used by Nepal Living Standard Survey III (CBS, 2011a) as measure for well-being of population. Housing condition for example presence of dampness can affect health condition. Similarly, overcrowding (more than 2 people per room) may also affect health outcomes due to spread of infectious diseases.

5.2.2. Environmental and Health Indicators

Environmental and health indicator related to inequalities are developed based on literature review in context of Kathmandu. The indicators are proposed on environmental state, exposure and health on three domains: Air pollution, noise pollution and water pollution. Rationale and descriptions for indicators is presented in Annex 9.1.

5.2.2.1. Domain: Air pollution

Comparatively lots of studies have been done in air pollution and human health than other environmental issues in Nepal. Gurung and Bell (2013) identified 89 studies on air pollution, of which, 23 linked air pollution to health impacts and few studies focused on indoor air pollution in rural areas during cooking. The studies show that transport and industries are major source of air pollution (Asian Development Bank & CIA-Asia, 2006; C. Gautam, 2006; R. M. Shrestha & Malla, 1996) roadside air pollution is very high, especially due to high emission vehicles of all types, and resuspension of street dust and litter (Shah & Nagpal, 1997). According to C. Gautam (2006), vehicular emissions are responsible for 38% of the total PM10 emitted in Kathmandu valley whereas resuspended dust accounts for 25% and brick kilns 11%. However, according to emission inventory by ICIMOD in Rapid Urban Assessment (RAU) of air quality for Kathmandu (B. B. Pradhan et al., 2012), transport comprises of 69% of total emission as calculated whereas combustion in sectors like residential, commercial and forestry was responsible for 24% of total emission. Industrial emission is considered negligible in case of Kathmandu.

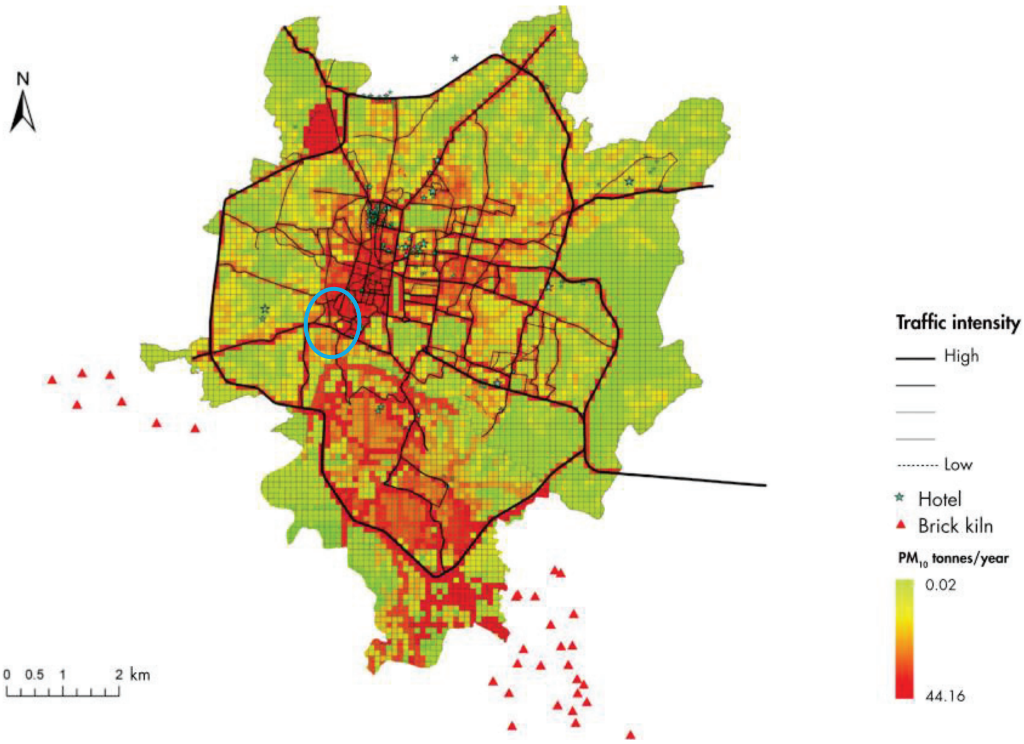


Figure 10: Map of PM10 emission in Kathmandu (tonnes/year/grid)

Source: B. B. Pradhan et al. (2012)

The report provides a detailed account of the pollution hotspot areas in Kathmandu, which is the first study done using quantitative data to get an overall picture of the major pollutants. Figure 10 shows the annual average map of PM_{10} emission in Kathmandu and Lalitpur based on emission inventory database. Due to the limited numbers of air quality monitoring stations installed by MoSTE and even not all of them functioning well, the RAU for Kathmandu can be used as the basis for air pollution data.

As air pollution is considered as the major environmental problem of Kathmandu, the indicators to measure the state of environment, exposure and its effects is important. The indicators should show inequalities between geographies or class or sub-population which is necessary for proper action to reduce its effects.

When we consider air quality, odour is also one of the most common concerns. There are many different sources of odour like smell due to accumulation of garbage, improper sewerage system, chemicals from manufacturing industries or gases etc. It is more dependent on perception of people. However, if unpleasant odours in environment frequently bother a person, it can worsen their quality of life (Oregon Health Authority, 2013). Though there are lots of complain on solid waste management, issue of bad odour has never been raised. However, not everyone in KMC is exposed to it. Therefore, exposure to bad smell has been included in proposed environmental exposure indicators.

State: Initially six monitoring stations are installed in various locations in 2002 to monitor PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO and Benzene. However, not all stations are currently working, and those working are monitoring PM_{10} only. WHO considers air pollutants as particulate matter, ozone, nitrogen dioxide and sulphur dioxide as common air pollutants. B. B. Pradhan et al. (2012) calculated total emission from human activities from all uses is 196 tonnes per year of which more than half were particulate matter PM_{10} and $PM_{2.5}$; CO is second higher major pollutant contributing 32% in total emission.

Exposure: Though studies are done on state of air pollution, the population exposed to pollution has not been studied yet. Gurung and Bell (2013) indicated the need for studies to understand intra-urban variation of traffic-related exposure in urban areas of Kathmandu Valley. Comparing proportion of population exposed to air pollutants can show inequalities between different areas or group of people.

Effects:

Respiratory Illness

Relation between outdoor air pollution and health in Kathmandu has been studied based on hospital admission data. Health burden was observed for daily PM10 based on hospital admission for acute respiratory illness for children (Saraf, 2005) and respiratory illnesses for all admitted patients (S. L. Shrestha, 2007). Asian Development Bank and CIA-Asia (2006) provides summary of health impact studies conducted (12 studies) in Nepal from year 1984 to 2005 which suggests adverse health outcomes from exposure to air pollution, mainly acute respiratory illness (ARI), premature mortality, COPD. Health effects of air pollutants has been also documented in Saraf (2005). Therefore, morbidity and mortality due to respiratory illness among children, adults and elderly can be measured separately to find out inequalities between certain group of people or in certain locality. Experts interviewed too suggested that illness like asthma and acute respiratory infection can demonstrate the effect of air pollution.

External Effects

In addition to respiratory illness, few studies had tried to find other effects due to exposure to polluted air, which includes eye problem, fever, and skin problems (CIWIN, 1997) in child labours working as conductor in three wheelers public vehicle (Tempo) in Kathmandu. Similarly, Shakya (2001) studied health problems in traffic police due to vehicular air pollution reported impacts on nervous system like dizziness, depression, irritation as well as impacts on eye along with respiratory illness. similarly, bad odour in environment also have health effects like breathing difficulties, eye irritation, dizziness and headaches, increased blood pressure and psychological (mood change, behavioural change) (Florida Health Lee County, 2013), however studies have not been done in Nepal.

Table 7: Indicators related to air pollution

Domain	Indicator	Measurement	DPSEEA
Air Pollution	Outdoor Air Pollution	Mean annual concentration of PM10, PM2.5, TSP, SO2, NO2, O3 etc.in outdoor air in urban	State

		areas	
		% of population exposed to air pollutant above the standard	Exposure
	Indoor Air pollution	% of household using coal, wood or kerosene as main source of cooking fuel	Exposure
	Respiratory Illness	Incidence of morbidity due to respiratory infections in children under 5 yrs of age	Effect
		Incidence of morbidity due to respiratory infections in elderly above 60 yrs	
		Incidence of morbidity due to respiratory infections in all age group	
	Respiratory Illness	Annual mortality rate due to acute respiratory infection	Effect
	Allergy	Incidence of allergic effects in skin, eye	Effect

5.2.2.2. Domain: Noise Pollution

Comparatively very less study had been done in noise pollution. However, frequent news and reporting on newspaper (Gorkhapatra, 2013; The Kathmandu Post, 2012) about it say that it has become a tough challenge for human health in Nepal. Major sources of noise in Kathmandu are vehicles, construction activities, social gatherings, noise from workshops and industries etc. D. R. Gautam (2000) surveyed noise pollution with 30 monitoring stations covering residential, commercial, busy traffic and industrial areas of KMC in 1999. The highest range is 80-115 decibels and lowest noise level recorded was 60-75 decibel in peak hours. The people engaged in commercial activities in high traffic area have to bear 60-115 decibels of noise and the road side areas are mostly affected by noise pollution.

State: Noise level at different points including residential, institutional, commercial, educational and industrial areas in day and night should be measured.

Noise Exposure: Population exposed to noise level higher than standard should be measured to check whether some neighbourhoods or specific groups of people are suffering more. Although people seem to adjust by ignoring it, the transmission of signals through ear to nervous system stimulates reactions in human bodies (Ouis, 2001). However, some controversies are seen regarding the outcomes of investigations that states the subjects may react differently to similar noise situations due to subjective factors in the perception of noisy environment. Therefore, it is also worthwhile to consider subjective indicator in addition to objective indicator.

Noise Effects: The first and direct reactions to noise pollution is in terms of annoyance and continuous exposure that leads to suffering from various kinds of discomfort reducing the well-being (Ouis, 2001). WHO (2011a) provides evidences on the relationship between environmental noise and specific health effects including cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus and annoyance. To measure sleep disturbance and noise induced annoyance in large sample, WHO suggests using self-reporting studies using survey questionnaires at the population level. Other effects like tinnitus, hearing loss and hypertension can be measured as effect of noise.

Table 8: Indicators related to noise pollution

Domain	Indicator	Measurement	DPSEEA
Noise pollution	Noise Level	Noise level in residential zone	State
		Noise level in commercial and industrial zone	State

		% of people exposed to noise level higher than standard	Exposure
		% of people reporting non-tolerable noise	Exposure
	Noise Effect	% of people reported annoyance due to noise	Effect
		% of people with illness like tinnitus, hearing loss, hypertension	Effect

5.2.2.3. Domain: Water Pollution

With increase in population and development, the pressure in water resources is increasing. In most of the areas, water is supplied only once or twice a week for limited period of time. Frequent reports show poor water quality, particularly faecal and bacterial contamination, including piped water supply in Kathmandu Valley (JICA & ENPHO, 2005). Due to insufficient water supply, people largely depend upon ground water sources like dug wells, shallow tube wells etc. Study conducted by JICA and ENPHO (2005) found high bacterial contamination specially in shallow dug wells. It is found that the values of selected chemical parameters are within WHO guideline but there are bacteriological contamination either at source or at the points of consumption (B. Pradhan, Gruendlinger, Fuerhapper, Pradhan, & Pradhanang, 2005). Major causes that pollute the water in KMC are sewerage, industrial effluents, agricultural residues, pesticides etc. (D. R. Gautam, 2000).

State: State of contamination level in water used by people for drinking in terms of chemical parameters, bacterial contamination should be measured for monitoring access to safe drinking water which can be related with inequalities in health outcomes.

Exposure: Proportion of households with municipal water supply in their home as well as other sources of water in addition to pipe water would give better measure to assess the relationship between access to safe water and health outcomes. Additional water sources such as jar water, private tankers also have extra financial burden for people (Upaadhyaya, 2006, p. 124) as well as they are exposed to the risk of contaminated water.

Effects: Diseases related to contamination of drinking water is a major burden on human health (WHO, 2011b). Contact with microbial contaminated water is one of the risk factor for a number of diseases such as viral hepatitis, gastroenteritis etc. (Tammy Hambling & Slaney, 2007). Those at greatest risk of waterborne disease are infants and young children, people who are debilitated or living under unsanitary conditions and the elderly (WHO, 2011b). Diarrhoea is one of the most common gastrointestinal infections. According to Nepal LSS III (CBS, 2011a), diarrhoea makes up for 16% of all acute illness in Nepal and 19% in urban areas of Kathmandu Valley which is higher than average value for all Nepal. Diarrhoea morbidity and mortality can be good indicator to demonstrate health inequalities. Similarly, outbreak of other waterborne disease like typhoid, jaundice etc.in a certain time frame can be assessed.

Table 9: Indicators related to water pollution

Domain	Indicator	Measurement	DPSEEA
Water Pollution	Water Quality	Quality of drinking water	State/Exposure
	Access to pipe water	Percentage of household with access to pipe or tap water in their home	Exposure
	Water quality/supply	Percentage of household using other source than pipe water for drinking	Exposure
	Diarrhoea morbidity	Incidence rate of diarrhoea morbidity in children under five years of age and adults	Effect

		Diarrhoea mortality rate in children under five years of age and adults	Effect
	Waterborne disease	Incidence of outbreak of waterborne disease	Effect

5.3. Subset of Indicators for Household Survey

For case study in context of Kathmandu, primary survey had to be done. Therefore, from the indicators above, the subset of indicators was selected. The measurement methods used in household survey are given in Table 10.

Table 10: Selected indicators for socio-economic context

	Indicator	Measurement	Rationale
Socio-economic context	Household Income	Range of monthly household income in NRs. 1. Less than 13000 2. 13000-30000 3. 30000-60000 4. Above 60000	In KMC, average family size is 3.83 according to (CBS, 2012a). Assuming number of members in a family as 4, and maintaining poverty line of yearly consumption of NRs. 40933 per person, NRs. 13000/month per household is taken as the first break line in the study
	Education	Highest level of education attained by household members 1. Masters 2. Bachelors 3. Intermidiate 4. High school 5. Can read and write 6. Illiterate	Health behaviour is changed with increasing education level of member of the family. So, the highest education level attained by member of the family is chosen as an indicator in this study.
	Occupation	Occupation of household head/major source of income 1. Business/Services 2. Daily wage/others	Occupation is closely related with social status and is a proxy for income indicator.
	Vehicle ownership	Numbers of bike owned, car owned	Vehicle ownership shows ability to maintain certain level of living standard. In combination with income, evaluation of such asset can be used for differentiating socio-economic condition
	House ownership	Status of house ownership: owned or rented	Ownership of house can show stability of household and ensures less financial burden for paying monthly rent
	Age group	Age group of household members	Children and elderly are consider as dependent population and they are more vulnerable to adverse health effects as well. More members in working age (15-59) can be related with economic stability of a household.

The indicators selected for environment exposure and health effects are shown in Table 11. Rationale and other description for selected indicators as well as other indicators are shown in Annex 9.1. Questionnaire for household survey is shown in Annex 9.3.

Table 11: Selected indicators for environment exposure and health effects

Domain	**Indicator**	**Measurement**
Air Pollution	Indoor Air pollution	% of household using coal, wood or kerosene as main source of cooking fuel
	Respiratory Illness	Incidence of morbidity due to respiratory infections
	Allergy	Incidence of allergic effects in skin, eye
Noise Pollution	Noise	Major source of noise
	Noise Effect	% of household reported annoyance/headache due to noise
		% of household reported illness like tinnitus, hearing loss, hypertension
Water Pollution	Water Quality	Perceived Quality of drinking water
	Access to pipe water	Percentage of household with access to pipe or tap water in their home
	Water quality/supply	Percentage of household using other source than pipe water for drinking
	Waterborne morbidity	Incidence rate of morbidity due to waterborne disease

6. RESULTS

This chapter presents results of case study using household survey. Socio-economic context is presented initially. The analysis of inequalities is done in different levels of study. First- assessing inequalities between Neighbourhoods, Second- assessing inequalities within neighbourhood and finally assessing inequalities between different socio-economic classes in terms of environmental exposure and health effects across the study areas to find out if there is any condition of injustice.

6.1. Socio-economic context

6.1.1. Household characteristics of sampled households

The primary household survey was done in 408 sampled households about the socio-economic condition, perception on environment and morbidity related to environment. General characteristics of households were explored before running other analysis. The number of male respondents was slightly higher than female. Majority of household were composed of 3 to 6 members with average household size of 4.95. Among the respondents 82% of households are in owned house whereas only 18% of household are rented. However, almost 57% of household have rented rooms to others in their house. Household monthly income was classified into four ranges starting from less than NRs 13000 to above NRs 60000 per month. Household income NRs. 13000 per month can be considered as poverty line in Kathmandu (discussed in section 0). 59% of respondent have household income ranging from 13000 to 30000 (Figure 11). Lowest and highest range of income is only around 6% in sampled data. Motorbike, which has been common mode of transport in Kathmandu at present, is owned by 76% of households whereas only 10% owned car. 10% of people are illiterate (average illiteracy rate for 3 wards is 10.14 as given in CBS, 2012). Most of the households have inhabited for more than 10 years in same place. Regarding highest education level attained by members of the household, half of the sampled households had member with bachelor degree (Figure 12). Households with member having no formal education, but can read and write account only 6% and households with all illiterate members is negligible.

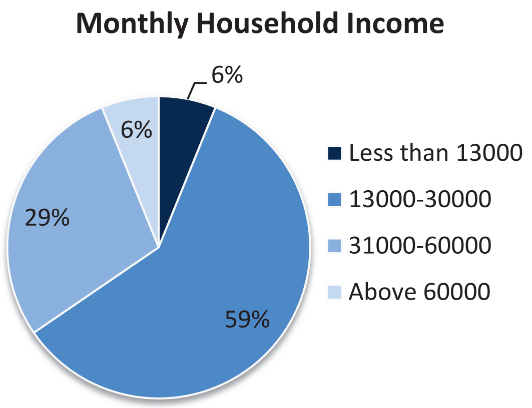


Figure 11: Distribution of Household Income range in sampled data

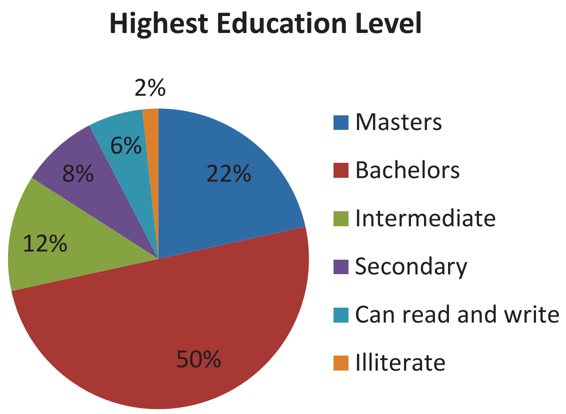


Figure 12: Household with highest education level

6.1.2. Socio-economic characteristics of Neighbourhood

Socio-economic characteristics of Neighbourhoods with respect to collected data are explored with respect to income groups, house ownership, occupation, education and vehicle ownership. The general physical characteristics of the area are also presented.

Neighbourhood 1 (N1)

N1 lies in ward no. 14, which is a housing project by government named as Kuleshwor Housing Project in late 1970s as a “site and services project” to house government service holders. It covers 26.5 ha of land with 842 number of plots provided with access road, water, drainage and electricity. The majority of people are upper middle and high income group. Higher numbers of households are staying in owned houses. Average household size is 5.02. Since, this area is mostly occupied by government employees at its establishment, lots of them are retired by now, but still the counts for higher education is greater than any other selected neighbourhoods. The car ownership, one of the proxy indicators for income is also highest in this neighbourhood.

Neighbourhood 2 (N2)

It lies in ward no. 14. This neighbourhood is along one of the busiest road. It is mostly occupied by middle income group, where 32% of household are in rent. The car ownership is around 14% of the total household surveyed. The area is characterised by mostly literate people, less elderly population (8.14%) and around 14% of household with low wage occupation.

Neighbourhood 3 (N3)

It lies in ward no. 13. The area is mostly residential and commercial mixed. Majority of households are of middle income group, yet there is significant number of households in upper middle and high income group. In contrast to other neighbourhoods with same income structure, car ownership is lower (6.2%). Around 12% of households are in rent. As the houses are still occupied by local people, 12% of total population are elderly. Mostly literate population with higher percent of households with higher education is found in this neighbourhood.

Neighbourhood 4 (N4)

It lies in ward no. 13. The vegetable market being the main commercial activity of the neighbourhood and due intersection of two major roads, the place is mostly congested with heavy traffic. The area is occupied by middle income group; yet, significant numbers of low income as well as upper middle income are also present. However, there is absence of higher income households and households owning car among the surveyed population. This neighbourhood has lowest percent of elderly among selected neighbourhoods and almost 31% of household are rented that indicates the majority is migrated population of working age. Similarly, percent of households with higher education is also least in this neighbourhood.

Neighbourhood 5 (N5)

Neighbourhood 5, located in ward no. 12 is still in the setting of old traditional town with clay mortar buildings with courtyards and public squares. The compact settlement is inhabited by indigenous people. This neighbourhood has highest percent of elderly among selected neighbourhoods. It is mainly characterised by middle income group and mainly depends on small retail shops as business. Majority of illiterate people and people without formal education seems in middle aged and elderly people while new generations seems enrolled in educational institutes.

Neighbourhood 6 (N6)

Neighbourhood 6 also lies in ward no. 12 but in contrast to N5, it is a low density settlement comprising of mixed groups of people who are migrated from core area and a few from outside the Kathmandu Valley. However, more than 75% of households have inhabited for more than 10 years. Majority of households fall in low and middle income group but car ownership is quite high compared to other neighbourhoods with similar income group. Mixed land use with shops and workshops are seen significantly in this area. 20% of households are in rent. Waste transfer station of KMC is situated in this neighbourhood. In terms of occupation, in addition to most frequent occupation business and services, labour, driver, people working in workshops are also found higher in N6.

6.1.3. Socio-economic clusters

Due to the heterogeneous nature of the neighbourhoods in terms of socio-economic characteristics except some with distinct character like N1, it is necessary for further analysis to categorize the households to homogenous classes. In general, households with high income and high education with high asset value can be classified into higher socio-economic class. Although majority of households have medium income range, mostly education, occupation and assets make difference in their socio-economic conditions. Low socio-economic class are mainly characterized by low education level, low wage service occupation etc. in addition to medium or low household income.

To assign each household a socio-economic class, clusters were created using a number of socio-economic indicators in two step cluster analysis. Table 12 shows indicators used and the characteristics of output clusters. Household income is most important predictor for formation of cluster followed by highest education attained by members in the households, occupation and car ownership and bike ownership. The characteristic of each cluster are described below:

Table 12: Characteristics of clusters

		Cluster characteristics (%)		
Indicators	**Overall frequency %**	**HSEC (C2)** N=144 (35.3%)	**MSEC (C1)** N=144(35.3%)	**LSEC (C3)** N=120 (29.4%)
Range of monthly household income				
Less than 13000	6.1	3.5	0	16.7
13000-30000	59.3	0	100	81.7
30000-60000	28.4	79.2	0	1.7
Above 60000	6.1	17.4	0	0
Highest Education Level				
Masters	21.6	34	27.1	0
Bachelors	50	56.3	72.9	15
Intermediate	12.5	4.9	0	36.7
High School	8.3	4.9	0	22.5
Can read and write	5.9	0	0	20
Illiterate	1.7	0	0	5.8
Occupation				
Business/services	86.3	100	100	53.3
Daily wage/others	13.7	0	0	46.7
Car ownership				
Yes	91.2	25	0	0
No	8.8	75	100	100
	Overall mean		**Cluster Mean**	
Number of Motorbikes/household	0.99	1.24	0.97	0.71

[Note: HESC= Higher socio-economic class; MSEC= Middle socio-economic class; LSEC= Low socio-economic class; N=number of households]

Cluster C2 is composed of 35.3% of total sample households. Almost all higher household income range i.e. 30-60000 and 60000 above fall in this cluster (Figure 13). Out of 8.8% households with car in total sample, all are included into this cluster. Highest education level attained by family members is mostly bachelor degree however households with master degree is also high with less households below bachelor degree. All households have business or services as major occupation. The average number of motorbikes owned is also highest in this cluster. Thus, this cluster having income, better education, high asset value is considered as higher socio-economic class (HSEC).

Cluster C1 with all households in income range 13000-30000 accounts for 35.3% of total sample. Majority of households have Bachelor's degree as highest education level. However, more than one third of households have Master's degree. All households have major occupation business or services. Average number of bike owned is 0.97 with no car ownership. Thus, this cluster has been considered as Medium socio-economic class (MSEC) with medium range of household income but mostly educated.

Cluster C3 is composed of 29.4% of total sample households which consists of mainly households with household income range 13000-30000 and few households with income less than 13000 (Figure 13). Almost all households with highest education level below bachelor degree falls in this cluster. Master's degree as highest education level attained is nil and only 15% of households have at least one member with bachelor degree. Although majority of households have major occupation as business or service, all households with major occupation with daily wage services are grouped into this cluster. The average number of bike owned is the lowest and no household owns a car. Thus, this cluster having mostly middle income, but low education level and less asset value is considered as lower socio-economic class (LSEC).

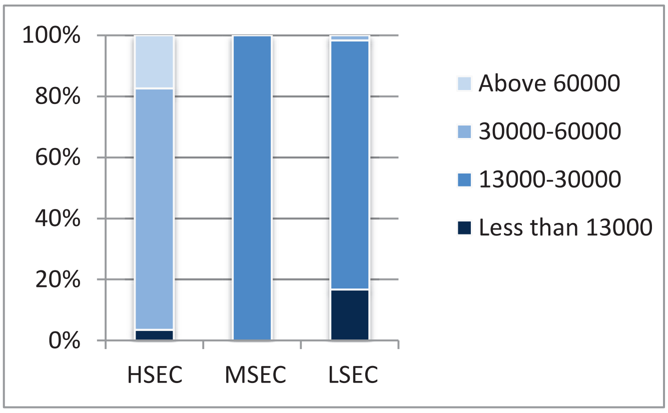


Figure 13: Household income range distribution across socio-economic classes

Three socio-economic classes are analysed in terms of age group. MSEC consists of highest 78% of population of working age (16-60) and lowest dependent population (age below 15 and above 60 years). HSEC consists of highest percent of elderly compared to rest whereas LSEC consists of higher % of population below 15 years (Figure 14). Higher the percent of dependent population, higher is poverty according to Nepal Living Standard Survey (CBS, 2011a) and it seems appropriate in case of LSEC and MSEC. However, proportion of elderly is also related with place of origin as migrated population is mostly working age, migrated for better working opportunities and better education for themselves and their children, leaving old age population in rural areas. In addition, it can also be related with stable income of households required for maintaining good health condition.

Regarding house ownership, higher percent of households in LSEC are staying in rent (Figure 15) and it decreases step by step with MSEC and HSEC, with only 7% household in rent in HSEC.

Figure 16 and Figure 17 show distribution of classified households in the neighbourhoods. N1 comprises of highest number of households with HSEC. N4 contains highest number of households of LSEC, whereas N3 has highest number of households of MSEC. N2 and N3 has almost similar composition with highest MSEC, followed by HSEC and LSEC. N5 and N6 are largely composed of MSEC and LSEC, almost with equal numbers of households.

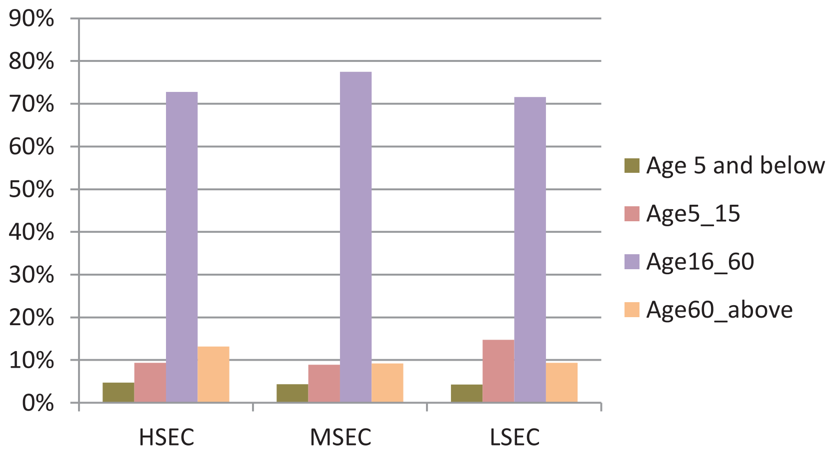


Figure 14: Age distribution among socio-economic classes

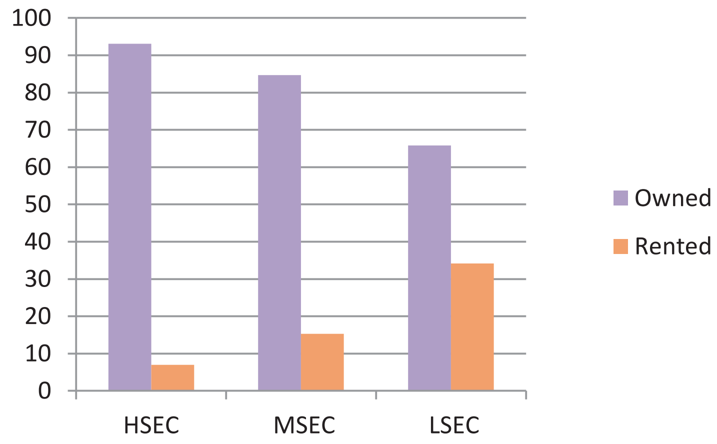


Figure 15: Ownership of house among socio-economic classes

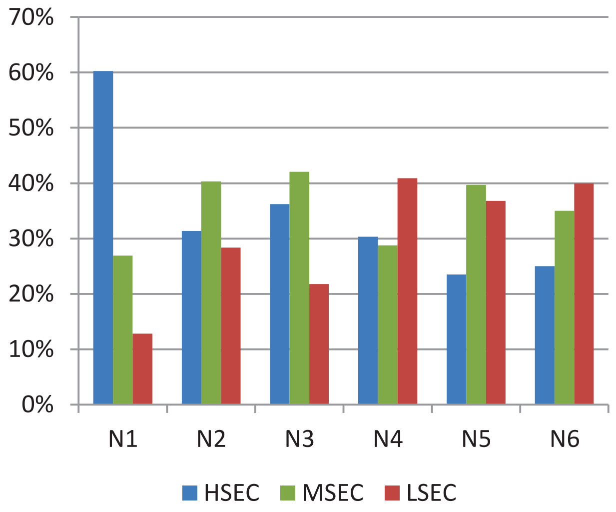


Figure 16: Distribution of different socio-economic class in neighbourhoods

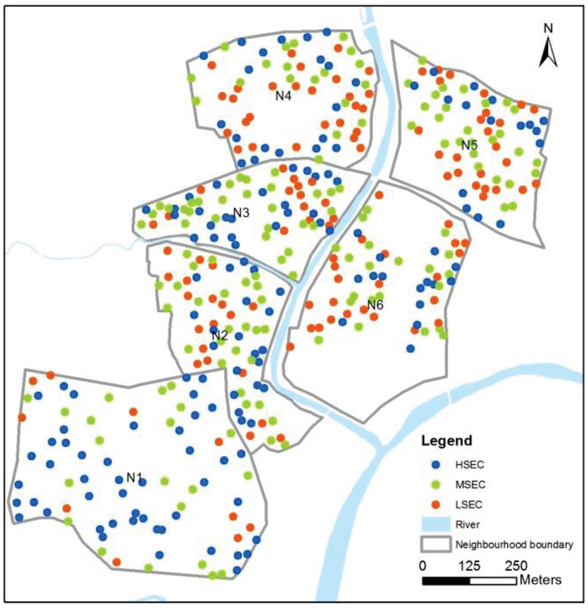


Figure 17: Map showing distribution of Socio-economic classes of households in different neighbourhood

6.2. Assessing Inequalities between Neighbourhoods

The selected neighbourhoods are checked in terms of exposure to environment and health effects if there are any inequalities. Socio-economic context of neighbourhoods shows they are heterogeneous. Major concern is to determine if any neighbourhood is higher burden of environment externalities in terms of exposure or if any of them are having more effect even with the similar level of exposure compared to other neighbourhoods. Environment exposure data like air quality monitoring data, noise level data, water quality and supply etc. are not available at disaggregated level (not even in ward level). Therefore, subjective indicators are used for environment exposure like perceived bad odour, major source of air pollution, water source etc. from the household survey.

6.2.1. Environmental Exposure

Perceived bad smell by households in neighbourhoods and the average amount of air pollutants emitted is compared between 6 neighbourhoods in this section.

Bad smell

In case of Kathmandu, generally unmanaged garbage is the main source of bad odour. Other source is river; all the rivers are polluted due to mixing of sewer line without treatment. So, the areas close to river have bad smell especially in dry season when water level is low. In addition, vehicle emission is also a source of odour.

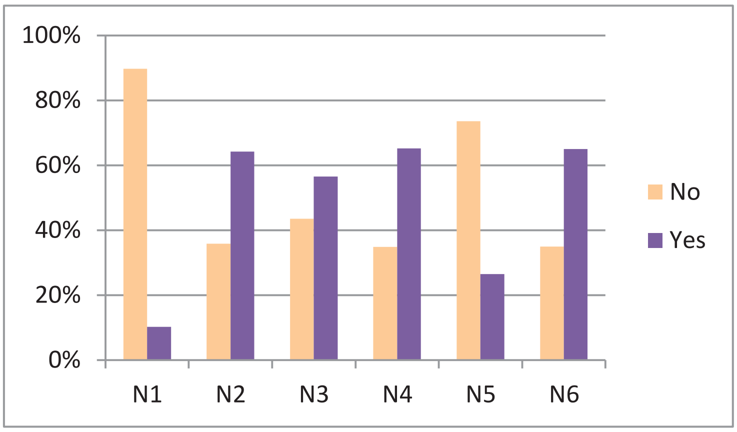


Figure 18: Perception of bad odour in environment in different neighbourhoods

Households in neighbourhoods were asked if they perceive bad smell in air, time and frequency of smell. In N1, lowest percent of people complaint about bad smell whereas in N2, N4 and N6 about 64-65% of households perceive bad smell and in N3, slightly less (56.5%) households perceived bad smell (Figure 18). Most of the neighbourhoods that lie close to the river perceived bad smell except N1. In addition to the river, in N4 vegetable market produces bad odour due to rotten vegetables and in N6, bad odour from waste transfer station makes air polluted. About 1/4 households in N5 perceived bad smell as main settlement is a bit far from river. In general, it can be said that N2, N3, N4 and N6 are mostly affected by bad odour in environment.

Air pollutants

Data from ICIMOD published on “Rapid Urban Assessment of Air Quality for Kathmandu, Nepal” by B. B. Pradhan et al. (2012) had been studied in the selected neighbourhoods. The units are in ton/year/grid of 100m x 100m based on emission inventory. Box plots in Figure 19 shows distribution of emission grid values of four air pollutants PM_{10}, SO_2, NO_x and CO in sampled neighbourhoods. In terms of emission of all four pollutants, N5 has highest range as well as higher grid values among the neighbourhoods. This high emission values might be due to road on northern side of N5 and high population density which produces more emission according to emission inventory calculation by ICIMOD, however the figures are excessively high, which effects mean value of 6 neighbourhoods.

PM_{10} emission and $PM_{2.5}$ makes more than half of total emission in Kathmandu (B. B. Pradhan et al., 2012). Comparing remaining five neighbourhoods except N5 for PM_{10} emission, N3 and N4 have comparatively higher average values per grid (Table 13) whereas N1 has the lowest value followed by N2. Emission of other pollutants like NO_x and SO_2 and CO is higher in N4 followed by N6. N1 and N2 have lowest average value per grid in terms of these pollutants.

Therefore, in terms of exposure to air pollutants of neighbourhoods referring to total emission, it can be said that N5 is exposed to highest level, whereas N4 and N6 also have higher exposure than other neighbourhoods.

Table 13: Average values of emission of selected pollutants in Neighbourhoods based on emission grid

	PM_{10}	**SO_2**	**NO_x**	**CO**	Total emission
Average (whole sampled area)	**2.48**	**0.56**	**0.84**	**47.23**	
N1	0.98	0.14	0.23	11.96	13.31
N2	1.66	0.20	0.33	16.96	19.15
N3	2.75	0.28	0.53	24.09	27.65
N4	2.51	0.51	0.82	43.55	47.39
N5	6.34	2.02	2.76	167.46	178.58
N6	1.69	0.42	0.64	35.62	38.37

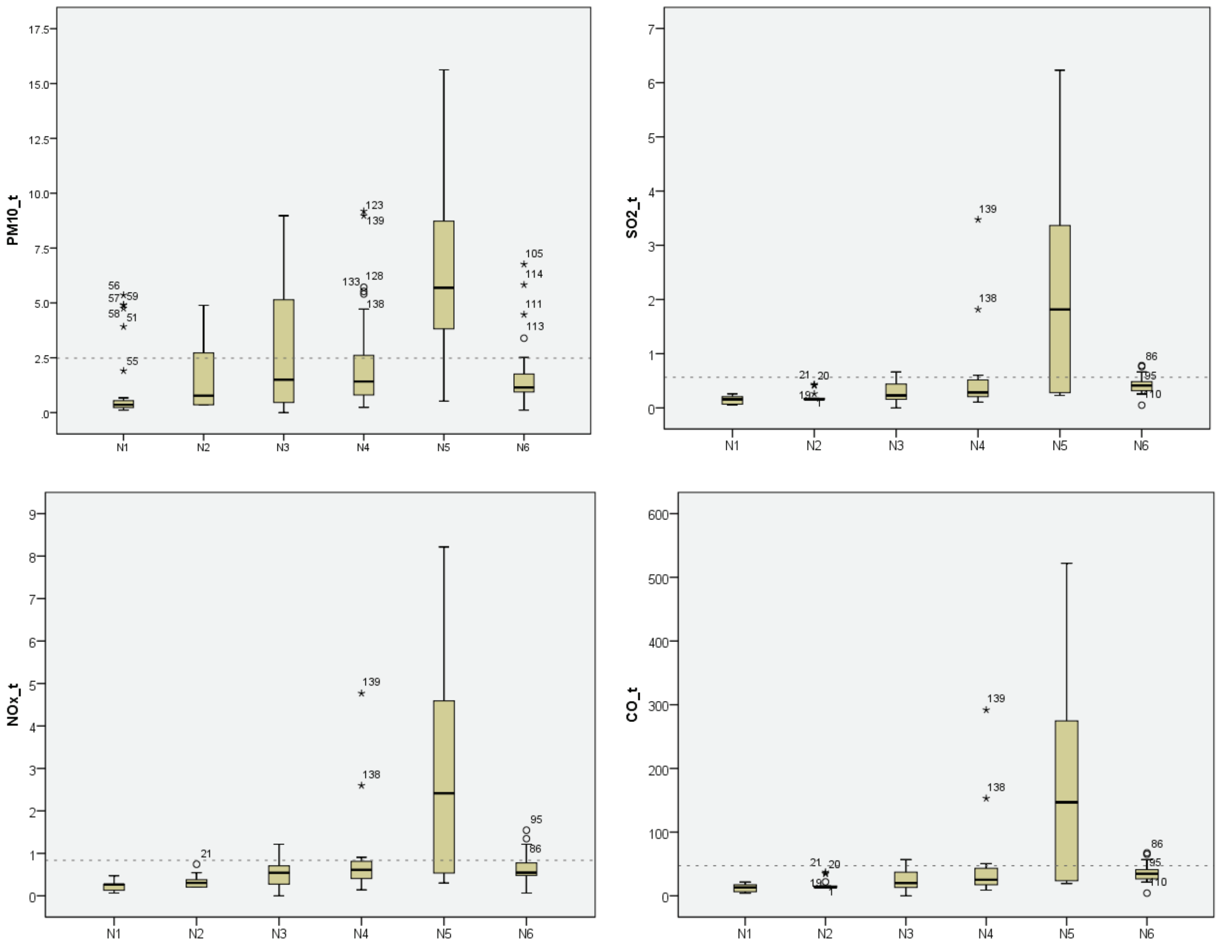


Figure 19: Box plot showing average value of air pollutants in Sampled Neighbourhoods.
Source: B. B. Pradhan et al. (2012), modified by author

6.2.2. Health effects

Morbidity due to waterborne disease was checked by asking if anyone in household has been suffered by fever, diarrhoea, dysentery, jaundice and typhoid in last six months. Households which had reported yes to one or more family member have been considered for as "Yes". Almost 70% of households in N4 reported having at least one of the waterborne disease occurrences in last six months. In all other neighbourhoods, 30-40% of households reported for the same.

In case of respiratory illness too, N4 has highest occurrence, similar to waterborne disease. Respiratory illness is in approximately half of households in N1, N2, N3 and N5 whereas N6 has more than 60% households reporting it (Figure 20).

External effects from polluted air like skin irritation/rashes and eye irritation has been reported apart from other illness. 78% of households in N6 reported that they have at least one of these effects. Bad smell from nearby river and air pollutants from waste transfer station at south west corner might be the main reason for higher allergic effects in N6. N4 again has almost 55% of households with this effect, might also be due to polluted air from high traffic jams in two major intersection nodes as well as bad smell from vegetable market due to vegetable waste.

Regarding effects of noise like headaches and irritation, household reported effects is highest in N3 followed by N4 where almost half of households reported for it. N1 and N2 are least affected with lower percent of household complaining the effects of noise.

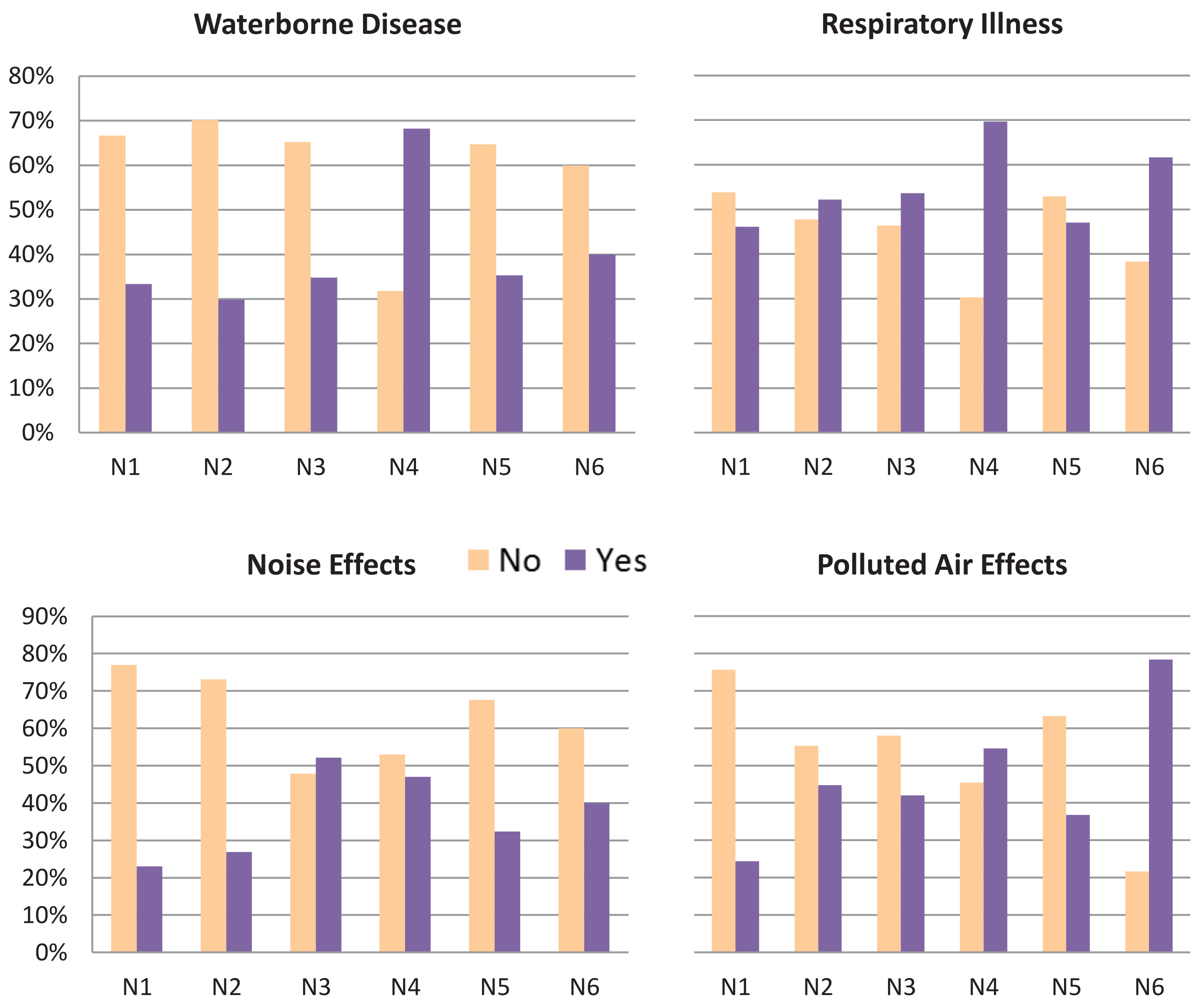


Figure 20: Health effects in Neighbourhoods

In all four effects, households in N1 seems to be almost least affected. In terms of waterborne and respiratory illness, households in N4 are most affected (Table 14), whereas for noise effect N3 and N4 are mostly affected. N6 is mostly affected by polluted air allergy.

Table 14: Summary of health effects in neighbourhoods

	WBD	Res. Illness	Poll. Air Effects	Noise effects
N1	33.3%	46.2%	24.4%	23.1%
N2	29.9%	52.2%	44.8%	26.9%
N3	34.8%	53.6%	42.0%	52.2%
N4	68.2%	69.7%	54.5%	47.0%
N5	35.3%	47.1%	36.8%	32.4%
N6	40.0%	61.7%	78.3%	40.0%

6.3. Assessing Inequalities within Neighbourhoods

From above section it is clear that some neighbourhoods are more exposed to bad environment condition than others, as well as health effects are also varying between the neighbourhoods. Therefore, three neighbourhoods N1, N4 and N6 are selected for further analysis and discussions to check whether certain group of population or certain socio-economic classes are having more burdens. N1 least affected and N4 most affected in almost all health effects. N6 also has higher households complaining health effects after N4. Proportion of socio-economic class was also considered[1]. (Refer Table 21 in Annex for health effect data of all neighbourhoods).

6.3.1. Environmental Exposure

Perceived bad smell and air pollutants had been presented for all neighbourhoods in Section 6.2.1. Least households (10%) in N1 perceived bad smell whereas almost equal (65%) households in N4 and N6 reported it. Regarding air pollutants emission, N1 has lowest average value per grid among three neighbourhoods followed by N6 and N4. N4 has higher values in most of pollutants except NO_x which is higher in N6.

6.3.2. Health Effects

Regarding the occurrence of waterborne disease as reported by households, three neighbourhoods have different patterns between different socio-economic classes. In N1, one third of households reported waterborne diseases. Chi square test between different socio-economic classes and incidence of waterborne disease shows there is no significant relation between them. In case of N6, where 40% of household reported the illness, also does not show any significant association between 3 socio-economic classes and incidence of disease. However, only in N4, the association is significant where LSEC has higher rates of occurrence than MSEC and HSEC ($\chi^2(2)= 6.867$, $p< 0.05$) (Figure 21).

Regarding respiratory illness, N4 and N6 both have almost similar pattern of increment of incidence rate increasing from HSEC to LSEC, however chi square test shows only significant in case of N6 ($\chi^2(2)= 8.204$, $p<0.05$). In case of N1, the pattern is opposite, but the relation is not significant from chi square test.

[1] In N1 more than 60% of the household belong to HSEC whereas N4 is the neighbourhood with the highest % of LSEC household among all neighbourhoods. However N4 has almost equal household in MSEC and HSEC. N6 has composition step by step increase in number of household from HSEC, MSEC to LSEC (Figure 16)

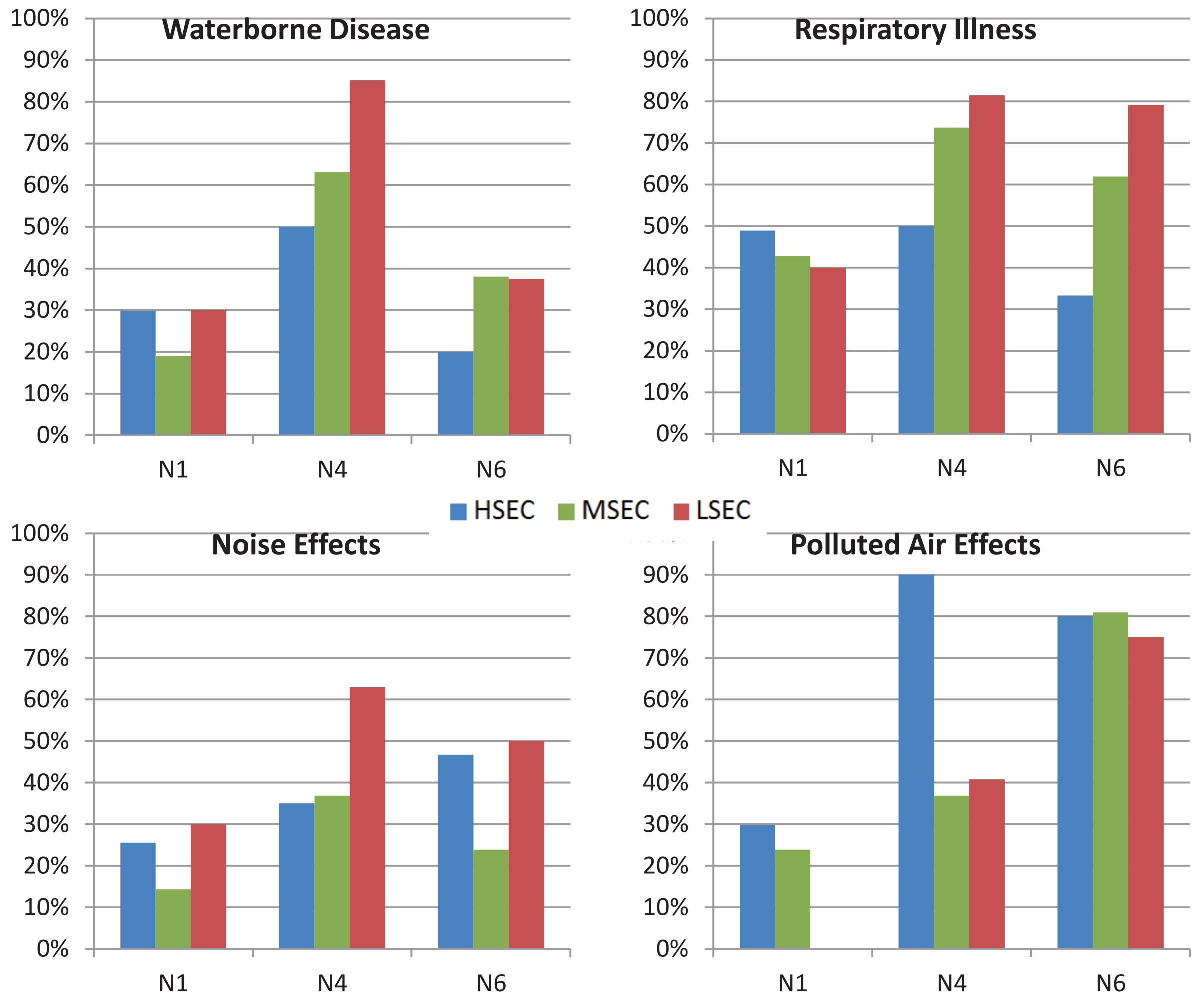


Figure 21: Health effects in different socio-economic clusters within selected neighbourhoods

External effects from polluted air, is reported highest in N6 (more than 78% of households). However, almost equal rate of effect is reported by three socio-economic classes. Hence, chi square test does not show significant relationship between socio-economic class and external effects due to polluted air. In N1, where around 25% of total households reported for polluted air effects, only HSEC and MSEC reported for it; HSEC reported slightly higher than MSEC but chi square test does not show significant relationship. N4 has highest rate of effect reported by HSEC (90%), whereas other two classes has almost equal rate which is less than half of HSEC. Chi square test between socio-economic class and presence or absence of polluted air effect shows a significant relationship in N4 ($\chi^2(2)= 14.617$, $p<0.01$).

In terms of noise effect, none of the neighbourhoods have sample data strong enough to conclude that there is a significant relationship between socio-economic class and households having or not having noise effect, though the trend is mostly LSEC reported higher in all 3 neighbourhoods. MSEC in N1 and N6 has less effect compared to HSEC and LSEC.

6.4. Assessing Inequalities between Socio-economic Classes

Assessment of inequalities between neighbourhoods and within few selected neighbourhoods with respect to different socio-economic groups, inequalities are found in some neighbourhoods. There seems to be association between environmental exposure and health effects with socio-economic classes, though in some cases the data are not sufficient to prove it. Therefore, it's necessary to check with the whole data, if there is any association. The following sections present the results of this analysis using whole data to find out environmental exposure and health inequalities in different socio-economic groups.

6.4.1. Environmental Exposure

Exposure to bad smell

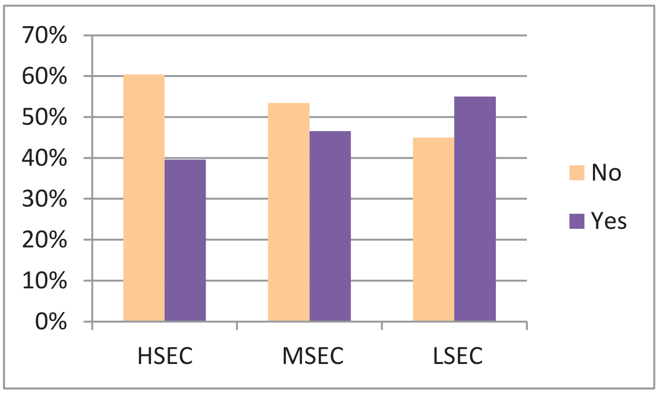


Figure 22: Perception of bad smell by different socio-economic classes

Regarding bad odour in the neighbourhood, 47% of total household surveyed complained of bad odour which is quite high and shows that lots of people are suffering from it. Most households said they suffer from bad odour daily in the morning and evening whereas only 13% feel it seasonal and mostly in dry season. Perception of bad odour by different socio-economic class shows that slightly higher percent of households in LSEC (55%) bother of bad odour in environment than MSEC and HSEC (Figure 22). Chi square test shows significant relationship different socio-economic class and perception of bad smell ($\chi^2(2)=6.252$ $p<0.05$).

Figure 23 shows the position of household in different socio-economic class throughout the study area and the locations of major source of bad odour- river, vegetable market, and waste transfer station. Figure 24 shows the households that perceived bad smell or not. In all neighbourhoods, mostly the households in close proximity to river seem to perceive bad odour. In N4, the households surrounding vegetable market also are suffering from bad smell and they are mostly LSEC households and MSEC households.

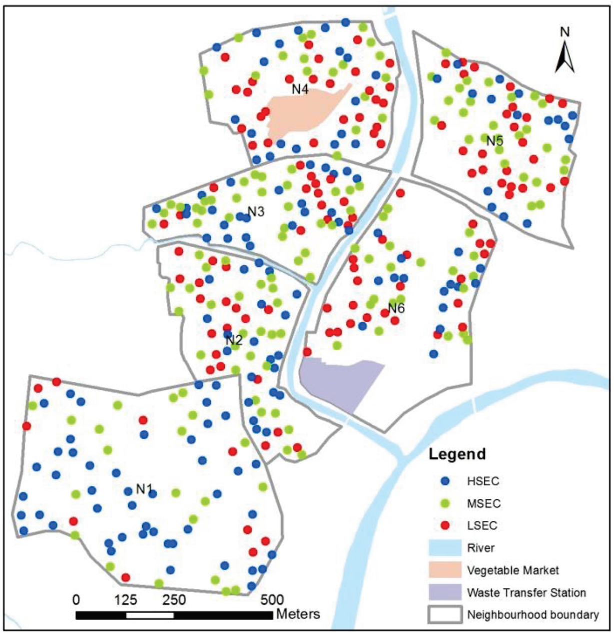


Figure 23: Socio-economic classes with proximity to bad odour sources

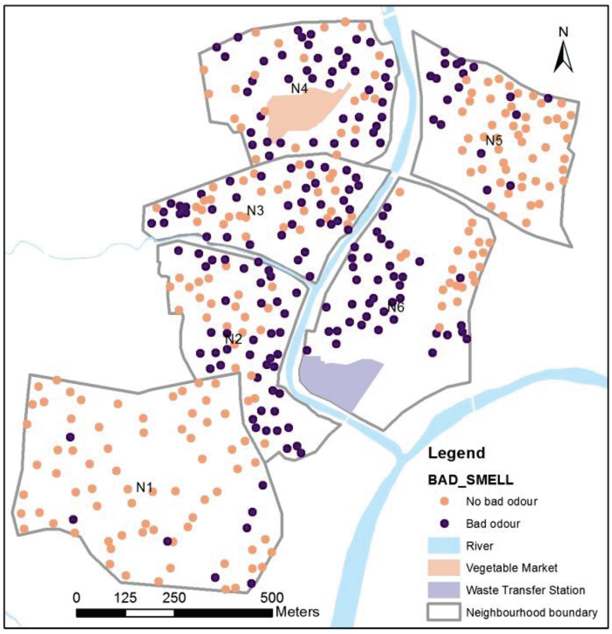


Figure 24: Perception of Bad smell in neighbourhood

Exposure to air pollutants

Average value of pollutants that different socio-economic groups are facing is shown in Table 15, which shows they are almost similar. The level of exposure is not dependent with socio-economic class. Box plots in Figure 25 shows slightly higher median values in LSEC than in MSEC and HSEC. The range is also high in LSEC except for PM_{10}.

As the values are taken from emission grid map which is modelled for 100m x 100m of area, there is not much variation throughout the study area. Few household with higher values are shown as outliers in box plots and most of them are from N5, where the grids in neighbourhood boundary have higher values due to high density settlement and adjoining road towards north. Figure 26 also shows households in three economic classes and PM_{10} emission/year/grid. The highest emission values are along the major roads and throughout the area in N5. However, no specific pattern related to socio-economic class is seen. Therefore, no significant difference is seen in exposure to environment pollutants between socio-economic classes.

Table 15: Average value of environment pollutants exposed

		PM_{10}	SO_2	NO_x	CO
	Mean	2.40	0.519	0.783	43.41
HSEC		2.52	0.469	0.717	38.98
MSEC		2.25	0.496	0.751	41.54
LSEC		2.45	0.607	0.901	50.97

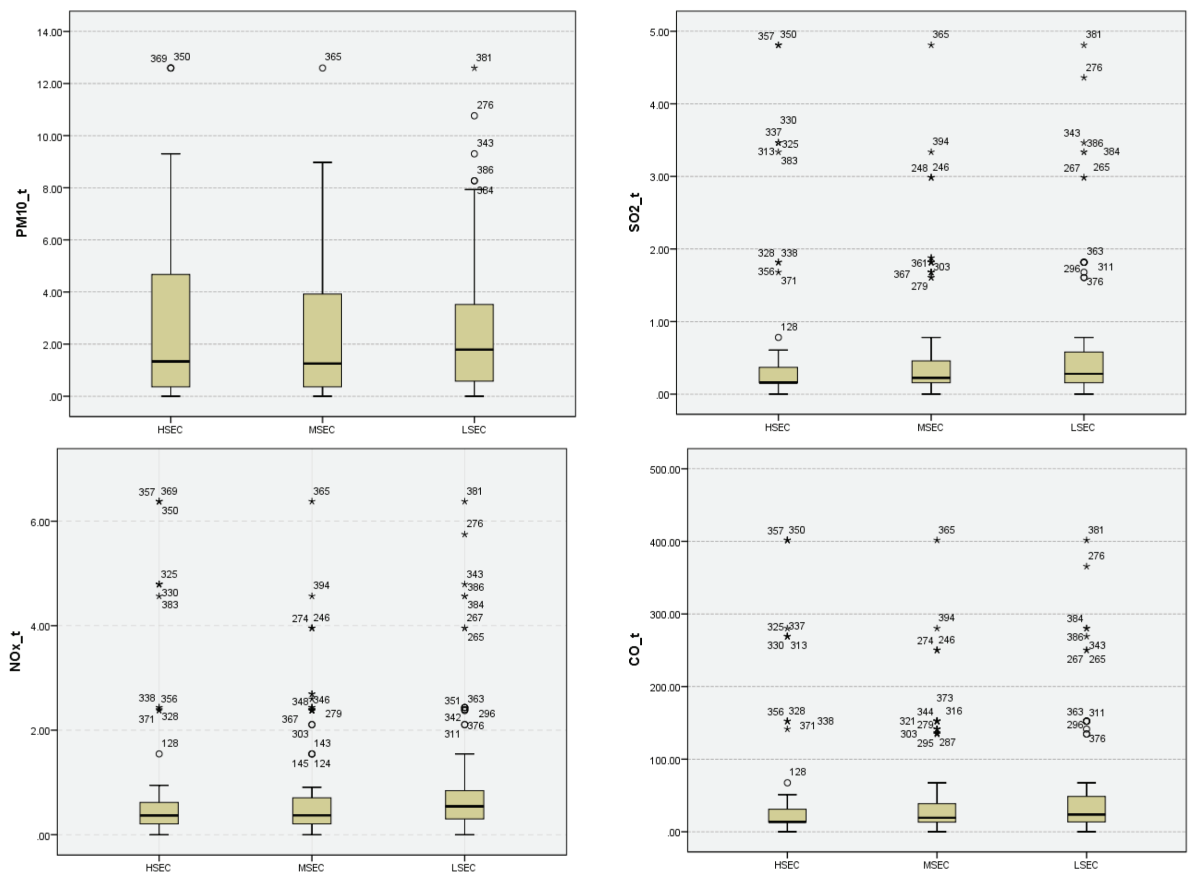


Figure 25: Distribution of average value of PM_{10}, SO_2, NO_x and CO across different socio-economic classes

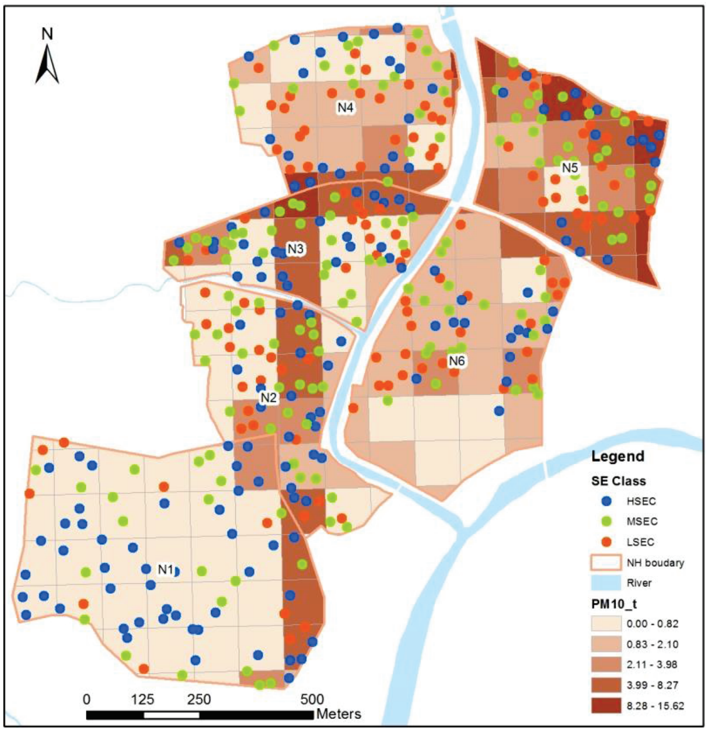


Figure 26: Emission of PM_{10} ton/year/grid and spatial pattern of households in 3 socio-economic classes

Water Quantity and quality

Water supply quality and quantity is one of the major environment concerns in Kathmandu. Although around 95% of total households surveyed had pipe water supply, only 13% of them said that they are sufficient for daily use. Water is supplied only once a week and the quality is also varying that more than 78% of households depend upon other alternative source than pipe water for drinking purpose specially buying jar water and water from private tankers.

There is no significant difference among socio-economic groups in terms of using alternative source of drinking water. Figure 27 shows bar diagram of sources of water used based on responses of households with multiple responses. Other sources include shallow wells, water from public tap in the neighbourhood. Wells are specially used for other household use than drinking purpose. Highest percent of households in LSEC (42%) are using jar water though the figure is not much differing with remaining classes (Figure 27). Tanker water seems to be purchased mostly by MSEC and least by LSEC.

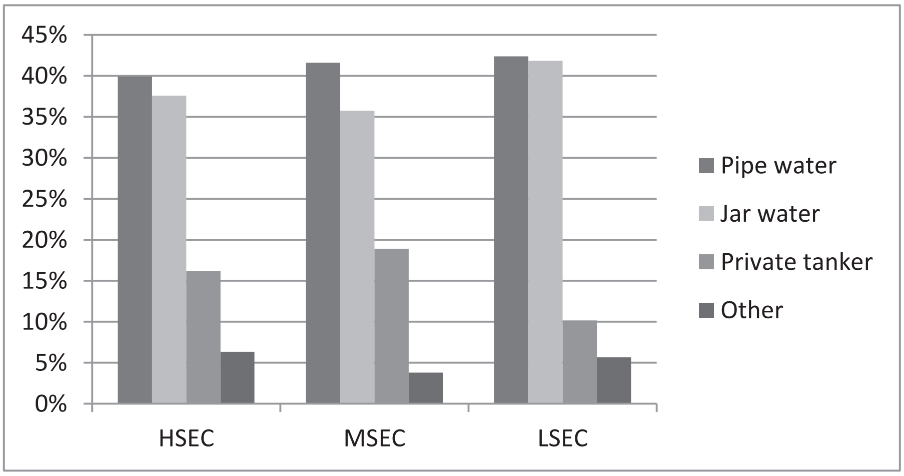


Figure 27: Sources of drinking water used by socio-economic groups

6.4.2. Health Effects

6.4.2.1. Morbidity due to Waterborne Diseases

Around 40% of the total sampled households reported for waterborne disease to one of the household member in last six months. Households in LSEC have reported highest percent of morbidity due to waterborne disease, whereas least percent is reported by households in HSEC (Figure 28). More than 50% of households in LSEC had suffered from at least one of above mentioned disease in the last six months. Chi square test between socio-economic class and reported morbidity shows there is a significant relationship between socio-economic class and morbidity due to waterborne disease ($\chi^2(2)=15.247$, $p<0.001$).

Although more than 30% of MSEC and HSEC also reported waterborne disease, 54% of LSEC household reporting for it can be considered as quite high. In detail, type of diseases that different socio-economic group mentioned can be seen from Table 16. It shows that highest % of total responses were for fever, followed by diarrhoea and least for dysentery. In most of the cases, LSEC seems to have more occurrences of diseases except for dysentery in which all households that reported it fall in MSEC. The difference is higher between LSEC and HSEC.

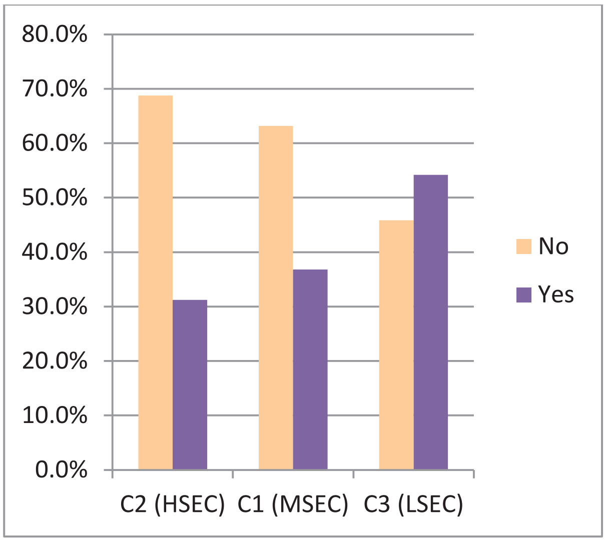


Figure 28: Morbidity due to Water-borne Disease

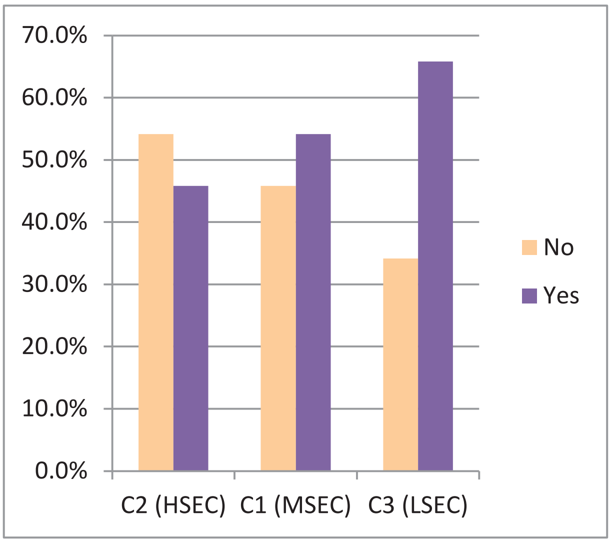


Figure 29: Morbidity due to Respiratory Disease

Table 16: Types of diseases mentioned by different socio-economic groups

	Fever	Diarrhoea	Jaundice	Typhoid	Dysentery	Total
HSEC	27.8%	24.2%	36.4%	27.3%	0.0%	26.9%
MSEC	32.3%	30.3%	18.2%	36.4%	100.0%	33.2%
LSEC	39.8%	45.5%	45.5%	36.4%	0.0%	39.9%
Total responses	(133) 68.9%	(33) 17.1%	(11) 5.7%	(11) 5.7%	(5) 2.6%	100%

6.4.2.2. Morbidity due to Respiratory Diseases

Regarding respiratory diseases, 55% of total households have one or more of its member suffered from one or more of respiratory diseases in last six months. Households in LSEC have reported highest % of morbidity due to respiratory disease (66%), whereas least percent is reported by households in HSEC (46%) (Figure 29). Chi square test between socio-economic class and reported morbidity shows there is a significant relationship between type of socio-economic cluster and morbidity due to respiratory disease (χ^2 $(2)=10.586$, $p<0.01$).

Table 17: Types of respiratory diseases mentioned by different socio-economic groups

	Running Nose/Sneezing	Sore Throat/ tonsillitis	Cough	Asthma	Chest Pain	Total
HSEC	31.4%	36.7%	29.5%	15.6%	23.5%	29.4%
MSEC	34.3%	30.0%	37.5%	43.8%	35.3%	35.8%
LSEC	34.3%	33.3%	33.0%	40.6%	41.2%	34.7%
Total responses	(169) 46.9%	(30) 8.3%	(112) 31.1%	(32) 8.9%	(17) 4.7%	100%

Table 17 shows details on responses for different respiratory diseases by households in different socioeconomic groups based on total responses of a multiple response question set. Out of total responses, 47% was for running nose/sneezing followed by cough, and according to them, these are very normal and they frequently suffer from these diseases. Highest percent of households that reported cough and asthma are in MSEC, whereas for chest pain maximum is from LSEC. Hence, out of total reported respiratory diseases, households MSEC accounts for highest percent followed by LSEC and HSEC, however the difference is very less between MSEC and LSEC.

Comparing Figure 30 and Figure 31, lower socio-economic households mostly seems to have reported respiratory illness; however, proximity to main road also seems as main factor, specially seen in N2. Groups of households situated along the road between N3 and N4 have reported respiratory illness.

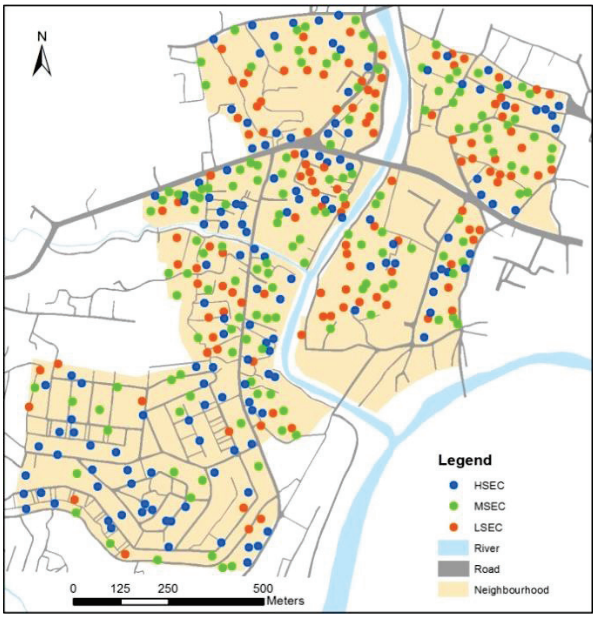


Figure 30: Location of households of three socio-economic classes and road (main source of pollution)

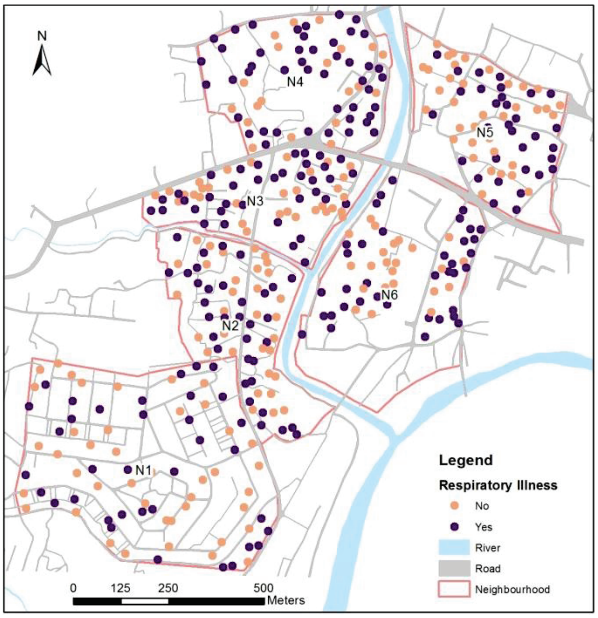


Figure 31: Spatial patterns of household with response to respiratory illness

6.4.2.3. Effects due to Polluted Air

Regarding the responses to the effects due to polluted air like skin irritation or eye irritation, it seems more than half of households in HSEC reported it (Figure 32) whereas MSEC and LSEC have almost similar (around 42%) of household that reported the effects. Chi square test does not show significant relation between external effects of air pollution and socio-economic class. Figure 34 shows spatial distribution of households that reported polluted air effects; more households along the road sides have reported the effect. However in case of N6 most of the households have reported the polluted air effect showing rather than socio-economic class, spatial location of household matters more in resulting polluted air allergy.

6.4.2.4. Effects due to Noise Pollution

Regarding effects due to noise, in total about 64% of households said that they are not affected by noise as they have been used to with noise in their areas (Figure 33). Almost same percent of households in all three socio-economic class reported effects due to noise like irritation and headache; no significant relationship is seen between noise effect and socio-economic status from chi-square test. From Figure 35, it can be seen that, the households nearby main roads are more affected. Therefore, noise effects are more related with proximity of house to major road rather than socio-economic class they belong.

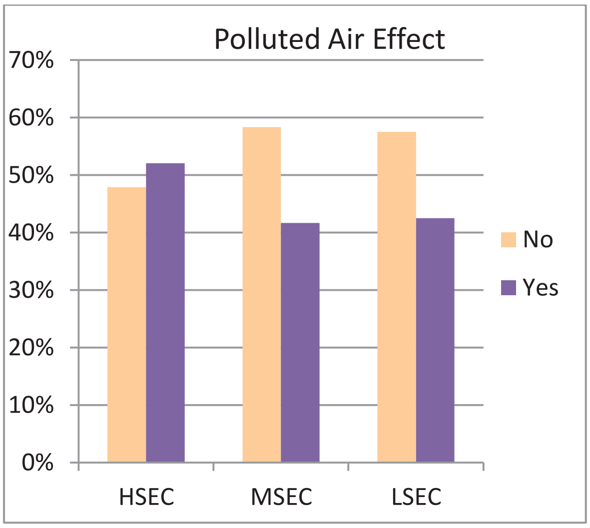


Figure 32: Effects due to polluted Air

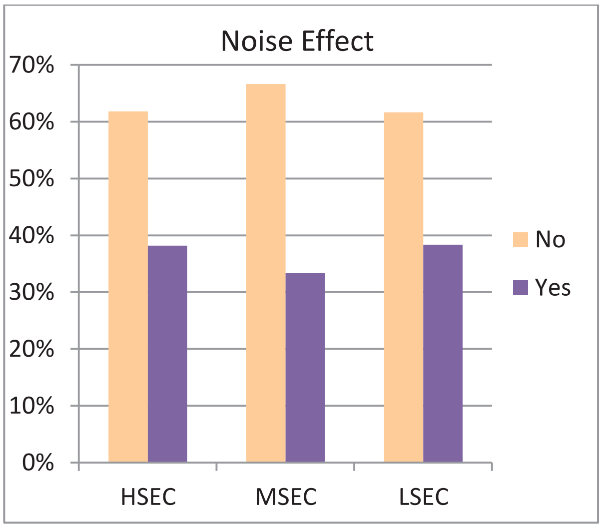


Figure 33: Effects due to noise pollution

Thus, the study on health effects due to environment shows that in general LSEC is having higher effect even with the similar level of exposure to bad environmental conditions. Specifically, clear variation is seen in terms of reported respiratory diseases and waterborne diseases by the households. Regarding external effects due to polluted air and noise irritation, they are more dependent upon sensitivity of a person as well as adaptation. It might be that HSEC are more sensitive towards those allergies than LSEC and MSEC. Due to lack of data on noise level in the study area, noise effects cannot be checked with reference to exposure.

6.5. Multiple Effects

The reported effects are explored to check whether same household is having multiple environment effects for all four effects respiratory diseases, waterborne disease, effects due to excessive noise and allergy due to polluted air. Households having no effect at all are mostly in MSEC. All four effects in the same household are seen highest in LSEC (Figure 36). Households having both respiratory illness and waterborne disease are highest in LSEC followed by MSEC and lowest in HSEC. In contrast, effects due to noise and polluted air both are mostly seen in households with HSEC and lowest in LESC.

Table 18 summarizes the proportion of households in each neighbourhood with and without multiple effects. Out of total households with no effects, N1 has the highest percent and N4 the lowest. Regarding households reporting all four effects, 41% falls in N4. Similarly, having two effects in a household-waterborne disease and respiratory illness too, N4 has highest percent. For both noise and polluted air effects, N4 and N6 have highest percent of household.

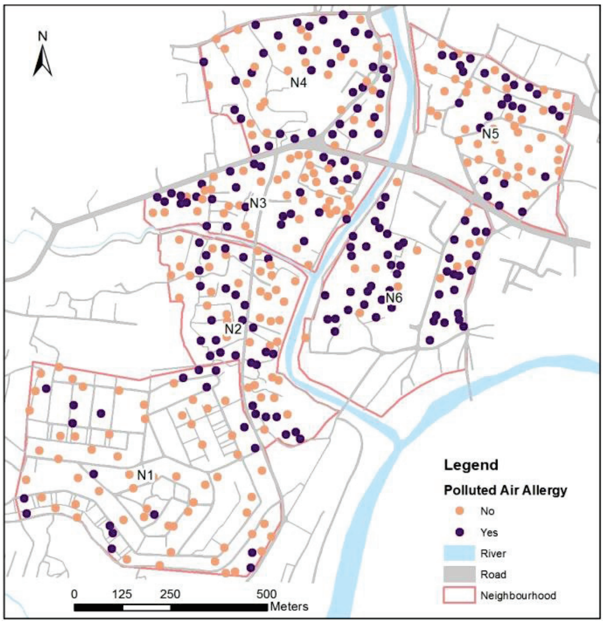


Figure 34: Distribution of houses with reported polluted air effects

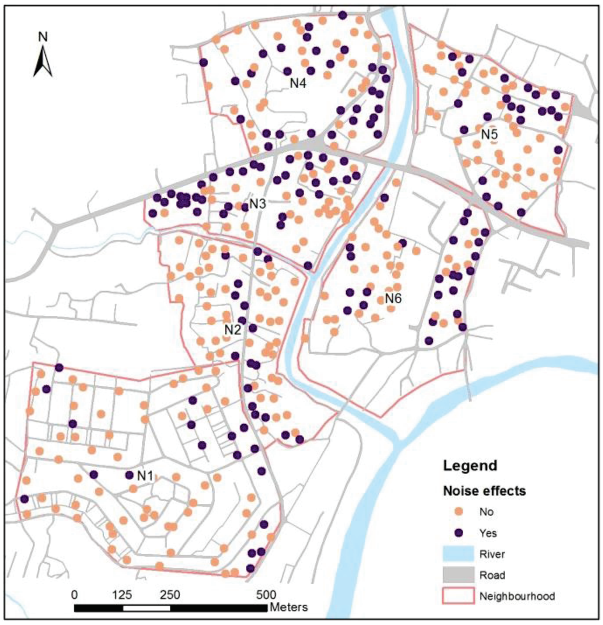


Figure 35: Reported noise effects and its proximity to major noise source (Transportation in roads)

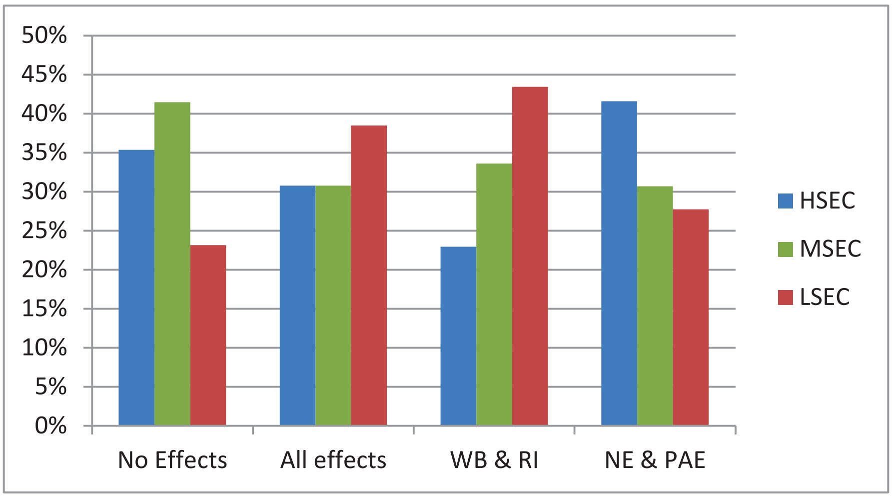


Figure 36: Households with no effects and all four effects in different socio-economic class

Table 18: Proportion of households with multiple effects in neighbourhoods

Neighbourhood	No Effects	All effects	WB & RI	NE & PAE
N1	**32%**	8%	14%	8%
N2	18%	8%	11%	14%
N3	16%	10%	14%	20%
N4	4%	**41%**	**28%**	**21%**
N5	23%	5%	14%	17%
N6	7%	28%	20%	**21%**
Total no. of households	82	39	122	101

Note: WB= Waterborne Disease; RI= Respiratory Illness; NE= Noise Effect; PAE= Polluted Air Effect

6.6. Effects on Children and Elderly

Table 19: Age group reported for respiratory illness and waterborne disease

Age Group	Respiratory Illness	Waterborne Disease
Up to 15 yrs.	15.7%	35.2%
16-35 yrs.	26.1%	21.6%
36-59 yrs.	19.4%	20.0%
60 above yrs.	38.8%	23.2%

The age group of people reported respiratoy illness and waterborne disease is shown in Table 19. It is seen that elderly group are most affected by respiratory illness whereas children upto age of 15 years are mostly affected by waterborne disease.

7. DISCUSSIONS

This chapter contains discussions addressing the sub-objectives of this study in four section. First section discusses on Development of Indicators. Remainging sections presents the analytical discussion on the result obtained in emperical study.

7.1. Assessing inequalities between neighbourhoods

To assess whether certain neighbourhoods suffer disproportionately adverse health of environmental effects from pollution or environmental hazard (Department of Justice, 1994), analysis was done between selected six neighbourhoods. The assessment however determined that the neighbourhoods selected were not homogenous in terms of socio-economic characteristics.

Due to the lack of data on exposure of polluted environment in neighbourhoods, the assessment had to rely on the grid based inventory by B. B. Pradhan et al. (2012), ICIMOD. These data cannot be compared with Nepal ambient air quality standard, 2012 due to difference in test methods adapted by MoSTE, which is based on averaging time of 24 hours or annual maximum concentration in ambient air where units are $\mu g/m^3$. However, studies show that, concentration of NO_2 and SO_2, are generally within the national standard 40 and 50 $\mu g/m^3$ respectively in the stations where air quality monitoring stations are set in Kathmandu valley (MoEST, 2005). In case of PM_{10} concentration, it varies according to dry or rainy seasons, weekends or weekdays. In heavy traffic area, it exceeds annual average of concentration i.e. 120 µg/m3 in the national standard. However, according to emission grid data N5 has extremely high value for all the pollutants. N4 and N6 have respectively higher total average emission value/grid after N5.

Perception of bad smell in neighbourhoods was another aspect measured, though it is more subjective. Comparatively, less people are suffering from bad smell in N1 and N5. The existing river being the main source of bad smell with vegetable market in N4 and waster transfer station in N6 seem to affect more in N2 and N6. The position of houses which reported as they perceive bad smell is shown in Figure 24. Most of the households along the river seem to complain about the bad odour especially in morning and evening, and more in summer time when water level is low. In N4, households surrounding vegetable market too are complaining about bad odour and they feel it almost all day and specially at garbage collection time. Weakness of Municipality in managing solid waste and treatment of sewerage (Manandhar, 2001) is affecting the environment of neighbourhoods near by the river, which can be considered as an issue of injustice.

Regarding health effects, waterborne diseases like diarrhoea, dysentery, fever, typhoid and jaundice etc. are considered though it cannot be claimed only due to the polluted water or environment alone. For instance, fever is not by itself an illness, but symptom of other illness or infection. However, all above mentioned illnesses are considered as waterborne diseases in this study for simplification and reported "yes" if any of those illnesses occurred to any of the members in households in last six months. Highest occurrence of waterborne diseases was in N4. Almost 90% of household in N4 are using other sources of drinking water apart from pipe water, in which jar water accounts for 45%, private tankers 16.5%, and shallow well 6.4% (refer Figure 40 in Annex). As these additional sources are proved to be contaminated by different reports (JICA & ENPHO, 2005; WASH news Asia & Pacific, 2010), higher consumption from these water sources might be the main reason for high occurrence of waterborne diseases in N4. However, other neighbourhoods too have 30-40% of households that reported occurrence of waterborne disease.

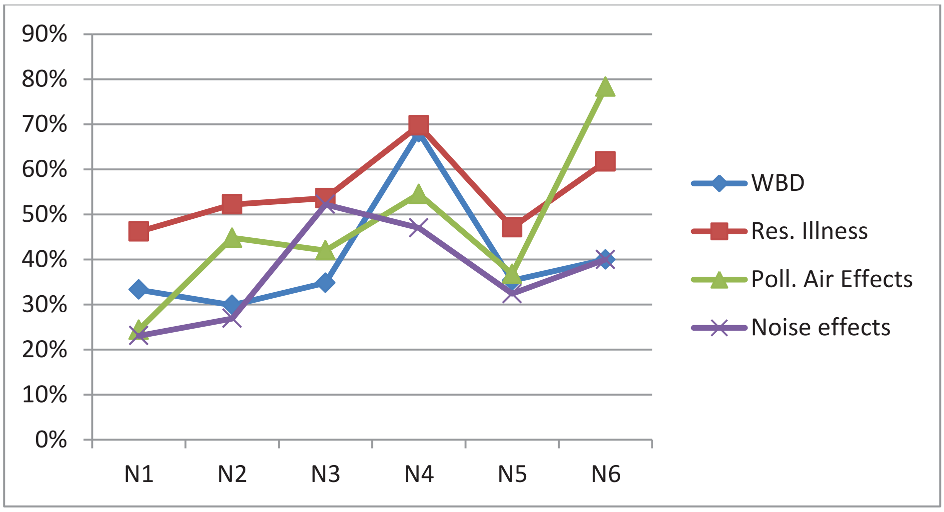


Figure 37: Summary of percent of reported effects in 6 neighbourhoods

The data regarding respiratory illness was also collected with self-reporting by the households. If it is checked with reference to exposure to air pollutants, N5 being highly exposed to air pollutants, respiratory illness and polluted air effects are comparatively less as compared to other neighbourhoods. However in case of N4 and N6, the occurrence of respiratory illness and polluted air effects is relatively higher. It therefore suggests that high concentration of air pollutants might be the major reason for such illness. In fact, the rate of occurrence in all neighbourhoods is actually high; around half or more of the household in each neighbourhood had some kind of respiratory illness. Transportation is the main cause of emission of air pollutants especially $PM_{10,}$ due to re-suspension of dust particles (C. Gautam, 2006; B. B. Pradhan et al., 2012; Shah & Nagpal, 1997), resulting major respiratory illness. Figure 31 shows that most of the households nearby major roads reported respiratory diseases.

Transportation is also major source of noise as well; the effect is mainly seen on N3 and N4 which consists of busy roads and intersections. Therefore higher reported effects due to noise in these two neighbourhoods are reasonable according to the results.

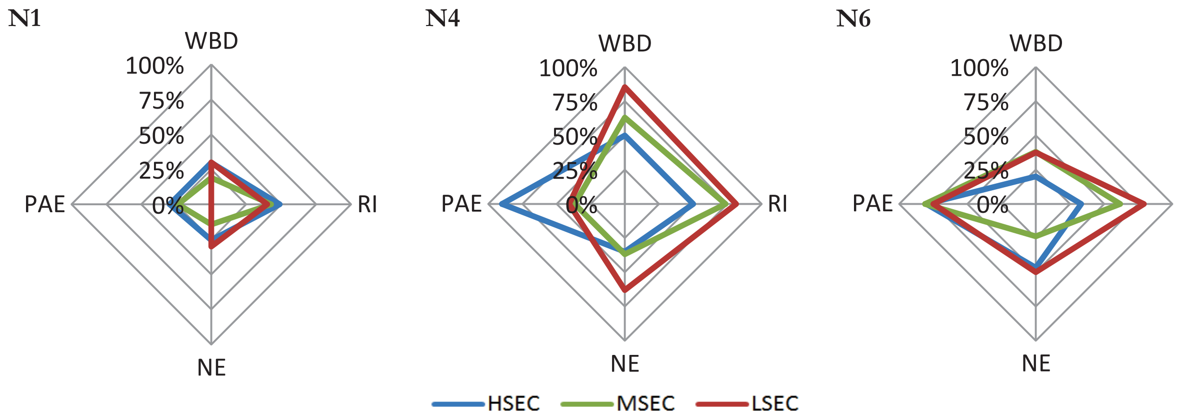
In summary, households in N4 and N6 have higher adverse health effects due to environmental pollution whereas N1 is least affected one (Figure 37). As already discussed on socio-economic class composition, N1 is mostly composed of HSEC households and N4 and N6 is composed of much LSEC households.

7.2. Assessing inequalities within neighbourhoods

After knowing that there are inequalities between the neighbourhoods, analysis is done within each neighbourhoods for finding out whether certain group of people (socio-economic class) suffer disproportionately adverse health effects from environmental exposure. Each household in neighbourhoods are classified to different socio-economic class using cluster analysis as described in section 6.1.3. N1, N4 and N6 were selected to assess the inequalities within each neighbourhood.

Each Neighbourhood is analysed separately in terms of exposure and health effects between three different socio-economic classes. Comparing health effects between socio-economic groups in N1, does not show significant relationship. It is noticeable that, between six neighbourhoods, N1 is the least affected in most of the cases. Exposure to air pollutants is also lowest in N1. Regarding exposure to noise, N1 is comparatively quieter in terms of vehicular noise except for the main road in east, the internal roads are mostly used by private vehicles only.

N4 had most adverse health effect compared to other neighbourhoods. The association between the socio-economic class and all three health effects except noise effects is noticed highly significant in this case. Reported morbidity of waterborne diseases and respiratory illness shows gradual increase in the proportion of households reported for illness from HSEC, MSEC to LSEC respectively. Noise effect is also reported higher in LSEC. In contrast to these results, HSEC reported drastically higher (90%) polluted air effects than in MSEC and LSEC. As the effect of polluted air (allergy) depends more upon sensitivity of people, almost all (18 out of 20 households) in HSEC reporting allergy might be linked to the sensitivity as well as awareness on certain diseases. The MSEC depicts nearly neutral in this aspect and might be the result of ignorance to certain effects which cannot be confined through this study. Similarly, noise effect can also be taken with the sensitivity of people. However in this study; proximity to main road seems to be the major factor in reporting noise effects (Figure 35). The neighbourhood has heavy vehicular traffic at two major intersections as well as connecting roads to northern part that produce noise. In addition to, the crowd in vegetable market and commercial areas is also major source of noise. As LSEC households are mostly surrounding the vegetable market area and area in the southeast part, which is surrounded by road in all sides, they are prone to much noise exposure than rest of the areas, which affects them more.



WBD= Waterborne disease; RI= Respiratory Illness; NE= Noise Effect; PAE= Polluted Air Effect

Figure 38: Radar chart of 3 Neighbourhoods on reported health effects with respect to socio-economic class

Regarding health effects in N6 between socio-economic classes, in case of respiratory illness, proportion of household increase from HSEC, MSEC to LSEC similar to N4. N6 being most affected by polluted air effect, no differentiation is found between socio-economic groups. 78% of total household in N6 complaining about polluted air allergy is quite surprising, as emission grid map does not show excessive high exposure to air pollutants compared to N4 (refer Table 13). So, it might be due to psychological effect for bad smell in the neighbourhood and presence of waste transfer station. Other effects like waterborne disease and noise effect do not show significant association though there are little variations among socio-economic groups. Regarding noise effects, the cluster of households in eastern part mainly seem to complain the noise effect due to heavy vehicles carrying solid waste to waste transfer station as well as continuous flow of vehicles due to connecting bridge with adjacent Lalitpur sub-metropolitan city.

From Figure 38, comparing the reported diseases in three neighbourhoods, it can be said that, N1 being less affected by the health effects, there is not much variation between socio-economic groups. Exposure to air pollutant in N4 and N6 is slightly higher than in N1 according to emission grid value, but the effects are disproportionately higher and among the affected households, higher proportion is seen in LSEC. However, the result might be affected due to use of self-reported health effects which have limitations discussed earlier (for example, information about specific health problem, income, education, health behaviours etc.).

Referring to N4, it can be concluded that LSEC households have higher effects due to environmental exposure than MSEC and HSEC regarding effects due to waterborne diseases and noise; while HSEC have more polluted air allergy. In N6, LSEC are having higher burden due to polluted air. The association is further analysed for environment exposure and health effects throughout the study area irrespective of neighbourhood boundary.

7.3. Assessing inequalities between socio-economic classes

After analysing inequalities within neighbourhood, inequalities between different socio-economic classes are explored to see whether certain socio-economic class is having disproportionate burden due to environmental exposure and health effects.

Perceived bad smell in different socio-economic classes shows that there is a significant relationship between them. HSEC are least exposed whereas LSEC are most exposed. It is supported by the fact that for perceived bad smell in different neighbourhoods, higher percent of households in N2, N3, N4 and N6 reported for it, where N4 and N6 consists of more LSEC in the neighbourhood, N2 and N3 has more MSEC. N1 with mostly HSEC households, very less had perceived bad smell (Figure 18). The major source of odour is the river. Other sources are garbage from vegetable market, solid waste containers, waste transfer station etc. Therefore, this issue is mainly related with proximity to bad smell source. It can be said that, mostly, LSEC are staying in close proximity to bad smell source (Figure 23), might be because of low rent/housing price in those areas. For example, most of the households in N4 have the owners migrated to other place renting houses for residential and commercial purposes specially warehouses and some houses are left ruined.

With respect to exposure to pollutants, there is no significant difference found between socio-economic classes exposure to average emission value/grid (Table 15) though the median is slightly higher in LSEC than others. As discussed earlier, exposure to air pollutant is more related with proximity to main emission source such as transport roads, waste transfer station etc. Figure 26 shows emission of PM_{10} ton/year/grid in study area where emission of PM_{10} increases according to proximity with road and there is no pattern seen in location of households of three socio-economic classes.

Although there is no significant difference among socio-economic groups in terms of using alternative source of drinking water, it is clear that LSEC depends more on jar as compared to others. Since people who cannot afford full tankers buy jar water from vendors for drinking and cooking (Rai, 2011), it shows LSEC may have more financial burden to spend on drinking water (Upaadhyaya, 2006, p. 124) . The price per jar of 20 litres ranges from NRs. 35 to 80, depending upon the quality. According to a report, one fourth of the bottled water distributed is contaminated in Kathmandu valley (WASH news Asia & Pacific, 2010) due to mushrooming of bottled water companies taking advantage of heightening shortage of water. Another study in 2009 shows that 90% of sealed jar water bottles samples contaminated with total coliforms and 60% with faecal coliforms (Subedi & Aryal, 2010). Even pipe water and shallow well water is contaminated (JICA & ENPHO, 2005).

Regarding health effects, in terms of waterborne diseases and respiratory illness, there is a significant association between socio-economic classes and reported illness. Figure 39 shows radar chart showing all four health effects with respect to different socio-economic class; shows less variation between MSEC and HSEC, but LSEC has higher occurrence of illness except for polluted air effects. As discussed above about water quality and LSEC household's dependence on jar water from vendors, they are more prone to waterborne diseases. In addition, due to low level of education, personal hygiene is very less practiced in such societies. More than half of households in LSEC reported waterborne diseases. Most of the people think quality of jar water is reliable and use without any further treatment. Diarrhoea accounts for 17% of total waterborne diseases reported, of which more than 45% fall in LSEC. It thus shows that they are facing adverse environmental effects.

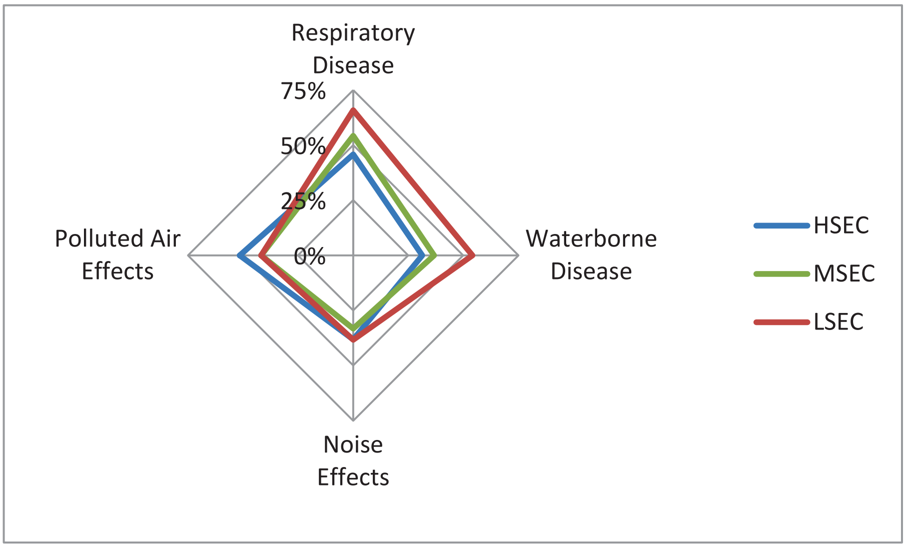


Figure 39: Radar chart showing Health effects in three socio-economic classes

Similarly, around 2/3 of households reported for respiratory illness in LSEC which is higher compared to MSEC and HSEC. However, it is found that the exposure to air pollutant does not vary much, though average air pollutant is slightly higher in LSEC. With almost similar exposure, higher rate of respiratory illness can be linked to the conclusions made by Deguen and Zmirou-Navier (2010) referring to studies done in Europe; which says that, irrespective of level of exposure to ambient air, poor are more affected by effects associated with air pollutants.

In overall study area, more than half of total household surveyed had some kind of respiratory illness. It would have been better to have hospital reports to find out the exact illness and severity of illness along with self-reports. Very common and general terms are only used in questionnaire for easy understanding. During survey, it is also noticed that, people don't take these illness seriously, until they have to be hospitalized.

Reported allergic effects due to polluted air had different pattern than respiratory illness. HSEC households reported slightly higher and similar percent of household in MSEC and LSEC, though the association is not statistically significant. The reporting of polluted air effect may vary depending upon sensitivity and knowledge on causes of certain effects as discussed earlier. The result that HSEC households reported higher external effects might be due to more consciousness; since occurrence of internal effects (such as respiratory illness) seems lower than in MSEC and LSEC.

Noise effects also do not show association with socio-economic class in overall study area. However, within N4 it had significant relationship with socio-economic class (Section 6.3.2). This shows that noise effect is mainly related to proximity to noise source (mainly road, then crowd). In some cases, it is even seen that the households lying very nearby had different perspectives on exposure to noise in their neighbourhoods, so as the effect, which can be due to lack of knowledge of environment and its health consequences or other pre-dominant stress factors associated with socio-economic condition as suggested by Riedel et al. (2013).

Analysis of multiple effects within socio-economic classes also shows that LSEC households have higher effect in terms of all four effects as well as effect from both waterborne and respiratory illness in a same household. However, for both polluted air allergy and noise effect, less effect is seen in LSEC (Section 6.5). This indicates that LSEC has multiple health effects due to environmental stressors. It can be seen that mostly in N4 (28%) and N6 (20%), households reported both respiratory and waterborne disease.

From above discussion, LSEC have more adverse health effect from air pollution and water pollution, though variation in environmental exposure is comparatively low. This can be inferred as "disproportionately adverse health effects" mentioned in Department of Justice (1994) for population in LSEC.

Apart from inequalities in socio-economic classes, the results also suggested that children and elderly are most suffered by environmental burdens as argued by (Adhikari, 2003) and (Jha, 2006). Children are most affected by waterborne disease whereas elderly seem to be most affected by respiratory diseases.

7.4. Conclusion

Analysing inequalities between neighbourhoods shows that N4 and N6 have higher adverse health effect due to environmental pollution (water and air pollution); air pollutant are slightly higher than other neighbourhoods except N5. N1 is least affected among all neighbourhoods.

Further analysis on selected three neighbourhoods for variation within neighbourhoods found that, N4 with higher reported illness and exposure, there is association between socio-economic class and health effects. LSEC are mostly affected from waterborne disease, respiratory illness and noise effect. In the other hand, N1 which has lower exposure to environment pollution and less reported illness, the data does not show any significant relationship between socio-economic class and health effects.

The results of assessment between socio-economic classes within whole study area show significant relation with waterborne and respiratory illness. LSEC have higher occurrence of illness, followed by MSEC and HSEC. Similarly, multiple effects are also seen in higher in LSEC.

In summary, it can be said that, households in N4 is having more adverse health effect due to environmental pollution. Regarding socio-economic class, LSEC is bearing disproportionate health effects from either similar or higher environmental exposure.

8. CONCLUSIONS AND RECOMMENDATIONS

This chapter contains the outline of research finding with respect to research objectives as well as recommendations and future research directions.

8.1. Conclusions

The main objective of the study was to develop a set of indicators related to environment and health inequalities and to assess environmental justice in Kathmandu. Set of indicators has been proposed to evaluate inequalities in environmental exposure and health effects for the study area.

Major environmental issues identified in Kathmandu are air quality, water quality and supply, and noise pollution whereas major environmental health issues are gastritis, acute respiratory infection etc. which are mainly related to air and water pollution.

For indicator development, DPSEEA framework was found most suitable to show the association between environmental exposure and health with addition of socio-economic context. The indicators for inequalities need to be developed based on specific geographic location incorporating local knowledge through stakeholders' participation, which this study has attempted to some extent. The indicators had been developed focussing on major environmental and health problems in study area, sorted out by experts. Indicators of socio-economic context are also developed; as contexts like poverty, education, occupation etc. play important roles in the health of the people.

Taking advantage of the benefits from neighbourhood scale analysis in environmental justice, this study attempts to assess inequalities between neighbourhoods and socio-economic groups, which had never been studied in Kathmandu. Previous studies in environment and health mostly have districts as unit of analysis, with few municipal level studies. Intra-urban variations as well as variation between sub-groups identified by this study enables wider opening for future studies in environmental justice.

The study found higher exposure as well as adverse health effects in some neighbourhoods. However, further analysis was conducted on those neighbourhoods in order to examine whether different socio-economic class bears disproportionate burden, it is found that, lower socio-economic class households have more burden in some neighbourhoods. It is confirmed after analysing inequalities between different socio-economic group in the whole study area, that lower socio-economic households are affected more by environmental pollution, though differences in exposure is less. Hence, the disproportionately adverse health effects in some neighbourhoods as well as in some socio-economic groups suggest environmental injustice in case study area.

8.2. Recommendations

This study is the first attempt to assess environmental justice in urban context of Nepal. It has broadened the concept of environmental justice in urban context of developing countries, apart from siting dangerous facilities as in USA, from where the concept emerges. Data unavailability was the major challenge which is the common problem in most of the developing countries. The lower resolution data are hardly available. So, the study mainly depends upon primary data, and it can be taken as an opportunity, for the major stakeholders i.e. affected people are directly involved in the study. Limitations of the research and further research directions have been listed.

- The combination of self-reported health as well as hospital data would have been better for more specific analysis. However, hospital data in Nepal don't contain the spatial information.Only general diseases were included in questionnaire, which normal people can understand and respond about.

- For the development of indicators, it would be better to involve more statkeholders and let them select the indicators as applied by Todd and Zografos (2005). Due to time limitations, only few interviews with expert could be managed for this study.
- Due to unavailability of environmental exposure data on disaggregated level, subjective indicators are used, such as perceived quality of environment. It would have been better if perceived indicators can be linked to actual state of environment. Modelled environment data for pollutant emission by ICIMOD can be used for general overview of air pollutant.
- Rate of occurrence of specific disease like asthma, diarrohea etc. would be better to assess actual health effect; however due to limited sample, considering individual illness is not possible for statistical significance.
- The study could be done best with the use of detail data on socio-economic conditions. Data is not available for all indicators proposed at present. However, it is expected to have data in near future if they are incorporated with other surveys like demographic and health survey.
- Though some exposures and specific health effects are checked in this study, causality cannot be explained or claimed through this analysis.
- It is assumed that residential location is an adequate representation of environmental exposure while other settings such as work place, leisure, travelling from and to work place are not considered in this study.
- Ward is the smallest administrative boundary in Nepal. The area of ward is not uniform and it is also not homogenous in terms of social and physical characters. Census tract boundaries are also not available. So, the neighbourhood boundary delineation may effect the results.

LIST OF REFERENCES

Adhikari, J. (Ed.). (2003). *Urban Context of Environmental Justice: A study in Pokhara*. Kathmandu, Nepal: Martin Chautari and Social Development and Research Center (In Nepali).

Adhikari, J., & Ghimire, S. (Eds.). (2002). *A Bibliography on Environment Justice in Nepal*. Kathmandu, Nepal: Martin Chautari.

Adhikari, J., & Ghimire, S. (Eds.). (2003). *Batabaraniya Nyaya Shrot Sangalo (in Nepali)*. Kathmandu, Nepal: Martin Chautari.

Adhikary, P. R. (1995). Problems in the Kathmandu Valley: Some Issues in Planning and Management. *Contribution of Nepalese Studies, 22*, 1-19.

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., & Syme, S. L. (1994). Socioeconomic status and health: the challenge of the gradient. *American psychologist, 49*(1), 15.

Ako, R. (2013). Environmental Justice in Developing Countries: Perspectives from Africa and Asia-Pacific. London and New York: Routledge.

APEN. (2002). What is Environemntal Justice. Retrieved January 2, 2014, from http://archive.apen4ej.org/issues_what.htm

Asian Development Bank, & CIA-Asia. (2006). Country Synthesis Report on Urban Air Quality Management: Nepal. Philippines: Asian Development Bank, Clean Air Initiative for Asian Cities.

Baden, B. M., Noonan, D. S., & Turaga, R. M. R. (2007). Scales of justice: Is there a geographic bias in environmental equity analysis? *Journal of Environmental Planning and Management, 50*(2), 163-185. doi: 10.1080/09640560601156433

Barzyk, T. M., White, B. M., Millard, M., Martin, M., Perlmutt, L. D., Harris, F., . . . Geller, A. (2011). Linking Socio-Economic Status, Adverse Health Outcome, and Environmental Pollution Information to Develop a Set of Environmental Justice Indicators with Three Case Study Applications. *Environmental Justice, 4*(3), 171-177. doi: 10.1089/env.2010.0047

Briggs, D. (1999). Development of environmental health indicators. In: Linkage methods for environment and health analysis. General guidelines *Protection of the Human Environment, Occupational and Environmental Health Series*. Geneva: WHO.

Briggs, D. (2003). *Making a difference : indicators to improve children's environmental health: Summary*. Geneva: World Health Organization.

Brulle, R. J., & Pellow, D. N. (2006). Environmental justice: Human health and environmental inequalities. *Annual Review of Public Health, 27*, 103-124. doi: 10.1146/annurev.publhealth.27.021405.102124

Buzzelli, M., & Jerrett, M. (2004). Racial gradients of ambient air pollution exposure in Hamilton, Canada. *Environment and Planning A, 36*(10), 1855-1876.

Carneiro, F. F., Oliveira, M. L. C., Netto, G. F., Galvão, L. A. C., Cancio, J. A., Bonini, E. M., & Corvalan, C. F. (2006). Meeting Report: Development of Environmental Health Indicators in Brazil and Other Countries in the Americas *Environ Health Perspect* (Vol. 114(9), pp. 1407–1408).

CBS. (2011a). Nepal Living Standards Survey 2010/11 *Statistical Report, Volume 1*. Kathmandu.

CBS. (2011b). Poverty in Nepal (Summary Based on Nepal Living Standard Survey III 2010/11). Kathmandu: Central Bureau of Statistics.

CBS. (2012a). National Population and Housing Census 2011 (Vol. 02): Central Bureau of Statistics.

CBS. (2012b). National population census 2011 household and population by sex: Ward level. Kathmandu: Central Bureau of Statistics.

CEN, & ENPHO. (2003). Health Impacts of Kathamandu's Air Pollution. Kathmandu: Kathmandu Electric Vehicle Alliance.

Cha, J. M. (2007). *Increasing Access to Environmental Justice: A Resource Book for Advocacy and Legal Literacy in South Asia*. Kathmandu, Nepal: International Centre for Integrated Mountain Development (ICIMOD).

CIWIN. (1997). Tempo conductor child labour's condition (Tempo Khalassi Baal Sramikharuko Sthiti). Kathmandu: Child Workers in Nepal.

Cohen, A. K., & Schuchter, J. W. (2013). Revitalizing Communities Together The Shared Values, Goals, and Work of Education, Urban Planning, and Public Health. *Journal of Urban Health-Bulletin of the New York Academy of Medicine, 90*(2), 187-196. doi: 10.1007/s11524-012-9733-3

Cutter, S. L., Holm, D., & Clark, L. (1996). The Role of Geographic Scale in Monitoring Environmental Justice. *Risk Analysis, 16*(4), 517-526. doi: 10.1111/j.1539-6924.1996.tb01097.x

Daly, M., Duncan, G., McDonogh, P., & Williams, D. (2002). Optimal Indicators of Socioeconomic Status for Health Research. *American Journal of Public Health, 92*(7), 1151-1157.

Deguen, S., & Zmirou-Navier, D. (2010). Social inequalities resulting from health risks related to ambient air quality—A European review. *The European Journal of Public Health, 20*(1), 27-35. doi: 10.1093/eurpub/ckp220

Department of Justice. (1994). Guidance concerning Environmental Justice. Retrieved 22 August, 2013, from http://www.justice.gov/ej/docs/DOJ_Guidance_Concerning_Environmental_Justice.pdf

Dhakal, S. (2006). Urban Transportation and the Environment in Kathmandu Valley, Nepal. Nepal: Institute for Global Environmental Strategies (IGES), Japan.

DoHS. (2012). Annual Report 2010/2011. Kathmandu: Government of Nepal, Ministry of Health and Population.

Dowd, J. B., & Zajacova, A. (2007). Does the predictive power of self-rated health for subsequent mortality risk vary by socioeconomic status in the US? *Int J Epidemiol, 36*(6), 1214-1221. doi: 10.1093/ije/dym214

Down to Earth. (2012). Clean environment has to be a fundamental right. Retrieved 24 august, 2013, from http://www.downtoearth.org.in/content/clean-environment-has-be-fundamental-right

ENPHO. (2007). Analysis of Urban Environmental Issues *Nepal Country Environment Analysis* Kathmandu: Environment and Public Health Organization, The World Bank, Government of Nepal.

Evans, G. W., & Kantrowitz, E. (2002). SOCIOECONOMIC STATUS AND HEALTH: The Potential Role of Environmental Risk Exposure. *Annual Review of Public Health, 23*(1), 303-331. doi: 10.1146/annurev.publhealth.23.112001.112349

Field, A. (2009). *Discovering statistics using SPSS*. London: SAGE Publications Ltd.

Florida Health Lee County. (2013). Sanitary Nuisances. Retrieved November 14, 2013, from http://www.floridahealth.gov/

Galobardes, B., Shaw, M., Lawlor, D. A., & Smith, G. D. (2006). Indicators of socioeconomic position (part 1). *Journal of Epidemiology and Community Health, 60*(1), 7-12. doi: 10.1136/jech.2004.023531

Gautam, C. (2006). Action plan for air quality management in Kathmandu valley. Kathmandu: Ministry of Science, Technology and Environment.

Gautam, D. R. (2000). *Urban Environment and Human Health in Kathmandu Metropolis.* (Doctor of Philosphy), Banaras Hindu University, India.

Ghimire, S. (2003). Concept of environmental justice in Nepal: Environmentalism of poor for sustainable livelihood. *Himalayan Journal of Sciences, 1*(1), 45-70.

Gorkhapatra. (2013). Noise pollution a new threat in Nepal. Retrieved 21 December 2013, from http://www.gorkhapatra.org.np/detail.php?article_id=26878&cat_id=8

Gurung, A., & Bell, M. L. (2013). The state of scientific evidence on air pollution and human health in Nepal. *Environmental Research, 124*, 54-64. doi: 10.1016/j.envres.2013.03.007

Gwatkin, D. R. (2002). Reducing health inequalities in Developing Countries. In R. Detels, J. McEwen, R. Beaglehole & H. Tanaka (Eds.), *Oxford Textbook of Public Health* (pp. 1791–1809). Oxford: Oxford University Press.

Hambling, T., & Slaney, D. (2007). Environmental Health Indicators for New Zealand: Annual Report 2007: Wellington: Institute of Environmental Science and Research (ESR).

Hambling, T., Weinstein, P., & Slaney, D. (2011). A Review of Frameworks for Developing Environmental Health Indicators for Climate Change and Health. *International Journal of Environmental Research and Public Health, 8*(7), 2854-2875. doi: 10.3390/ijerph80x000x

Health Council. (2002). Devloping National Environmental health indicators. Canberra, Australia: Department of Health and Ageing.

Health Magazine. (2013, 12 November, 2013). Pneumonia causes 5600 child mortality. Retrieved 12 November, 2013, from http://ehealthnewspaper.com/

ICIMOD. (2007). Kathmandu Valley Environment Outlook. Kathmandu: International Centre for Integrated Mountain Development (ICIMOD), Ministry of Environment, Science and Technology (MoEST), United Nations Environment Programme (UNEP).

Jerrett, M., Burnett, R. T., Kanaroglou, P., Eyles, J., Finkelstein, N., Giovis, C., & Brook, J. R. (2001). A GIS - environmental justice analysis of particulate air pollution in Hamilton, Canada. *Environment and Planning A, 33*(6), 955-973.

Jha, P. K. (2006). Vatavarn pradushan: samasya ra samadhan (In Nepali) (Environment Pollution: Problem and Solution). In N. Belbase (Ed.), *Vatabaraniya Nyaya tatha samanyaya: sambhawana tatha chunautiharu (Environmental justice and equity: probabilities and challenges)*. Kathmandu: Nyaya Manch (Forum for Justice).

JICA, & ENPHO. (2005). Ground Water Surveillance in Kathmandu and Lalitpur Municipality Areas. Kathmandu: JICA Expert Office at MPPW and Environment and Public Health Organization.

Kockler, H., & Flacke, J. (2013). *Health-related inequalities in the global north and south- A framework for spatially explicit environmental justice indicators*. Paper presented at the N-AERUS IVX, Enschede.

Kramers, P. G. N., & ECHI team. (2005). Public Health Indicators for Europe: Context, Selection, Definition. from http://hdl.handle.net/10029/7294

Liberators, P., Link, B. G., & Kelsey, J. L. (1988). THE MEASUREMENT OF SOCIAL CLASS IN EPIDEMIOLOGY. *Epidemiologic Reviews, 10*(1), 87-121.

Maantay, J. (2002). Mapping environmental injustices: pitfalls and potential of geographic information systems in assessing environmental health and equity. *Environ Health Perspect, 110 Suppl 2*, 161-171.

Manandhar, S. (2001). Dhal sangai nadi ra treatment plant ma bageko paisa. [Flow of money with river, drain and treatment plant]. *Haka Haki, 4*(5).

Ministy of Environment. (2010). Vatabaraniya mapdanda tatha sambandhit suchanaharuko sangalo. Kathmandu: Ministy of Enviornment, Government of Nepal.

MoEST. (2005). Ambient Air Quality of Kathmandu Valley 2003-2004. Kathmandu: Ministry of Environment, Science and Technology.

MOHP, New ERA, & ICF International Inc. (2012). Nepal Demographic and Health Survey 2011. Kathmandu, Nepal: Ministry of Health and Population, Nepal, New ERA and ICF International, Calverton, Maryland.

Morris, G. P., Beck, S. A., Hanlon, P., & Robertson, R. (2006). Getting strategic about the environment and health. *Public Health, 120*(10), 889-903. doi: http://dx.doi.org/10.1016/j.puhe.2006.05.022

National Academy of Sciences. (2006). The impact of social and cultral environment on health. In L. M. Hernandez & D. G. Blazer (Eds.), *Genes, Behavior, and the Social Environment: Moving Beyond the Nature/Nurture Debate*. Washington, D.C.: The National Academies Press.

Nest (P) Ltd. (2013). Urban Environment Indicators, Final Report: Department of Urban Development and Building Construction.

NHRC. (2009). Situation analysis and environmental health in Nepal 2009 (First ed.). Kathmandu, Nepal: Nepal Health Research Council.

OECD. (1993). OECD Core Set of Indicators for Environmental Performance Reviews: A synthesis report by the Group on the State of the Environment. (Vol. 83). Paris: Organization for Economic Co-operation and Development.

Openshaw, S. (1984). *The Modifiable Areal Unit Problem*. Norwich: Geo Books.

Oregon Health Authority. (2013). Odours and your health. Retrieved November, 14, 2013, from http://public.health.oregon.gov/

Ostrove, J. M., Feldman, P., & Adler, N. E. (1999). Relations among Socioeconomic Status Indicators and Health for African-Americans and Whites. *Journal of Health Psychology, 4*(4), 451-463. doi: 10.1177/135910539900400401

Ouis, D. (2001). ANNOYANCE FROM ROAD TRAFFIC NOISE: A REVIEW. *Journal of Environmental Psychology, 21*(1), 101-120. doi: http://dx.doi.org/10.1006/jevp.2000.0187

Paavola, J., & Adger, W. N. (2002). Justice and Adaptation to Climate Change. Tyndall Centre Working Paper No. 23.

Pant, P. R., & Dongol, D. (2009). *Kathmandu Valley Profile: Briefing Paper*. Paper presented at the Governance and Infrastructure Development Challenges in the Kathmandu Valley.

Pearce, J. R., Richardson, E. A., Mitchell, R. J., & Shortt, N. K. (2010). Environmental justice and health: the implications of the socio-spatial distribution of multiple environmental deprivation for health inequalities in the United Kingdom. *Transactions of the Institute of British Geographers, 35*(4), 522-539. doi: 10.1111/j.1475-5661.2010.00399.x

Pearce, J. R., Richardson, E. A., Mitchell, R. J., & Shortt, N. K. (2011). Environmental justice and health: A study of multiple environmental deprivation and geographical inequalities in health in New Zealand. *Social Science & Medicine, 73*(3), 410-420. doi: http://dx.doi.org/10.1016/j.socscimed.2011.05.039

Ploubidis, G. B., & Grundy, E. (2011). Health measurement in population surveys: combining information from self-reported and observer-measured health indicators. *Demography, 48*(2), 699-724. doi: 10.1007/s13524-011-0028-1

Pradhan, B., Gruendlinger, R., Fuerhapper, I., Pradhan, P., & Pradhanang, S. (2005). Knowledge of water quality and water borne disease in rural Kathmandu Valley, Nepal. *Aquatic Ecosystem Health & Management, 8*(3), 277-284. doi: 10.1080/14634980500208176

Pradhan, B. B., Dangol, P. M., Bhaunju, R. M., & Pradhan, S. (2012). Rapid Urban Assessment of Air Quality for Kathmandu, Nepal. Kathmandu: ICIMOD.

Rai, J. (2011, June 9, 2011). Tanker, jar water business booms, *The Kathmandu Post*.

Riedel, N., Scheiner, J., Müller, G., & Köckler, H. (2013). Assessing the relationship between objective and subjective indicators of residential exposure to road traffic noise in the context of environmental justice. *Journal of Environmental Planning and Management*, 1-24. doi: 10.1080/09640568.2013.808610

Rogerson, P. A. (2001). *Statistical Methods for Geography*. London, California, New Delhi: SAGE Publications Ltd.

Saraf, A. (2005). Health Impact of Particulate Pollution in Children: A Case Study of Kathmandu, Nepal. *Journal of Nepal Health Reasearch Council, 3*(2), 43-50.

Shah, J., & Nagpal, T. (Eds.). (1997). *Urban Air Quality Management Strategies in Asia: Kathmandu Valley Report*. Washingtion D.C. : World Bank.

Shakya, S. (2001). *Health problems prevalent in the Traffic police personnel due to vehicular air pollution in Kathmandu.* (Bachelors of Science), St. Xavier's College.

Shortt, N. K., Richardson, E. A., Pearce, J., & Mitchell, R. J. (2012). Mortality inequalities by environment type in New Zealand. *Health & Place, 18*(5), 1132-1136. doi: http://dx.doi.org/10.1016/j.healthplace.2012.04.008

Shrestha, A. (1993). *A case study of social aspects of Solid Waste Management in Kathmandu.* (M.A.), Tribhuvan University, Kathmandu.

Shrestha, R. M., & Malla, S. (1996). Air pollution from energy use in a developing country city: The case of Kathmandu Valley, Nepal. *Energy, 21*(9), 785-794. doi: http://dx.doi.org/10.1016/0360-5442(96)00023-0

Shrestha, S. L. (2007). Time series modelling of respiratory hospital admissions and geometrically weighted distributed lag effects from ambient particulate air pollution within Kathmandu Valley, Nepal. *Environmental Modeling & Assessment, 12*(3), 239-251. doi: 10.1007/s10666-006-9071-5

Smith, G. D., Shipley, M. J., & Rose, G. (1990). Magnitude and causes of socioeconomic differentials in mortality: further evidence from the Whitehall Study. *Journal of Epidemiology and Community Health, 44*, 265-270.

Smyth, F. (2008). Medical geography: understanding health inequalities. *Progress in Human Geography, 32*(1), 119-127. doi: 10.1177/0309132507080628

Subedi, M., & Aryal, M. (2010). Public perception about drinking jar water and its bacteriological analysis. *Nepal Med Coll J, 12*(2), 110-114.

Thapa, R. B., Murayama, Y., & Ale, S. (2008). City Profile: Kathmandu. *Cities, 25*, 45-47. doi: 10.1016/j.cities.2007.10.001

The Kathmandu Post. (2012). Govt plan to make noisy Kathmandu more livable. Retrieved 21 December, 2013, from http://www.ekantipur.com/the-kathmandu-post/2012/10/11/metro/govt-plan-to-make-noisy-kathmandu-more-livable/240647.html

Todd, H., & Zografos, C. (2005). Justice for the environment: Developing a set of indicators of environmental justice for Scotland. *Environmental Values, 14*(4), 483-501. doi: 10.3197/096327105774462692

Upaadhyaya, M. (2006). Jal shrot ra vatavaraniya nyaya (In Nepali) (Water resources and envionmental justice). In N. Belbase (Ed.), *Vatabaraniya Nyaya tatha samanyaya: sambhawana tatha chunautiharu (Environmental justice and equity: probabilities and challenges)*. Kathmandu: Nyaya Manch (Forum for Justice).

US-EPA. (2004). Toolkit for accessing potential allegation of Environmental Injustice: United States Environmental Protection Agency.

Waheed, B., Khan, F., & Veitch, B. (2009). Linkage-Based Frameworks for Sustainability Assessment: Making a Case for Driving Force-Pressure-State-Exposure-Effect-Action (DPSEEA) Frameworks. *Sustainability, 1*(3), 441-463.

Walker, G. (2003). *Environmental Quality and Social Deprivation: R&D Technical Report E2-067/1/TR*: Environment Agency.

Walker, G. (2009). Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. *Antipode, 41*(4), 614-636. doi: 10.1111/j.1467-8330.2009.00691.x

WASH news Asia & Pacific. (2010). Nepal, Kathmandu Valley: one-fourth of bottled water 'contaminated'. Retrieved November 15, 2013, from http://washasia.wordpress.com/

Weeks, J. R., Hill, A. G., & Stoler, J. (Eds.). (2013). *Spatial Inequalities: Health, Poverty, and Place in Accra, Ghana*: Springer Netherlands, Business Media Dordrecht.

WHO. (2011a). Burden of Disease from Environmental Noise- Quantification of healthy life years lost in Europe. Denmark: WHO Regional Office for Europe.

WHO. (2011b). Guidelines for drinking-water quality - Volume 1: Recommendations (4th ed.). Geneva: World Health Organization.

WHO. (2012). Environmental health inequalities in Europe. Denmark: World Health Organization.

WHO Europe. (2004). Environmental health indicators for Europe : a pilot indicator-based report: World Health Organization Europe.

9. ANNEX

9.1. Descriptions and Rationales of Indicators

Domain: Air Pollution **State: Outdoor Air Pollution**	
Indicator	**Mean annual concentration of PM_{10}, $PM_{2.5}$, TSP, SO_2, NO_2, O_3 etc. in outdoor air in urban areas**
Rationale	This indicator provides a measure of the state of the environment in terms of air quality and is an indirect measure of population exposure to air pollution in urban areas. The purpose of this indicator is to measure overall air quality and the potential exposure of people to air pollutants of health concern.
Data Required	Mean annual concentration of PM_{10}, $PM_{2.5}$, TSP, SO_2, NO_2, O_3 etc.in outdoor air in urban areas
Data Sources	Data on air monitoring stations can be obtained from MoSTE, however, Kathmandu valley only 6 monitoring stations are located. Alternatively, modelled data like emission grid inventory by ICIMOD for Rapid Urban Assessment can be used.
Measurement	Mean annual concentration of PM_{10}, $PM_{2.5}$, TSP, SO_2, NO_2, O_3 etc.in outdoor air in urban areas
Unit of measurement	$\mu g/m^3$
Reference and further information	Briggs, D. (1999). Development of environmental health indicators. In: Linkage methods for environment and health analysis. General guidelines *Protection of the Human Environment, Occupational and Environmental Health Series*. Geneva: WHO. http://whqlibdoc.who.int/hq/1999/WHO_SDE_OEH_99.10.pdf?ua=1 Pradhan, B. B., Dangol, P. M., Bhaunju, R. M., & Pradhan, S. (2012). Rapid Urban Assessment of Air Quality for Kathmandu, Nepal. Kathmandu: ICIMOD.

Domain: Air Pollution **Exposure: Outdoor Air Pollution**	
Indicator	**% of household exposed to air pollutant above the standard**
Rationale	Measurement of % of population exposed to air pollutants higher than the standard will show the inequalities between different areas
Data Required	Mean annual concentration of PM_{10}, $PM_{2.5}$, TSP, SO_2, NO_2, O_3 etc.in outdoor air in urban areas (modelled data like emission map) Population density data per unit of analysis
Data Sources	Data on air monitoring stations can be obtained from MoSTE, however, Kathmandu valley only 6 monitoring stations are located. Alternatively, modeled data like emission grid inventory by ICIMOD for Rapid Urban Assessment can be used.
Measurement	(A*PD)/P where A= areas with standard Mean annual concentration of PM_{10}, $PM_{2.5}$, TSP, SO_2, NO_2, O_3 etc. higher than standard, PD= population density , P= Total population density
Unit of measurement	Percentage
Reference and further information	Briggs (1999)

Domain: Air Pollution **Exposure: Indoor Air Pollution**

Indicator	**% of household using coal, wood or kerosene for cooking**
Rationale	Indoor exposures to air pollution are an important factor in respiratory illness and mortality. Much of this exposure relates to the use of fuels such as wood, kerosene or coal for cooking and heating. The indicator thus provides a measure of the potential exposure to air pollution from indoor sources in different areas that can also be linked with variations in health effects.
Data required	Number of households using coal, wood or kerosene as the main source of heating and cooking fuel Total number of households
Measurement	The indicator can be computed as (C/H)*100, where C=No. of household using coal, wood or kerosene for cooking, H=Total no. of households
Unit of measurement	Percentage
Data source	Number of households using coal, wood or kerosene and total household both data can be obtained from Census.
Reference and further information	Briggs (1999)

Domain: Air Pollution
Effect: Respiratory Illness

Indicator	**Incidence of morbidity due to respiratory infections**
Rationale	The incidence of acute respiratory illness has been one of the major causes of morbidity especially in urban areas. Exposure to air pollution is one of the risk factors identified. So, measurement of morbidity with ARI can show the variation in geographical areas or groups of people that can be linked with inequalities in exposure.
Data required	Spatially resolved number of cases of acute respiratory infection and total population
Data source	Total cases of ARI can be obtained from hospital records and other health institutions. Department of health services under Ministry of Health and Population annually collect health records from health institutions across the nation which are in Health Information management system. The data published is aggregated to district level. Higher resolution spatial data can be expected in future. Else, designated survey might be required for case specific and spatially resolved data of required unit of analysis. Total population can be obtained from Census.
Measurement	The indicator can be computed as (R/P)*1000, where R=No. of cases of acute respiratory infection , H=Total population
Unit of measurement	Number per thousand population
Reference and further information	Briggs (1999)
Remarks	The measurement can be done separately for children or elderly or population as a whole.

Domain: Air Pollution
Effect: Respiratory Illness

Indicator	**Annual mortality rate due to acute respiratory infection**
Rationale	The mortality due to acute respiratory illness has been increasing. Exposure to air pollution is one of the risk factors identified. So, measurement of mortality rate due to ARI can show the variation in geographical areas or groups of people that can be linked with inequalities in exposure.
Data required	Spatially resolved number of mortality due to acute respiratory infection and total population
Data source	Total mortality due to ARI can be obtained from hospital records and other health institutions. Department of health services under Ministry of Health and

	Population annually collect health records from health institutions across the nation which are in Health Information management system. The data published is aggregated to district level. Higher resolution spatial data can be expected in future. Else, designated survey might be required for case specific and spatially resolved data of required unit of analysis. Total population can be obtained from Census.
Measurement	The indicator can be computed as (M/P)*1000, where M=No. of death due to acute respiratory infection , H=Total population
Unit of measurement	Number per thousand population
Reference and further information	Briggs (1999); Department of Health Services, Ministry of Health and Population, Nepal
Remarks	The measurement can be done separately for children or elderly or population as a whole.

Domain: Air Pollution **Effect: External Effects (Allergy)**	
Indicator	**Incidence of allergic effects in skin, eye**
Rationale	In addition to respiratory illness, measurement of external allergic effects due to air pollution can also be used to show the variation in geographical areas or groups of people that can be linked with inequalities in exposure. It is especially more related to occupations that are more directly linked with polluted air such as drivers, vendors in road side etc.
Data required	Spatially resolved number of outdoor patients or report of skin irritation, eye irritation etc. as consequence of long term exposure to polluted air
Data source	Total outdoor patients visit in hospitals and other health institutes or designated survey might be required for case specific and spatially resolved data of required unit of analysis. Total population can be obtained from Census.
Measurement	The indicator can be computed as (A/P)*1000, where A=No. of allergic cases , H=Total population
Unit of measurement	Number per thousand population

Domain: Noise Pollution **State: Noise Level**	
Indicator	Noise level at different points
Rationale	This indicator provides a measure of noise level to show variations in noise level in areas
Data required	Noise level data
Data source	Specific studies need to be done due to lack of noise monitoring by any specific organization
Measurement	Measurement of noise level at different points
Unit of measurement	decibel
Reference and further information	WHO (2011a)
Remarks	

Domain: Noise Pollution **Exposure: Noise Level**	
Indicator	% of population exposed to noise level higher than standard
Rationale	This indicator provides a measure of exposure to high level of noise. This indicator can show variations in noise level in different areas and can be linked with effects from excessive noise
Data required	Total population

	Level of noise from identified noise source Population in close proximity of excessive noise source (vehicles, industry etc.)
Data source	Specific studies need to be done due to lack of noise monitoring by any specific organization for level of noise Total population can be obtained from census
Measurement	GIS buffer function can be used to check the proximity from noise source, population on buffer area calculated using Measurement of noise level at different points
Unit of measurement	Percentage
Reference and further information	WHO (2011a)
Remarks	

Domain: Noise Pollution **Effect: Annoyance**	
Indicator	% of people reported annoyance due to noise
Rationale	This indicator provides a measure of % of people having annoyance as effect of noise, since annoyance for long duration reduces the quality of life.
Data required	Total population % of population reported annoyance due to noise
Data source	Specific studies need to be done for self-reported effects Total population can be obtained from census
Measurement	The indicator can be computed as (A/P)*100, where A=No. of annoyance reported, H=Total population
Unit of measurement	Percentage
Reference and further information	WHO (2011a)
Remarks	

Domain: Noise Pollution **Effect: Tinnitus, hearing loss, hypertension**	
Indicator	% of people with illness like tinnitus, hearing loss, hypertension
Rationale	This indicator provides a measure of % of people having tinnitus, hearing loss, hypertension as effect of noise which can be linked with noise exposure
Data required	Total population % of population with illness like tinnitus, hearing loss, hypertension
Data source	The data for illness can be obtained from hospitals and other health institution, spatially resolved data is required. Total population can be obtained from census
Measurement	The indicator can be computed as (T/P)*100, where T=No. of people suffering from tinnitus or hearing loss or hypertension , P=Total population
Unit of measurement	Percentage
Reference and further information	WHO (2011a)
Remarks	

Domain: Water Pollution **State/Exposure: Quality of drinking water**	
Indicator	**Quality of drinking water**
Rationale	This indicator provides the state of contamination level in water used by people for drinking. Measure of chemical parameters as well as bacterial contamination level of drinking water is essential for monitoring access to safe drinking water as well as to measure exposure to unhealthy drinking water.

Data required	Test report on concentrations of physical parameters, chemical parameters and micro-biological parameters on drinking water
Data source	Quality of water test can be obtained from ENPHO, however for test of water in specific areas and water sources might need specific study
Measurement	Physical parameter- Dissolved solid, electrical conductivity, pH, turbidity etc. Chemical parameter- Iron, magnese, arsenic, fluoride, cyanide, ammonia etc. Biological parameter- E-coli, Total coliforms
Unit of measurement	Unit of measurement depends upon the parameters
Reference and further information	National Water Quality Guidelines, 2006 Nest (P) Ltd. (2013), Ministy of Environment (2010)

Domain: Water Pollution **State/Exposure: Water Quality/Supply**	
Indicator	**Percentage of household with access to pipe or tap water in their home**
Rationale	This indicator provides the measure of proportion of households with municipal water supply in their home, assuming the water supply to be comparatively safer than other water sources like ground water though reports had shown it contaminated too. It can be used to assess the relationship between access to safe water and health outcomes as well as to identify areas with poor access
Data required	Total household number Number of household with water supply
Data source	Total household number as well as number of household with water supply can be obtained from census data.
Measurement	The indicator can be calculated as: (P/H)*100, where P=number of household with pipe water and H=Total number of household
Unit of measurement	Percentage
Reference and further information	Nest (P) Ltd. (2013), Briggs (1999), CBS, Government of Nepal

Domain: Water Pollution **State/Exposure: Water Quality/Supply**	
Indicator	**Percentage of household using other source in addition to or without pipe water for drinking**
Rationale	This indicator provides the measure of proportion of households using additional source of water other than municipal water supply due to insufficient supply. Additional water sources such as jar water, private tankers also have extra financial burden for people as well as they are exposed to risk of contaminated water. It can also be used to assess the relationship between access to safe water and health outcomes as well as to identify areas with poor access.
Data required	Total household number Number of households using well water/ buying jar water/ buying private tankers
Data source	Total household number can be obtained from census data. Number of households using jar water or private tankers can be obtained from census data however, if household has pipe water supply and but still buying water may not be shown clearly in census data. Specific study might be needed to find out actual number in study area.
Measurement	The indicator can be calculated as: (J/H)*100, where J=number of household buying jar water, private tankers or using well water and H=Total number of household
Unit of measurement	Percentage
Reference and further	CBS, Government of Nepal

information	

Domain: Water Pollution State/Exposure: Water Quality/Supply	
Indicator	**Incidence rate of diarrhoea morbidity in children under five years of age and adults**
Rationale	Water-borne is one of the major cause of ill health and death in Nepal though urban areas have less This indicator is intended to provide a measure of this human disease burden. It can be used: • to monitor changes in the number of reported outbreaks; • to help assess the effectiveness of intervention programmes (e.g. aimed at improving drinking water quality); • to identify areas with high rates of disease, where specific actions need to be taken; • to raise awareness about the problem, and encourage action at the local or national level.
Data required	Number of outbreaks of water-borne diseases within a specified area within a specified period (e.g. a year) Total population
Data source	Total cases of waterborne disease can be obtained from hospital records and other health institutions. Department of health services under Ministry of Health and Population annually collect health records from health institutions across the nation which are in Health Information management system. The data published is aggregated to district level. Higher resolution spatial data can be expected in future. Else, designated survey might be required for case specific and spatially resolved data of required unit of analysis. Total population can be obtained from Census.
Measurement	The indicator is computed as 1000 * (N / P) where N is the number of reported outbreaks and P is the total population.
Unit of measurement	Number per thousand population
Reference and further information	(Briggs (1999)); Department of Health Services, Ministry of Health and Population, Nepal

9.2. Interview Questions to Experts

Major Problems:

1. What are the major environmental problems in Kathmandu?
2. What are the main causes for the problems?
3. What are the environmental benefits people are receiving in Kathmandu?
4. Do you think these benefits are equally distributed?
5. What are other factors that affecting the health condition of people?
6. Are environmental conditions affecting the health conditions of people?
7. Do you think some group of people is more affected or less affected by environment burden?
8. What are the wards/ neighbourhoods/ groups which are facing most environmental effects than other in Kathmandu?

Indicators:

9. Does your organization have any indicator set to study the environmental conditions? Are they based on any specific framework?
10. What indicators could explain the socio economic conditions that relate with environment and health outcomes of the people?
11. What could be the indicators to measure these environmental conditions?
12. What could be the indicators to measure the health conditions due to these environmental conditions?

9.3. Household Survey Questionnaire

Ward No.................. Sheet & House No. .... House No. & street name: ....

Name of Interviewer:	Date:

1. Name of Head of household (HoH): ....

   Name of Interviewee:.. (Age)....................

Physical condition

2. Type of house: RCC/cement mortar/mud mortar/temporary
3. Condition of house: Good/Fair/Ruinous
4. Access to House: main road/secondary road/alley/underway passage
5. Road pavement: Blacktop/ Gravel/ Stone paved/ Brick paved/ Mud
6. House Use: Residential/ Residential and commercial/ Others
7. Anyone renting in house? Yes/ No

Socio-economic Status:

8. House: Owned/ Rented
9. No. of years lived here: less than 2 yr/2-5/ 6-10/10 and above
10. Reasons for migration:

	Land availability		Infrastructure		Employment		Education		Cultural background

11. Household Income (monthly in NRs):

	less than 13000		13000-30000		30000-60000		Above 60000

12. Fuel for Cooking:

	Gas		Electricity		Kerosene		Firewoods

13. No. of rooms for household use : ....
14. Rooms: Well Ventilated/Not well ventilated
15. Vehicles owned: (Indicate Number)

	Cycles		Motorcycles		Cars/Vans		Good Carriers

16. Schools where children go:

	International level		Government		Private		Community

17. Members in household:

Member	Age	Gender	Occupation	Level of Education
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

*Note: **Occupation**: Teaching/ Government Service/ Business/ Private company employee / Factory worker/ Agriculture/others **Education**: Illiterate/Can Read and write/High School/Intermediate/Bachelor/Masters and above*

Environment: *Water and Sanitation*

18. Do you have pipe water ? Yes / No If yes, is pipe water sufficient? Yes/No
19. What source do you use for drinking purpose?

	Pipe water		Public Tap		Jar (Mineral water)		Private Tankers		Boring/Well

20. What sources do you use for other household activities?

	Pipe water		Well/Boring		Public Tap		Private Tanker		Buying from public tank

21. Do you think the drinking water quality is good? (Note: 1 for Good, 2 for Moderate and 3 for Bad)

Colour	1	2	3	Smell	1	2	3	Taste	1	2	3

22. How much water does your family needs a day for household activities?

	Less than 100 lts.		100-200 lts.		200-300 lts.		More than 300 lts.

23. Where do you send the waste water?

	Kitchen Garden		Sewer line		Underground Street drain		Surface drain		Retreat

24. Toilet Connection - Septic tank/ municipal sewer line/ septic tank and municipal line

25. Where do you dispose the household solid waste?

	Container		Street Corner		River bank		Nearby open space		Private collection

26. How often the garbage is collected in your place?

	Daily		Alternate days		Once a week		Twice a week

Air and Odour

27. What sources do you see that are polluting the air?

	Vehicle emission		Dust particles		Decay and smell		Industry

28. Is there any bad smell on any particular time or period? Yes / No If yes , When...

Noise:

29. What are the main sources of noise?

	Vehicles		Industry		Crowd		Construction		Others

30. Is noise tolerable to you and your family? Yes/No

31. Any household member suffering from effects mentioned below due to noise?

	Irritation		Headache		Hypertension		Deafness		Dizziness

32. When do you hear much noise in a day?

	Early morning		Office hours		Afternoon		Evening

Health

33. Anyone smoking cigarettes in the house? Yes/No

34. Anyone drinking alcohol daily? Yes/No

35. Where do you go for health checkup?

	Private Clinic		Health post		Government hospital		Nursing home

36. Have anybody suffered from following effects due to polluted air, dust?

	skin rashes		Irritation		Swellings		Eye-lid burning

37. Does anyone in your household suffer from any of these respiratory health diseases?

	Sore throat		Running Nose, Sneezing		Cough		Asthma		Chest Pain

Please Mention: Age………….Gender: ……………….. Disease………………..

Age…………. Gender: ……………….. Disease………………..

38. Anyone suffered from water borne diseases in last six month?

	Fever		Jaundice		Diarrhea		Typhoid		Dysentery

Please Mention: Age………….Gender: ……………….. Disease………………..

Age…………. Gender: ……………….. Disease………………..

39. Most problematic pollution in your view:

	Air pollution		Noise pollution		Water pollution		Solid waste		Drainage

9.4. Charts, Tables and Figures

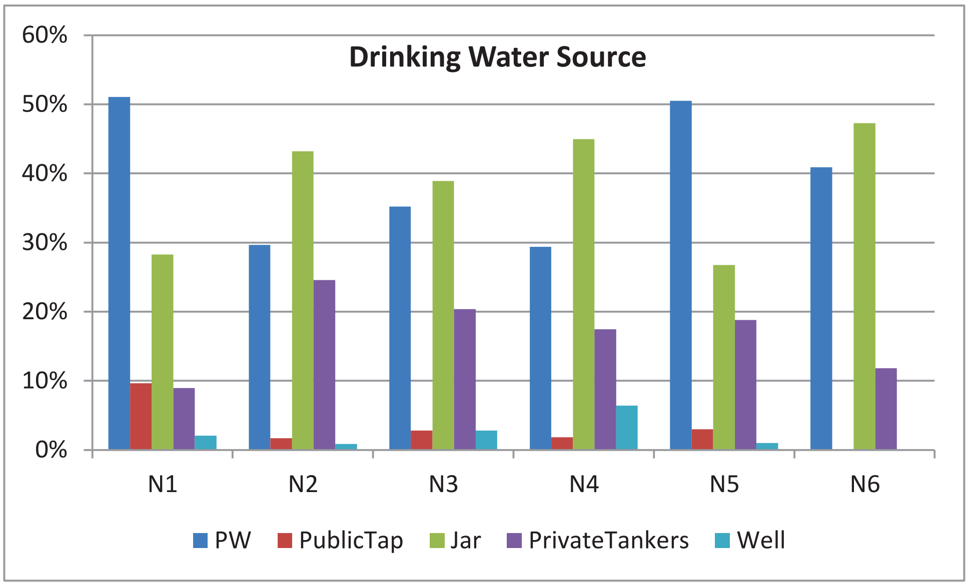


Figure 40: Major drinking water source in Neighbourhood based on multiple responses

Table 20: Waterborne disease reported in Neighbourhoods

	Fever	Diarrhoea	Jaundice	Typhoid	Dysentery	Total
N1	15.8%	18.2%	3.0%	18.2%	20.0%	(27) 14.0%
N2	10.5%	9.1%	6.1%	18.2%	20.0%	(20) 10.4 %
N3	15.8%	9.1%	21.2%	0.0%	0.0%	(29) 15.0%
N4	27.1%	54.5%	45.5%	36.4%	60.0%	(64) 32.3%
N5	15.8%	0.0%	12.1%	9.1%	0.0%	(26) 13.5%
N6	15.0%	9.1%	12.1%	18.2%	0.0%	(27) 14.0%
Total responses	(133) 68.9%	(33) 17.1%	(11) 5.7%	(11) 5.7%	(5) 2.6%	(193)100%

Table 21: Health effects in each Neighbourhood across different socio-economic class

Neighbourhood	Socio-economic class	Polluted Air Effect		Noise Effect		Waterborne Disease		Respiratory Illness	
		No	Yes	No	Yes	No	Yes	No	Yes
N1	**HSEC**	70.2%	29.8%	74.5%	25.5%	70.2%	29.8%	51.1%	48.9%
	MSEC	76.2%	23.8%	85.7%	14.3%	81.0%	19.0%	57.1%	42.9%
	LSEC	100.0%	0.0%	70.0%	30.0%	70.0%	30.0%	60.0%	40.0%
N2	**HSEC**	61.9%	38.1%	61.9%	38.1%	81.0%	19.0%	52.4%	47.6%
	MSEC	63.0%	37.0%	77.8%	22.2%	77.8%	22.2%	51.9%	48.1%
	LSEC	36.8%	63.2%	78.9%	21.1%	78.9%	21.1%	36.8%	63.2%
N3	**HSEC**	44.0%	56.0%	52.0%	48.0%	76.0%	24.0%	52.0%	48.0%
	MSEC	51.7%	48.3%	34.5%	65.5%	72.4%	27.6%	44.8%	55.2%
	LSEC	93.3%	6.7%	66.7%	33.3%	53.3%	46.7%	40.0%	60.0%

Neighbourhood	Socio-economic class	Polluted Air Effect		Noise Effect		Waterborne Disease		Respiratory Illness	
		No	Yes	No	Yes	No	Yes	No	Yes
N4	HSEC	10.0%	90.0%	65.0%	35.0%	50.0%	50.0%	50.0%	50.0%
	MSEC	63.2%	36.8%	63.2%	36.8%	36.8%	63.2%	26.3%	73.7%
	LSEC	59.3%	40.7%	37.0%	63.0%	14.8%	85.2%	18.5%	81.5%
N5	HSEC	43.8%	56.3%	43.8%	56.3%	100.0%	0.0%	62.5%	37.5%
	MSEC	74.1%	25.9%	70.4%	29.6%	63.0%	37.0%	51.9%	48.1%
	LSEC	64.0%	36.0%	80.0%	20.0%	56.0%	44.0%	48.0%	52.0%
N6	HSEC	20.0%	80.0%	53.3%	46.7%	80.0%	20.0%	66.7%	33.3%
	MSEC	19.0%	81.0%	76.2%	23.8%	61.9%	38.1%	38.1%	61.9%
	LSEC	25.0%	75.0%	50.0%	50.0%	62.5%	37.5%	20.8%	79.2%