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REVIEW ARTICLE

Is air pollution a challenge for climate change in mountainous country Nepal?

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ABSTRACT

Connectivity between pollution and climate change has been justified by the researchers. Different types of air pollutants are increasing air pollution, damaging ecosystem and challenging for climate change. Mainly industrialized and growing economies are blamed for deteriorating environment caused by pollution. Economically weak and developing countries like Nepal are bearing high cost of such air pollution led climate change. Nepal lies in the top 10 highly polluted country in the world and recently it is facing growing causality caused by climate change. Identifying the nature and type of air pollution could help Nepal to minimize adverse impact of climate change as well as demand for climate fund with regional pollutant countries. In this context, this study aims to expose the possible climate risk created by internal and external led air pollution in Nepal based on the review of past research papers. Available secondary data have also been used for analyzing challenge created by air pollution for climate change in Nepal. The study found the influence of transport of regional air pollutants, mobility and forest fire as a challenge for climate change in Nepal.

Keywords: air pollution; climate change; regional pollutants; particulate matter; Nepal

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1. Introduction

Air pollution is the outcome of mad rat race among nations for development[1]. Industrialization and globalized economy has spurred pollution all over the world. The cost of it has been realized in the form of spread of different diseases in the human society and climate change. Harmful levels of fine particulate matter (PM) exposed nearly all people (99%) on the planet with estimates linking household air pollution to 3.2 million people deaths globally and ambient (outside) air pollution to 4.2 million deaths in 2019[2]. Besides affecting human health increasing atmospheric gases are trapping energy and affecting climate in the earth[3]. Appearance of brown clouds in the atmosphere caused by pollution generated black carbon (BC) is one of the examples[4].

Nepal, a landlocked country situated between India and China and in 28^0 N and 84^0 E is facing deteriorating environmental problem. Nepalese people were suffered from indoor pollution due to use of firewood for household purposes for a long time. Now outdoor pollution is also being a challenge. Air pollution in Nepal is causing 42100 deaths every year leading to reduction of life expectancy by 4.1 years[5]. Motor vehicles which are consuming more than half of the total commercial energy use of Nepal are creating adverse environmental impact by emitting energy related emissions[6].

Incomplete and extended major road projects in Nepal are also responsible for increasing particulate matter in the air. Similarly, forest fire is also polluting the environment in Nepal. Ten times greater than the 2002-2020 average wildfires were recorded in 2021[7] and usually 2500 fire incidents occur every year in Nepal[8]. Forest fire increases the level of air pollution causing rise in the level of greenhouse gas and particulate matters in the environment[9,10] as well as creates challenges for climate change[11-13]. Air pollution, as a climate forcing agent, is one of the most alarming threat of 21st century[11]. Small countries like Nepal are bearing high socio-economic cost from it. Nepal lies in the top 10 highly polluted countries in the world[11] and such high level of pollution could have severe impact on climate change in the future.

Taking the core idea that air pollution leads to climate change, this paper has analyzed the air pollution situation of Nepal and tried to explore that how small landlocked country is being affected by air pollution caused by various means. Hence the paper aims to expose the recent sources of air pollution in Nepal and raises concern for its possible impact on climate change. In the context of growing inside and outside air pollution in Nepal, the paper attempts to attract the attention of the policy makers for prioritizing control of air pollution which can lower the adverse climatic impact in the long run. Such issue has got less attention in the academic sector of Nepal.

2. Materials and methods

The study is mainly based on secondary source of information and descriptive analysis. Hence, past scholarly articles published under the major theme of the paper "air pollution" and "climate change" are the primary source of information. Google Scholar search engine was used to find the related scholarly articles. Major key words: Air pollution in Nepal, climate change in Nepal, air pollution and climate change, waste pollution, perception on air pollution, mountain pollution, forest fire in Nepal, forest fire and air pollution were used to find the relevant academic papers. World Bank Database, mainly World Development Indicators was used to collect the data related to pollution and Global Climate Risk Index 2021 was used to collect information on climate vulnerability.

Based on the review of past research works[11-14] the linkage between air pollution and climate change was confirmed. Based on that conceptual framework was developed (**Figure 1**).

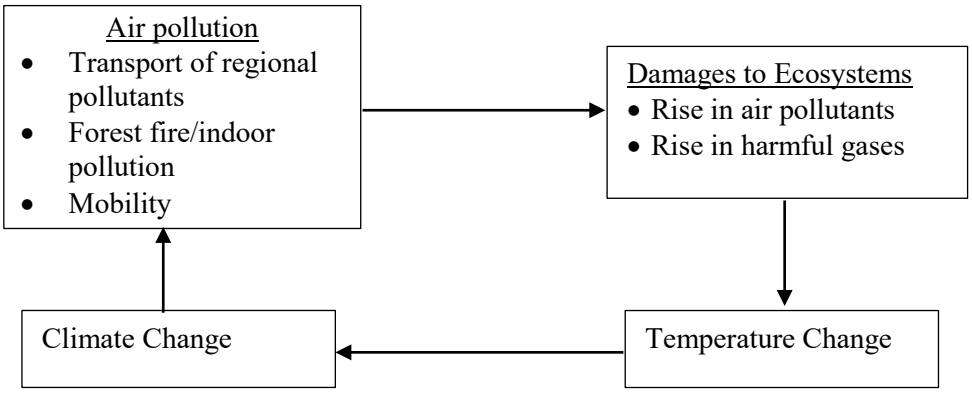

Figure 1. Conceptual framework.

Transport of regional pollutants, mobility and migration, forest fire and indoor pollution were identified as the major source of air pollution in Nepal. Air pollution through different ways damages ecosystem and leads to temperature change. Temperature change in the long run causes climate change. Climate change itself is fueling air pollution creating longer dry season and so forth.

3. Results

3.1. Transport of Regional Pollutants

Dhungel et al.[15] tried to justify that Indo-Gangetic plains are responsible for transporting pollutants to the higher Himalaya. The study used data from January 2013 to July 2015 and measured black carbon (BC) and ozone (O3) at Kali Gandaki Valley (located in western Nepal) from Jomsom station of Nepal. The high level of BC and O3 concentration during pre-monsoon season and day time was taken the major basis to justify the fact. However, the study of most populated part of Nepal, i.e., Kathmandu Valley showed that Hemispheric transport of air pollution underrates particulate matter emissions from vehicles by a factor greater than 100[16]. Long-range atmospheric transport (LRAT) was identified as primary factor for contamination on southern part of Mt. Everest[17]. It is estimated that around 50 % of the PM2.5 concentrations in Nepal is the outcome of outside country emissions, i.e., transboundary emissions[18].

3.2. Mobility and Air Pollution

Mobility and migration to urban area is causing air pollution in Nepal. Transport sector, mainly vehicles are one of major source of pollutants in Nepal. Generation of local air pollutant by motor vehicles is significant mainly in urban areas. Due to high population density and increased number of means of transport, outdoor pollution is being increased. Alongside waste management is being a major challenge in major cities of Nepal. Garbage burning was found as the major source of PM 2.5 in Kathmandu valley[19].

Different types of organic chemicals are found in fine particle in Nepal (**Table 1**). Study of Islam[20] found share of vehicle and other engines as the major source of organic chemicals. However, the Terai belt of Nepal uses dung as one of the major sources of energy which also contributes for generating organic chemicals. Share of Dung burning on organic chemicals was found as 24 % in Lumbini, which lies in the Terai belt of Nepal[20].

Table 1. Organic chemicals in fine particles in Nepal.

Sources of Organic Chemicals in Fine Particles	
Garbage burning	**15-21%**
Biomass burning	**10-17%**
Vehicle and other engines	**12-23%**

Source: *[20]*

3.3. Forest Fire and Air Pollution

Nepal lies in Hindu Kush Himalayan (HKH) Region and covers 4.1 % of the HKH area[21]. Overall HKH region is facing the challenge created by forest fire, i.e., unwanted wild fires[22]. It is perceived as the source of air pollution[10,12] and landlocked country Nepal is being highly affected by forest fire. Such forest fire is found increased during the period of increase in economic activities. During Covid-19 lockdown the number of forest fire incidents decreased by 6.51 % in community managed forests in Bagmati Province and 8.11 % in the districts having small area of community managed forests per capita[23]. Forest fire in Nepal is the primary driver to carbon stock changes, damage to ecosystem through severe impact on biodiversity loss like that of devastating wildfire of Australia in 2019-2020 and increasing environmental pollution[24]. Even the residence near by capital city Kathmandu is found highly affected by forest fire. Livelihood of the people living nearby Shivapuri Nagarjun National park was found highly affected and surrounding area was suffered from pollutants caused by the frequent occurrence of forest fire[25]. Emissions from forest fire influence the air quality up to a high altitude. Forest fire emission had influenced the air quality upto 6.5 km altitude in North Western Himalaya of Uttarakhanda, India[26]. Having a border with India, there seems the possibility of transmission of pollutants created through forest fire in Nepal also.

3.4. Perception on Air Pollution

Automobile traffic, cement and brick factories were blamed by the public for the poor air quality in big cities like in Kathmandu valley[27]. Perception of people engaged in different occupations of Kathmandu Valley indicates that vehicle emission and dust particle contribute air pollution by 38% and 45 % respectively[28]. Open burning of waste is creating problems even at regional area. People of Pokhara, a famous tourist destination accepted that 40.6% of the domestic waste was treaded by open burning[29]. Nepal Demographic and Health Survey (2016) based study revealed that still 60% of households use wood for cooking whereas 30 % were using LPG[30] and illiteracy is found contributing increasing such type of indoor pollution causing air pollution. Though people have started using improved cooking stoves in rural areas[31] which is contributing to improve indoor air quality yet such effort is insufficient to control indoor air pollution.

Thus, Nepal is grappling with the issue of air pollution from both internal and external sources. However, this study is unable to find the scientific linkage created by the past research papers related to Nepal on air pollution and its impact on climate change. However, past international research findings show the possible threat of air pollution on climate change. Growing climatic causalities in Nepal also indicate the increase in climate led pollution through wildfire during dry season. It indicates both the linkage between air pollution and climate change. So, there is the need for rigorous study on this subject matter in Nepal.

4. Discussion

Environmental pollution in Nepal is in increasing trend. CO_2 emission, total greenhouse gas emissions are showing increasing trend during the period 1990 to 2020 (**Figure 2** to **Figure 4**)[32]. As Nepal is in high altitude than its neighboring countries like India, Bangladesh, Pakistan and Sri Lanka and these neighbors are contributing for more pollution generation, it directly affects air pollution and climate change through atmospheric transport[15,17] of particulate matter.

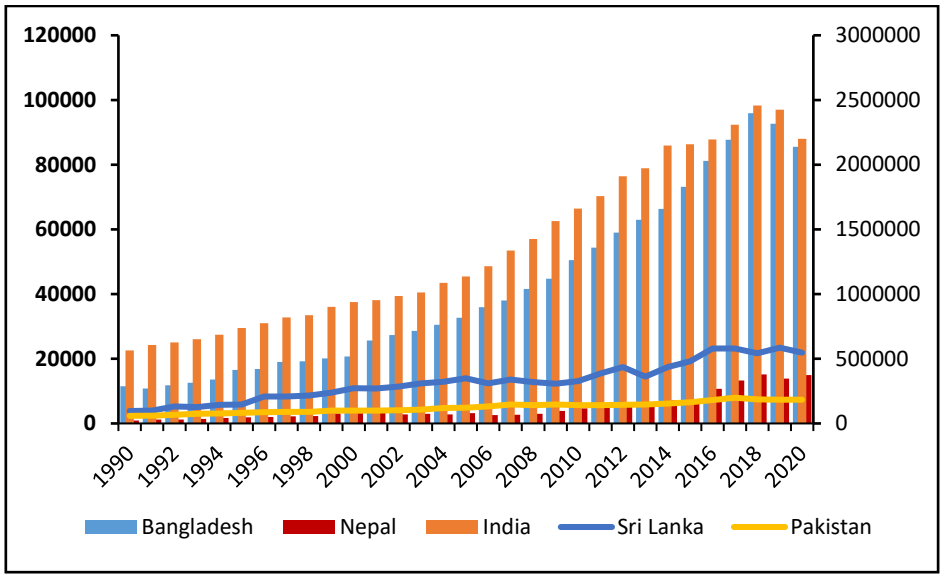

Figure 2. CO_2 emissions (kt).

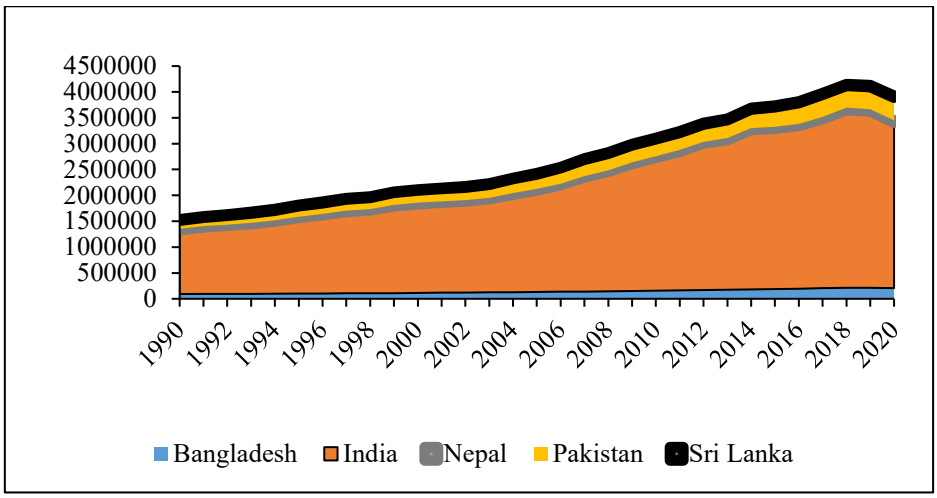

Figure 3. Total greenhouse gas emissions (kt of CO_2 equivalent).

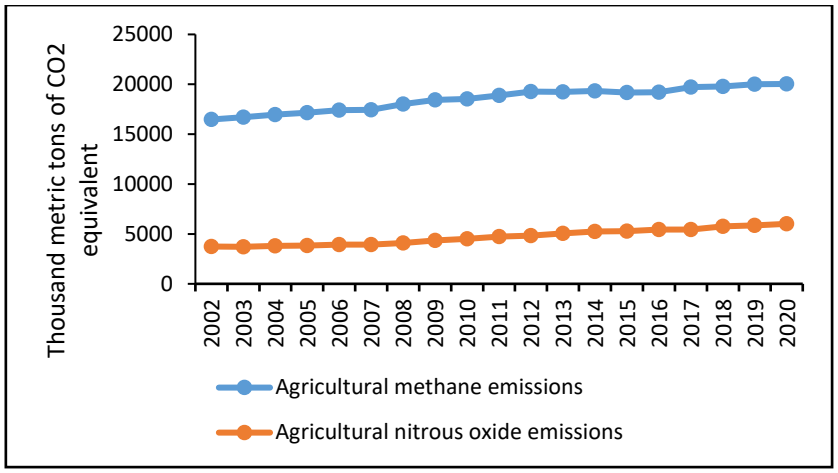

Figure 4. Methane and nitrous oxide emission by agriculture sector.

Different models used by the researchers over time indicates that the social cost of carbon is increasing over time[33]. Environmental pollution is leading to climate change which has resulted increasing number of fatalities along with the increased number of events. **Table 2** shows the status of South Asian countries falling in the 10 most affected countries from 2000 to 2019[34]. Bangladesh, Pakistan and Nepal lie on the 7th, 8th and 10th most affected countries from climate change. Though Nepal is 10th mostly affected country in terms of risk average annual number of events is highest (191) in comparison to Bangladesh and Pakistan. It indicates possibility of more economic and human damages in the future in Nepal. Glacier lake burst and expansion of their size in Nepal has attracted the attention of researcher worldwide. Research has shown ~25 % expansion of surface areas of glacial lakes of Nepal during the period 1987 to 2017[35] and it is further expected to burst of few lakes in the near future. This is the clear impact of climate change. Though this is the outcome of human led pollution, mainly air pollution concentration, focus is given more for climate change policy only.

Table 2. The Long-Term Climate Risk Index (CRI): The 10 countries most affected from 2000 to 2019 (annual averages).

Long-term climate risk index: CRI (2000-2019)	Country	CRI score	Fatalities	Fatalities per 100 000 inhabitants	Losses in million US$ PPP	Losses per unit GDP in %	Number of events (2000-2019)
7	Bangladesh	28.33	572.5	0.38	1860.04	0.41	185
8	Pakistan	29	502.45	0.3	3771.91	0.52	173
10	Nepal	31.33	217.15	0.82	233.06	0.39	191

Around 89% forest fire in Nepal is found occurred in Nepal during the dry season, i.e., in March, April and May[36]. During the period 2001 to 2020 average number fire incidence and hectare of forest area burnt was recorded as 3098 and 172,040.65 respectively[37]. Forest fire results abnormal change of air quality and air pollutants[38] which ultimately affects climate change. However, the real impact of forest fire on climate change in Nepal is yet to be explored.

Now a days, researchers are also prioritizing local air pollution as the more urgent problem than that of global climate change. Air pollution is the contemporary issue which is propelling climate change[3]. Bollen et al.[39] have shown larger short term benefits from air pollution control than the long term benefits that could be obtained through climate change measures and suggested for global climate change policy plus local air pollution policy for the long term solution. Indeed, risk of pollution and climate change is the outcome of the interaction between the natural phenomenon and human led actions or activities[40]. Though Nepal falls within top ten highly polluted countries of the world[41] yet focus is not found for controlling pollution and raising issues of pollution induced effect on climate change in Nepal. So, small mountainous country like Nepal can mitigate the problem of climate change along with keeping local air pollution in priority.

5. Conclusion

This paper has tried to explore the causes of air pollution in Nepal and raise attention for its future impact on climate change. Based on the review of Nepal based scholarly research papers the study found transport of regional air pollutants, forest fire, indoor air pollution and mobility of people as the major sources of air pollution in Nepal. As Nepal is unable to fully implement pollution control policies, increasing level of indoor and outdoor pollution has deteriorated the air quality. So, growing air pollution in the form of domestic pollution or transboundary pollution is a challenge for climate change in Nepal. The increased number of climatic events can be mitigated along with the air quality control policy. Nepal should increase its bargaining power for compensation of climatic impact caused by air pollution of neighbouring and industrialized countries by identifying the future climate risk caused by different sources of air pollution. However, there is lack of sufficient research in such areas. So, this study suggests further research based on the linkage of air pollution and climate change in different region of Nepal.

Conflict of interest

The authors declare no conflict of interest.

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