

Aerosol-Induced Climate Change Affects Rural Livelihoods: A Case Study

Dr. Rajesh Kumar

Assistant Professor, Department of Physics, Sardar Patel University Mandi, Himachal Pradesh, India

Abstract

Atmospheric aerosols vary widely in size and chemical composition and both are important in governing their effects on climate and health. For climate effects, the number of intermediate size particles is more important than the mass whereas the ecological effects are solely influenced by the mass concentration. The various examples of aerosols are nucleation particles, soot particles, ammonium sulphate particles, pollen, mineral dust particles etc. Aerosols affect the climate directly by scattering and absorbing the solar radiation and indirectly by modifying the properties of clouds. All aerosols except black carbon cause cooling. Aerosols have short lifetime of few days or weeks in comparison to the long lifetime of greenhouse gases. Therefore, aerosol effects are more regional and less persistent into the future than those of greenhouse gases. As a consequence of reductions in aerosol concentrations there will be a more pronounced warming due to greenhouse effect. Aerosols also contribute to acid rain and affects visibility in the troposphere by forming fog, mist, smog and haze etc. The climate change affects the social and economic status of farmers. The effects of change of the climatic factors are studied on the fruit crops, vegetable crops and agricultural crops along with the effect on livestock. The main aim of this study is to determine whether or not, climate has/had a detrimental effect on the choice of crop, usage of pesticides, and various adaptation techniques followed by the farmers. The study is based on the stratified random sampling technique.

Keywords: Aerosol, Climate Change, Health, Agriculture, Farmers.

1. INTRODUCTION

Air, water, and land are associated with the atmosphere by exchanging gases, which is important for the weather and property of climate. The climate has undergone considerable changes due to natural processes in recent decades. Impact of aerosols on climate change and health-related issues has drawn considerable attention (Y.J. Kaufman et. al., 2002, S. Menon 2002, J. Schneider 2013, T. Takemura 2010, J. Jung et. al., 2009) worldwide in last few decades. Aerosols (natural or anthropogenic), an aero-solution; clouds of microscopic particles in air, are suspensions of fine solid particles or liquid droplets within air or in gases. Aerosols are natural as well as anthropogenic and cause reduction in the visibility by forming fog, mist and brown clouds etc. The absorption and scattering of solar radiation by aerosols influences Earth's radiation budget and hence lead to climate change. Climate change involves heightened temperatures across numerous worlds (D. S. Battisti, 2009, C. Schuurmans, 2021, A. Weisheimer et. al., 2005, M. K. Yadav et. al., 2015). The absorption (scattering) of the solar radiation by aerosols results in warming (cooling) of the atmosphere thereby causing global warming (cooling). In addition to their role in climate change, aerosols are also of interest because they contribute to acid rain, are cause of poor visibility and can affect human health as well. Numerous international studies have looked at the relationship between aerosols and increased mortality. According to a recent international Commonwealth Science Council conference, aerosol pollution kills thousands of people every day worldwide. The health impact of aerosols consists of both short-term acute symptoms, like asthma and bronchitis, and

long-term chronic irritation and inflammation of the respiratory tract, which can potentially lead to cancer.

These pollution problems not only cause local problems, but also lead to the degradation of regional air quality. In concern to this, the pollution hazards that can be created by the aerosols as air pollutants in a small region or globally can be studied with the help of parameters like sources of aerosols and their formation, their size number distribution, mass concentration, chemical composition and optical activities etc. In this paper, we discuss few of these parameters and related aerosol effects. The impact of global climatic change on agriculture has recently become a subject of increasing importance. With increasing concentrations of green house gases, there have been many adverse impacts on the global climatic patterns (R. K. Mall, et. al., 2006). Increasing concentrations of CO₂ in the atmosphere are linked to a high probability of climate change, characterized by the increased surface temperatures, by the changed global and regional patterns of precipitation that could threaten ecosystem functions and human welfare (F. N. Tubiello et.al., 2002). The effects of change of the climatic factors are studied on the fruit crops, vegetable crops and agricultural crops along with the effect on livestock in Balh Block of District Mandi of Himachal Pradesh. The main aim of this study is to determine whether or not, climate has/had a detrimental effect on the choice of crop, usage of pesticides, and various adaptation techniques followed by the farmers. The study is based on the stratified random sampling technique. Effects of aerosols (Y.J. Kaufman et. al., 2002, S. Menon 2002, J. Schneider 2013, T. Takemura 2010, J. Jung et. al., 2009) are mainly; effects on atmospheric properties, visibility reduction, fog formation and precipitation, solar radiation reduction, temperature and wind distribution alteration e.g. climate change, effects on materials, effects on vegetation and health.

1.1 Effects of Aerosols on Climate:

Several types of atmospheric aerosol have a significant effect on Earth's climate: volcanic, desert dust, sea-salt, that originating from biogenic sources and human-made. Volcanic eruptions release large amounts of sulphuric acid, hydrogen sulfide and hydrochloric acid into the atmosphere. These gases represent aerosols and eventually return to earth as acid rain, having a number of adverse effects on the environment and human life. Volcanic aerosols are formed in the stratosphere after an eruption as droplets of sulfuric acid that can prevail for years and reflect sunlight. Desert dust, mineral particles blown to high altitudes, absorbs heat and may be responsible for inhibiting storm cloud formation. Human-made sulfate aerosols, primarily from burning oil and coal, affect the behavior of clouds. Aerosols interact with the Earth's energy budget in two ways, directly and indirectly. e.g., a direct effect is that aerosols scatter and absorb incoming solar radiation. This will mainly lead to a cooling of the surface due to backscattering of solar radiation but may also contribute to a warming of the surface due to absorption of incoming solar energy by black carbon. Intermediate sized aerosols, 0.1 to 2 μm diameter, are the most effective at backscattering of solar radiation. In order to model the climate effect of aerosols it is necessary to know the spatial distribution of aerosols. While the sign of the total aerosol forcing is uncertain, it is clear that the radiative forcing associated with sulfate and nitrate aerosols is negative. Thus, these aerosols produce a cooling that can potentially offset some of the warming due to increasing concentrations of greenhouse gases. This will be an additional element to the greenhouse effect and therefore contributing to the global climate change.

Another most noticeable effect of aerosol pollution is reduction in atmospheric visibility. Pollutants (particles and some gases) scatter and absorb light in the air and cause poor visibility. Those particles, referred to as fine particles, are in general smaller than 2.5 μm in aerodynamic diameter. Although all hydrometeors, solid and liquid, can be described as aerosols, a distinction is commonly made between such dispersions (i.e. clouds) containing activated drops and crystals, and aerosol particles.

The atmosphere of Earth contains aerosols of various types and concentrations, including quantities of natural inorganic materials; fine dust, sea salt, or water droplets, natural organic materials; smoke, pollen, spores, or bacteria anthropogenic products of combustion such as; smoke, ashes or dusts. Aerosols can be found in urban ecosystems in various forms, for example, dust, smoke, Mist from aerosol spray cans Soot or fumes in car exhaust. When aerosols absorb pollutants, it facilitates the deposition of pollutants to the surface of the earth as well as to bodies of water. This has the potential to be damaging to both the environment and human health.

1.2 Effects of Aerosols on Health:

Aerosol particles with an effective diameter smaller than 10 µm can enter the bronchi, while the ones with an effective diameter smaller than 2.5 µm can enter as far as the gas exchange region in the lungs, which can be hazardous to human health. In general, inhalation of airborne particles contributes to excess mortality and morbidity, not all adverse effects result in death. Specific health points include: Declines in lung function, increased respiratory symptoms such as cough, shortness of breath, wheezing and asthma attacks, chronic obstructive pulmonary disease, cardiovascular diseases, Lung cancer.

2. METHODOLOGY

The effects of aerosols induced climate change on rural livelihood of Balh block of Mandi District, Himachal Pradesh has been studied in terms of a survey on various parameters.

2.1 Study Area

Himachal Pradesh is situated in the north-west part of India and spreads between 30° 30' and 33° 15' north latitudes and 75° 30' and 79° 0' east longitudes. The entire state of Himachal Pradesh is covered under Himachal Pradesh Himalayas, which is a part of the Northern Mountains situated between Jammu & Kashmir Himalaya and Uttar Pradesh Himalaya. On the basis of homogenetic characteristics, this broad region of the state has further sub-divided into four micro regions viz. Northern Himachal Pradesh covering Chamba, Trans Himalayan Zone covering Lahul & Spiti and Kinnaur, Central Himachal Pradesh covering Kangra, Hamirpur, Una, Mandi and Kullu and Southern Himachal Pradesh covering Bilaspur, Shimla, Solan and Sirmaur districts. Mandi district falls in the central portion of Central Himachal Pradesh which is one of the four micro regions of the State. It lies between 31° 13' 30" and 32° 04' 22" north latitudes and 76° 36' 08" and 71° 23' 26" east longitudes and is bounded by Kangra district in the north and north-west, Hamirpur and Bilaspur districts in the west, by Solan and Shimla districts in the south and by Kullu district in the east. Balh is one of the 12 blocks of Mandi district lies between north latitude ~31°13'–32°04' and ~76°37'–77°23' east longitude, located in central Himachal Pradesh. The Balh block is spread over 51 panchayats and 193 villages (M.K. Vaidya, et. al., 2011).



FIGURE 1: Map of Mandi District showing study area Balh Block (Source Distt. Human Development Report Mandi, Himachal Pradesh).

2.2 Sampling Technique

The study area was selected using stratified random sampling technique. First the Balh block was chosen which consists of 53 panchayats. Thus, at the second stage, 10% of the total numbers of panchayats were selected randomly. Consequently, the survey was conducted in four panchayats, namely Mandal, Nagchala, Kummi and Nalsar. In the third stage, 10% of the total number of villages were selected in each panchayat and at the last stage, 10% of the total number of households were surveyed in each of the selected villages. In all, 25 households were chosen for the detailed survey. The information on different social, economic and climatic attributes was gathered using pre-structured questionnaire.

3. RESULTS AND DISCUSSION

The climate change due to atmospheric aerosols has major impact on status of farmers.

3.1 Status of livestock

The number of animals has reduced. In almost 80% of the cases, no income was reported from the livestock and the products were used for self consumption.

- The number of local cows, buffaloes and goats has reduced significantly since 1990.
- The number of exotic cows has increased since 1990.

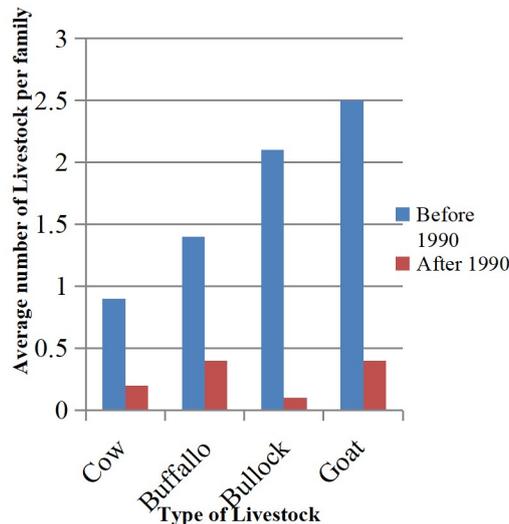


FIGURE 2: Graphical Representation of the average number of Local Breed livestock.

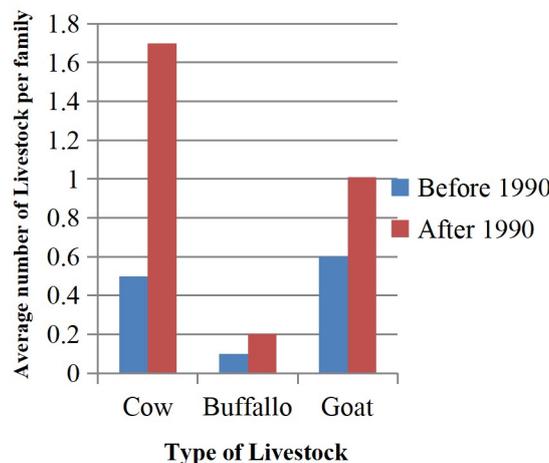


FIGURE 3: Graphical Representation of the average number of Improved Breed livestock.

3.2 Effect on Vegetable Crops

The main vegetable crops grown in the region include tomato, Cauliflowers, Radish and Capsicum. In the last 20 years, there has been an increase in the trend of growing cash crops. In some areas, farmers grow cauliflower, cabbage, pumpkin, brinjal, potato, onion, etc.; but these are mainly grown for the purpose of self utility. In some regions, Mustard was grown earlier and faced the problem of premature leaf fall. The reason for this could be occurrence of disease. Before 2000, the type of manure mainly used was cow dung; while after 2000, the farmers started using NPK fertilisers and urea in addition to cow dung. Even vermi compost is used in some areas. Before 2000, the pesticides used included lime, Blitox, Bavistin, Metasystox, Challenger and Dithane. The pesticides were used only by around 60% of the families included in the survey. After 2000, there has been a rapid increase in the application of pesticides and today almost 90% of the families use pesticides including lime, Blitox, Methyl parathion, Metasystox, Profenofos, Bavistin, Ridomil, and Nuvan. In addition, some of the farmers make use of Streptocyclin as a growth regulator. The number of diseases and pests has seen a rapid increase because farmers have replaced the local varieties with the improved (hybrid) varieties; for instance, occurrence of black spots and premature leaf fall in case of capsicum.

3.3 Effects on Agricultural Crops

The main types of agricultural crops grown in the region include Maize, Wheat and Paddy while Mustard is also grown in some regions. Earlier Paddy and pulses were grown in some areas, but now due to scarcity of water and other reasons (mainly animals such as monkeys, Peacocks and wild boar) these are not grown any longer or grown in meager amounts. The type of manure used before 2000 included cow dung; now the farmers make use of NPK fertilisers along with cow dung. There are not any types of pesticides employed by farmers, except a weedicide to control Lantana and Parthenium.

3.4 Farmers' Perception about the Changes in Climatic Parameters

- decrease in rainfall
- rise in temperature
- decrease in ground water recharge
- increase in the intensity of windstorm
- increased incidence of pests
- increased incidence of diseases
- increased incidence of rodents
- increased incidence of animals

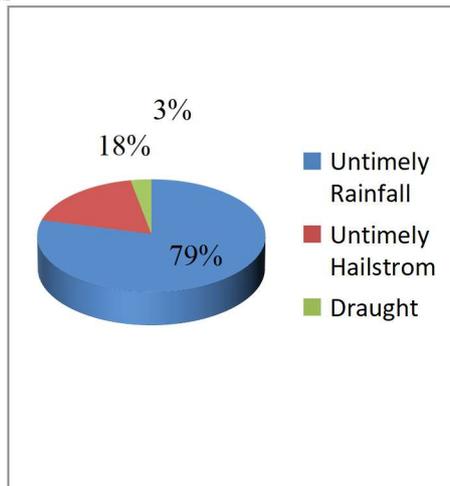


FIGURE 4: Farmer's perception about weather conditions in the region.

3.5 Adaptations Undertaken by Farmers:

(i) Rainwater harvesting & storage: The farmers have constructed water tanks and check dams at a community level. These tanks store the rain water and satisfy the requirement of water up to some extent. Farm ponds, check dams, and rainwater systems bolster water resilience during droughts. Moreover, terrace farming is practiced which reduces the runoff.

(ii) Controlled cultivation: The farmers have adapted towards the high temperature and increased incidence of pests and animals by constructing poly houses. There are around 50 poly houses in Balh block.

(iii) Cropping methods: Some of the farmers have adopted double lane sowing method for Tomato in order to protect them against the high velocity windstorms. In some regions, sticking is employed to provide support to the tomato crops, while in others rope system is used. With the use of rope system, the production has increased by about two times.

(iv) Organic farming: About 12% of the families included in the survey practice organic farming.

4. CONCLUSIONS

Aerosols have both natural and anthropogenic sources consisting of a mixture of components: Sulfates, nitrates, ammonium, organic carbon, black carbon, sea salt, mineral dust, trace metals and water. Aerosol concentrations are highly variable in space and time due to their short lifetime. This variability is an important factor in the relatively large uncertainty surrounding aerosol effects on climate. The global warming caused by greenhouse gases is masked to some extent by the aerosol. Over the longer term i.e. decades to centuries, CO₂ will be the main driver of climate change because of its very long presence in the atmosphere. The strong increase in man-made aerosols during the middle of the 20th century has counteracted the increase in greenhouse gases during that same period, causing the global temperature to remain relatively steady. After the late 1970's however, greenhouse forcing became dominant, and the globe warmed again. Aerosol concentrations are expected to be reduced globally, but at a different pace in different regions. Reductions are achieved first in developed countries, whereas in developing countries the aerosol burden may first increase before it starts to decline at a later stage. As a consequence of reductions in aerosol concentrations there will be a more pronounced warming due to greenhouse effect. Trends in aerosol concentrations continue to have an important influence on the climate, especially regionally. The health impact of aerosols consists of both short-term acute symptoms, like asthma and bronchitis, and long-term chronic irritation and inflammation of the respiratory tract, which can potentially lead to cancer. Thus, aerosols involves spate of pollutants which creates a lot of chronic and acute diseases in human being so we have to put the foreign particles within the constraint of standard limit. This shows that aerosols have reverse effects on climate and human health. Therefore, in devising policies to curb health effects, simultaneous climate impacts should also be considered, and vice versa as both the issues are intricately linked with one another.

On the basis of survey conducted it is found that the climate change significantly impacted the social and economic status of the farmers. The Shifts in temperature, precipitation patterns, and increased pest pressures are influencing crop choices and farming practices. The farmers have shifted to modern practices like organic farming and controlled cultivation. With the rise in the number of pests and diseases, the increased usage of various types of pesticides has been reported. This has ultimately led to increased production and rise in the living standard. We also notice that with the rise in educational level, farmers are adopting to various adaptation techniques. While in cases where there is lack of education coupled with the adverse climatic changes, low production rates and a deterioration of the standards of living have been witnessed. These results suggest that climate change is likely to impose significant costs on the agricultural yield unless farmers respond swiftly by adopting appropriate adaptation strategies.



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