*International Journal of Humanities and Social Science Invention (IJHSSI)*
*ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714*
*www.ijhssi.org ||Volume 9 Issue 10 Ser. I || October 2020 || PP 53-61*

# The Health Impacts of Climate Change: A Case Study of Delhi During 2010-2017

Shailesh Kumar[1]
[1]*Department of Humanities and Social Sciences, Indian Institute of Technology Roorkee*

***Abstract***
*Climate change and pollution have proved to be one of the biggest threats to humanity. It affects the health of the individuals and development of nations as a whole. The health issues resulting from climate change range from diarrhea, malaria, dengue, tuberculosis to known acute diseases and known chronic diseases. As climate emerged as a crucial determinant of human health, environmental epidemiology has gained relevance in understanding these health issues in the context of climate change. The present study is a quantitative study of environmental epidemiology investigating the linkage between temperature and daily number of deaths in Delhi during 2010-2017. From the analysis of environmental epidemiology investigating the linkage between temperature and daily number of deaths in Delhi it is found 63% of the total death is caused by the predictors. Further it also found that average temperature and precipitation has a positive association with death while ozone and average humidity has a negative association with death.*

***Keywords:*** *Climate Change; Economics; Health; Mortality, Epidemiology*

---

Date of Submission: 06-10-2020 Date of Acceptance: 20-10-2020

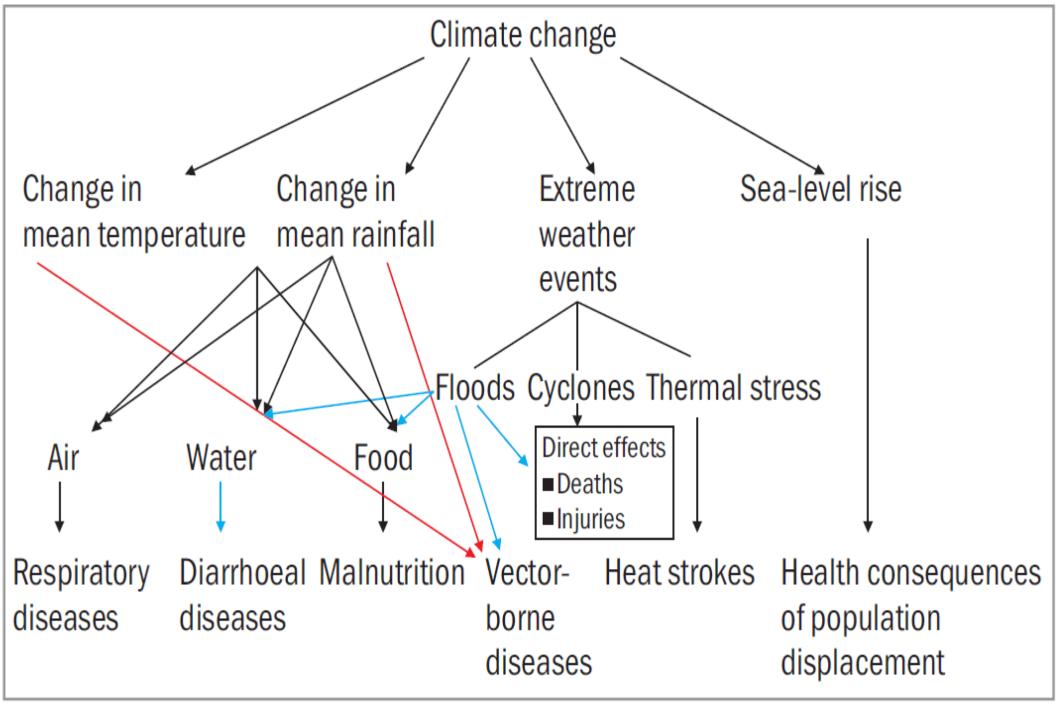
---

## I. INTRODUCTION

The climate change has stimulated many health consequences and this has become a serious concern for the humanity in the 21st century. Initially, Climate change arises from the localized sources, but it has had wide dispersed effects on our society. It has an adverse effect on all community and groups such as elderly, economically backward, women etc. are utmost vulnerable to these phenomena (Stern et al. 2006; Nordhaus, 2013). The depletion of atmospheric ozone by chlorofluorocarbons and other industrially produced compounds, the combined pressure of human population, aggregate energy consumption, and carbon-intensive technologies exceeded the coping capacity of the earth and thus human being started facing it. Global climate change may occur because of the anxiety of system operation on a global level and this makes it the human-induced environmental problem. These issues are interlinked with the economic activities (Campbell & Woodruff; 2007).

The impact of climate on human health is substantial and diverse. This can be illustrated in the following way; weather and climate affect the subsistence, distribution, and behavior of mosquitoes, ticks, and rodents that carry diseases like West Nile virus or Lyme disease. Climate and weather also influence food and water quality in a locality which will also affect human health in that area (Haines et.al. 2006). A convenient method to comprehend how climate change affects health is to consider specific exposure pathways and how they can lead to human disease. In some instances such as, heat wave impact on cardiovascular mortality. Thus, climate changes influences disease dynamics directly (Dogra & Srivastava; 2012). According to a study in World Health Organization (WHO) in 2014, Delhi categorized as the world's utmost polluted capital. The study indicated that about half the Indian capital's 4.4 million school children had issues with lung capacity and would never recover fully. The indirect effect of climate on human health is evident from crop failures or increase in activity of disease vectors. It is anticipated that infectious diseases will modify their range, intensity, and timing. The associations between climate change, mediating factors, and health consequences are complex (Hutton, 2011). The Figure 1 provides a comprehensive picture about this complex relationship.

**Figure 1: Conceptual Framework of Linkages to Climate Change and Health**




Source: Dogra & Srivastava; 2012

All the above health issues warrant a study of epidemiology and in particular environmental epidemiology which is "the study of the distribution and determinants of the health related states or events in specified population, and the application of this study to control of health problems" (Last & Logan; 1999). Therefore, having a good understanding of the health impacts of climate change through epidemiological study is a solid way to direct decision-maker in policy formulation. This research paper examines a quantitative study of health impacts of climate change in national capital of India, New Delhi during 2010-2017 and provides recommendations for policy maker.

## II. LITERATURE REVIEW

This section gives the relevant review of literature associated with climate change and health. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) estimates that global average temperatures will increase by 1-6 degree Celsius during the century (Parry et. al., 2007). Climate change affects the health of human populations via diverse pathways varying temporally and spatially (McMichael et al., 2008). Murray, 1994 proffers the development of a new method which estimates disease burden, detailing the Disability Adjusted Life Years (DALYs). In her study, she opines the pros and cons of different methods pertaining in assessment of number of deaths at each age. Last and Logan, 1999 studied the spread of awareness regarding various health hazards. The study stated that there is lack of existing framework to identify cause-effect relationship between fossil fuel combustion and global temperature trends and impact of global warming on human health and indeed on the biosphere more generally remains at least partially conjectural. Alkire et. al., 2015 to assess the consequent impact and legged effects of weather on total daily death, conducted a time-series analysis using the data obtained from 12 cities in US. In their study, for every 12 cities they used generalized additive Poisson regressions, whereas to controlling time trend and barometric pressure they applied non-parametric smooth functions. Curriero et al., 2001 looked in their study the impact of which the following factors- rainfall and runoff on site-specific waterborne disease became epidemic in United States. This paper is rested on waterborne disease database emanated from US Environmental Protection Agency. This study was an attempt, using data on precipitation from "National Climate Data Center", to highlight the relationship between waterborne diseases and precipitation. The study gave concrete evidences of the relationship that around 548 reported outbreaks from 1948 to 1994. For testing statistical significance, Fisher Exact Test (a Monte Carlo version) was applied. The results instigates that precipitation events proliferated water borne diseases around 51 percent above 90th percentile (P = .002) and 68 percent above the 80th percentile (P = .001). Endo et al,. 2007 stress out that in East Africa, the maelstrom caused by malaria will be hovered, whereas it will come down gradually in West Africa towards the end of 21st century. The synthesis, in their work, was to produce simulator for novel malaria transmission, called HYDREMATS. It has been developed acquiring complete and clear multi-year field surveys in both East and West Africa. The study finds out erratic future danger of malaria under the impact of climate change in both East Africa and West Africa. McMichael et al., 2008 have observed that the Stem report, in 2006, brings out the eventfully alarming distress to the economic system of world from climate change which has been unanticipated. They makes point that if current trend remains perpetual to erode the earth`s life support system then it will cause the vitality and health of all species suffer from greater risk. The study concludes that health professionals can play crucial role to make public comprehend for important linkage between climate and health to deal with this crisis.

Marimuthu et al., 2009 in their study analyzed the sickness prevailing in slum of metropolitan city. The objective of the work is to measure the morbidity of slum population in Delhi by taking into account their socio-economic and democratic perspectives. The paper uses a cross-sectional method. Data were composed by a two-stage random sampling method. Initially, slum locations were selected and in the next stage households were selected. Data were collected from 1049 households consisting information of 5358 individuals. The results revealed that the overall morbidity prevalence is 15.4%. It is 14.7% for males and 16.3% for females. The reported higher morbidity prevalence and the illiteracy status are pointedly associated. Ravi, Ahluwalia & Bergkvist, 2016 assesses the health risk of human being in the Delhi, the national capital in terms of morbidity and mortality because of air pollution. The model applied in this study includes spreadsheet model, the menace of mortality/morbidity due to air pollution (Ri-map) to assess the health impacts of different air pollutants existing in various parts of Delhi during the time span of 1991-2010. Researchers employed the guidelines of WHO on the concentration of air contaminants SO2, NO2 and total suspended particles (TSP), concentration-response relationship and population attributable-risk proportion. The study brings out that there were about excess case of 11934, 3912, 1697, and 16253 total mortality, cardiovascular mortality, respiratory mortality, and hospital admission of COPD respectively for the entire National Capital Region (NCT) Delhi in the year 2000. However, within a one decade, in year 2010, these numbers became 18229, 6374, 2701, and 26525 almost doubled. Kumar & Sharma 2014 estimated the impact on GHG production due to dumping of MSW in unsafe landfill sites in 23 Indian metro cities during 2001 to 2010. Measurement of waste produced was estimated using growth rate of present as well as past decades, while GHG emission are measured using LandGEM software, version 3.02. The total GWP (global warming potential) of GHG produced using dumping is identified to be 189,984 Gg of CO2equivalents which include 88.44% contribution from CH4 and the balance due to CO2. The study concludes by stating that the means to abate GHG emission and to raise funds for MSW management authorities, CH4 should be channelized as an inexhaustible energy resource.

The above literature review gave a lot of insights to formulate the present study. It is observed that most of the studies on ‘impact of climate change on health’ focused on drawing correlation between climate change and various health outcomes. However some research gaps are identified. There is no study based on the recent data particularly in the context of Delhi to address the outcome of climate change on health. The present study analyses to understand relationship between climate change and health effects from an epidemiological and public health perspective in the context of Delhi during 2010-2017.

## III. METHODOLOGY

This section presents the methodological features and analytical issues of the study. A quantitative study of environmental epidemiology demand applying statistical methods and interpreting the results, which is very challenging. The study employed out the same method and investigates the cause of deaths due to temperature humidity, and precipitation. Data on daily deaths due to different infectious disease and weather variables from 2010-2017 time periods has been gathered together. Mortality data pertaining to the time period from January 1st, 2010 to 31st December 2017 were obtained from the Health Management Information System (HMIS). Daily meteorological data during the time period of 2010-2017 which also included the daily minimum, maximum and mean temperature, pollution data, Ozone, precipitation and Relative Humidity (RH) was gathered from the Indian Meteorological Department and Central Pollution Control Board. Since mortality data is available on monthly basis, I have converted it into daily averages. The focus here is to provide insight into regression analysis in analyzing data. Data could be in principle is applied to epidemiological questions. For the temperature, Cold spells were defined as mean temperature ≤5th percentile and Heat waves as ≥95th percentile. The data on mortality contained data on the basis of diseases, and it is subdivided into diarreahal disease, reparatory disease, and heart disease, neurological, acute known and acute chronic disease.

The study attempts to quantify the association between climate factors and health mortality due to climate related diseases through regression analysis. The chief objective of regression is to investigate whether some of the short-term variation in the variable i.e. mortality can be explained by changes in the variables of climate. This study examines whether day-to-day changes in the number of deaths are explained according to the changes in different levels of Temperature. A regression approach will also allow control for multiple potential confounding factors: Ozone, Humidity, and Precipitation. The outcome variable here is a count (the number of deaths each day). R software is used for regression analysis. Independent statistical test has been used to compare the mean number of premature deaths due to different diseases which is likely to be affected by climate. Linear regression was applied to quantify the impacts of a temperature, humidity and precipitation on the daily number of deaths. Ozone, humidity, temperature, and precipitation has been considered as independent variable in the model. The model has been describe as,

$$Yt = \alpha + \beta Tempt + \gamma Ozonet + \eta humidt + \delta precipt$$

Where t is the daily observation; Yt is daily number of deaths observed ; α is the intercept term; Temp is temperature, and β is slope coefficient for temperature; and γ is Ozone coefficient, and Ozonet is independent variable observed. η is humidity coefficient, and humidt indicates humidity variable. δ is slope coefficient, and pricipt is independent variable observed for precipitation. Relative risks were estimated by the regression. Since multiple linear regression analysis has been examined, test will be two sided and probability of p value smaller than 0.05 ($P<0.05$) will be considered as statistically significant. R and Microsoft excel statistical software has been used throughout in the analysis.

## IV. RESULTS

### 1. Relations between climate variables and mortality

Descriptive analyses have been included in summary statistics and a correlation matrix for the covariates in the model. After detecting seasonality from the plots, I have find out correlation matrix between climate variables and mortality data which shows, positive relation between deaths and average temperature, average humidity and precipitation. It also shows a negative correlation between deaths and ozone.

**Table 1: Correlation matrix**

| Spearman Correlation Matrix | | | | | |
|---|---|---|---|---|---|
| | **Ozone** | **Average Temperature** | **Average Humidity** | **Precipitation** | **Deaths** |
| Ozone | 1 | 0.134 | -0.267 | -0.094 | -0.3 |
| Average Temperature | 0.134 | 1 | -0.476 | 0.051 | 0.69 |
| Average Humidity | -0.267 | -0.476 | 1 | 0.119 | -0.002 |
| Precipitation | -0.094 | 0.051 | 0.119 | 1 | 0.105 |
| Deaths | -0.253 | 0.69 | 0.002 | 0.105 | 1 |
| Data Sources: CPCB and HMIS (MFHW) | | | | | |

**Table 2: Summary Statistics**

| A brief account of mortality and climate conditions in Delhi, India, 2010–2017 | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | **Mean** | **Standard Dev** | **Minimum** | **5th per.** | **95th per.** | **Maxim** |
| **Deaths** | | | | | | |
| Total Deaths | 1053 | 498.32 | 155 | 265.25 | 1870.25 | 2118 |
| Diarrhea | 13 | 11.18 | 1 | 2 | 40.5 | 60 |
| Respiratory diseases including infections | 133 | 72.01 | 27 | 40.75 | 259.75 | 321 |
| Malaria | 5 | 6.17 | 0 | 0 | 16 | 41 |
| Tuberculosis | 50 | 21.65 | 7 | 15.75 | 81.25 | 93 |
| Fever related | 56 | 45.28 | 1 | 8.75 | 127.25 | 256 |
| Heart disease or related to Hypertension | 230 | 102.48 | 38 | 66.75 | 375 | 488 |
| Neurological disease including strokes | 66 | 40.78 | 9 | 15 | 150.75 | 234 |
| Known Acute disease | 206 | 120.96 | 8 | 31.25 | 416.25 | 464 |
| Known Chronic disease | 296 | 146.27 | 30 | 64.75 | 538.5 | 662 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Weather variables** | | | | | | |
| Mean temperature | 25 | 6.95 | 11.87 | 13.05 | 34.2 | 35.96 |
| Mean RH | 60 | 17.32 | 20.46 | 28.57 | 85.1 | 87.58 |
| | | | | | | |
| **Temperature(°C)** | | | | | | |
| Spring (March-May) | 28.79 | 4.66 | 21 | 21.73 | 34.29 | 34.48 |
| Summer (June-August) | 31.5 | 1.91 | 28.96 | 29.15 | 34.96 | 35.96 |
| Fall (September-November) | 25.57 | 3.78 | 19.26 | 19.72 | 30.05 | 30.36 |
| Winter (December-February) | 15.4 | 2.18 | 11.87 | 12.38 | 18.93 | 19.107 |

Data Sources: CPCB and HMIS (MFHW)

There were 101247 deaths happened during the period of study in Delhi, among which 1218 (1.20%) deaths happened due to Diarrheal diseases, 12771 (12.62%) of respiratory disease, 474 (0.46%) of malaria, 4809 (4.75%) of tuberculosis, 5381 (5.32) of fever related, 22060 (21.81%) of heart disease or related to hypertension, 6336 (6.26%) of neurological diseases including strokes, 19746 (19.52%) of acute know diseases and 28442 (28.12%) of acute chronic diseases.

The average monthly number of deaths observed was 1053.44 for mortality, 12.68 due to Diarrheal diseases, 133.03 for respiratory disease, 4.93 for malaria, 50.09 for tuberculosis, 56.05 for fever related, 229.79 for heart disease or related to hypertension, 66.00 for Neurological diseases including strokes, 205.68 for acute know diseases, and 296.27 for acute chronic diseases. The average mean temperature on a monthly basis was 25.31°C (range 11.87°C to 35.96°C). The average monthly mean relative humidity was 59.99% (range 20.46% to 87.58%). The 5th percentile of temperature stood 13.05°C and 95th percentiles of temperature stood 34.2°C (Table 2).

**2. Effects of climate change and health**

For the temperature, Cold spells were defined as mean temperature ≤5th percentile (13°C) and Heat waves as ≥95th percentile (36°C). There were cold spells of 245 days in the study period in 2010–2017. The lowest minimum temperature was below 6°C and the highest minimum temperature was 13°C. There were Heat waves of 196 days in the study period in 2010–2017. The lowest minimum temperature was below 36°C and the highest minimum temperature was 42°C.

There were an overall total of 24,465 non-accidental deaths in winter seasons in Delhi during 2010-2017. Among which 243 (0.99%) death happened due to Diarrheal diseases, 3336 (13.63%) of respiratory disease, 78 (0.31%) of malaria, 1170 (4.78%) of tuberculosis, 751 (3.06%) of fever related, 5601 (22.89%) of heart disease or related to hypertension, 1644 (6.71%) of neurological diseases including strokes, 4841 (19.78%) of acute know diseases, and 6865 (28.06%) of acute chronic diseases.

An aggregate of 25,578 deaths were revealed over the summer seasons of the period of study, among which 341 (1.33%) death happened due to Diarrheal diseases, 3131(12.24%) of respiratory disease, 148 (0.57%) of malaria, 1245 (4.86%) of tuberculosis, 1252 (4.89%) of fever related, 5378 (21.02%) of heart disease or related to hypertension, 1598 (6.24%) of neurological diseases including strokes, 5082 (19.86%) of acute know diseases, and 7408 (28.96%) of acute chronic diseases.

**Table 3: Regression result of climate variables on all causes death**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=65.48 |
| Model | 64075 | 4 | 16018.8 | | | Prob> F =0 |
| Residual | 713619 | 2917 | 244.6 | | | R-squared =0.6355 |
| | | | | | | Adj R-squared =0.6349 |
| Total | 777694 | 2921 | 16263.4 | | | Root MSE =15.64 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t stat | P value | 95% Confidence Interval | |
| Ozone | -0.16 | 0.01 | -14.58 | 0 | -0.18 | -0.13 |
| Avg_Temp | 0.17 | 0.04 | 3.85 | 0 | 0.08 | 0.26 |
| Avg_Humidity | -0.03 | 0.01 | -2.24 | 0.02 | -0.07 | -0.004 |
| Precipitation | 0.51 | 0.11 | 4.53 | 0 | 0.29 | 0.73 |
| intercept | 41.41 | 2.05 | 20.18 | 0 | 37.39 | 45.44 |

The results of linear regression (Table 3) show (F (4, 2917) =65.48, P =0.00) that the model is a good fit. The F statistics is 65.48 (P<0.00) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 63% of variance in Deaths is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths. It explains that Average temperature (β= 0.17, P<0.05), the precipitation (β= 0.51, P<0.05) has a positive association with Deaths whereas Ozone 10 (B= -0.16, P< 0.05) and average humidity (β= -0.03, P<0.05) has a negative association with Deaths, which is unexpected.

**Table 4: Regression result of the risk of deaths due to respiratory diseases**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=93.254 |
| Model | 1847.1 | 4 | 461.77 | | | Prob> F =0 |
| Residual | 14444.2 | 2917 | 4.95 | | | R-squared =0.743 |
| | | | | | | Adj R-squared =0.7425 |
| Total | 16291.3 | 2921 | 466.72 | | | Root MSE =2.225 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t-stat | P value | 95% Confidence interval | |
| Ozone | -0.026 | 0.001 | -17.09 | 0 | -0.029 | -0.023 |
| Avg_Temp | 0.009 | 0.006 | 1.45 | 0.14 | -0.003 | 0.022 |
| Avg_Humidity | -0.005 | 0.002 | -2.31 | 0.02 | -0.01 | -0.0008 |
| Precipitation | 0.117 | 0.016 | 7.29 | 0 | 0.085 | 0.14 |
| intercept | 5.918 | 0.291 | 20.27 | 0 | 5.34 | 6.49 |

The results of linear regression (Table 4) show (F (4, 2917) =93.25, P =0.00) that the model is a good fit. The F statistics is 93.25 (P<0) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 74% of variance in Deaths is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths. It explains that Average temperature (β = 0.009, P<0.05), the precipitation (β = 0.117, P<0.05) has a positive association with Deaths whereas Ozone (β = -0.02, P< 0.00) and average humidity (β = -0.005, P<0.05) has a negative association with Deaths, which is unexpected.

The results of linear regression (Table 5) show (F (4, 2917) =65.49, P =0.00) that the model is a good fit. The F statistics is 65.49 (P<0) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 57% of variance in Deaths is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths. It explains that the precipitation (β = 0.094, P<0.05) has a positive relationship with Deaths whereas Ozone (β = -0.035, P= 0.00) and average humidity (β = -0.019, P<0.05) has a negative association with Deaths, which is unexpected. The beta value of average temperature (β = 0.001, P>0.05) is statistically insignificant which is also unexpected.

**Table 5: Regression result of the risk of deaths due to heart diseases and related to hypertension**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=65.491 |
| Model | 2735.3 | 4 | 683.82 | | | Prob> F =0 |
| Residual | 30457.7 | 2917 | 10.44 | | | R-squared =0.572 |
| | | | | | | Adj R-squared =0.5712 |
| Total | 33193 | 2921 | 694.26 | | | Root MSE =3.231 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t stat | P value | 95% Confidence interval | |
| Ozone | -0.035 | 0.0023 | -15.29 | 0 | -0.0392 | -0.0303 |
| Avg_Temp | -0.001 | 0.0094 | -0.056 | 0.956 | -0.0189 | 0.0178 |
| Avg_Humidity | -0.019 | 0.0035 | -5.411 | 0 | -0.0261 | -0.0122 |
| Precipitation | 0.094 | 0.0234 | 4.015 | 0 | 0.0480 | 0.1395 |
| intercept | 10.669 | 0.4239 | 25.172 | 0 | 9.8380 | 11.5001 |

**Table 6: Regression result of the risk of deaths due to neurological diseases including strokes**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=9.6046 |
| Model | 73.7 | 4 | 18.42 | | | Prob> F =0 |
| Residual | 5594.2 | 2917 | 1.9178 | | | R-squared =0.392 |
| | | | | | | Adj R-squared =0.390 |
| Total | 5667.9 | 2921 | 20.3374 | | | Root MSE =1.385 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t stat | P value | 95% Confidence interval | |
| Ozone | -0.0057 | 0.001 | -5.89 | 0 | -0.0076 | -0.0038 |
| Avg_Temp | 0.0005 | 0.004 | 0.12 | 0.903 | -0.0074 | 0.0084 |
| Avg_Humidity | -0.0023 | 0.002 | -1.53 | 0.126 | -0.0053 | 0.0007 |
| Precipitation | 0.0152 | 0.010 | 1.52 | 0.128 | -0.0044 | 0.0348 |
| intercept | 2.6338 | 0.182 | 14.50 | 0 | 2.2776 | 2.9900 |

The results of linear regression (Table 6) show (F (4, 2917) =9.60, P=0.00) that the model is a good fit. The F statistics is 9.60 (P<0) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 39% of variance in Deaths is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths. It explains that Average temperature (β = 0.0005, P>0.05), the precipitation (β = 0.0152, P>0.05), average humidity (β = -0.0023, P>0.05 which is statistically insignificant whereas Ozone (β = -0.00057, P< 0.05) has a negative association with Deaths, which is unexpected.

The results of linear regression (Table 7) show (F (4, 2917) =100.51, P =0.00) that the model is a good fit. The F statistics is 100.51 (P<0.00) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 67% of variance in Deaths is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths due to acute known diseases. It explains that Average temperature (β = 0.036, P<0.05), the precipitation (β = 0.143, P<0.05) has a positive association with Deaths due to acute known diseases whereas Ozone (β = -0.048, P<0.05) and average humidity (β = -0.01, P<0.05) has a negative association with Deaths due to acute known disease, which is unexpected.

**Table 7: Regression result of the risk of deaths due to known acute diseases**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=100.51 |
| Model | 5550 | 4 | 1387.4 | | | Prob> F =0 |
| Residual | 40265 | 2917 | 13.8 | | | R-squared =0.6719 |
| | | | | | | Adj R-squared =0.6714 |
| Total | 45815 | 2921 | 1401.2 | | | Root MSE =3.715 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t stat | P value | 95% Confidence interval | |
| Ozone | -0.048 | 0.003 | -18.51 | 0 | -0.053 | -0.0432 |
| Avg_Temp | 0.036 | 0.011 | 3.3 | 0.001 | 0.014 | 0.0567 |
| Avg_Humidity | -0.010 | 0.004 | -2.39 | 0.0166 | -0.018 | -0.0018 |
| Precipitation | 0.143 | 0.027 | 5.32 | 0 | 0.090 | 0.1954 |
| intercept | 9.103 | 0.487 | 18.68 | 0 | 8.148 | 10.0588 |

**Table 8: Regression result of the risk of deaths due to known chronic diseases**

| Source | SS | df | MS | | | Number of obs=2922 |
|---|---|---|---|---|---|---|
| | | | | | | F(4, 2917)=33.027 |
| Model | 2888 | 4 | 722.06 | | | Prob> F =0 |
| Residual | 63774 | 2917 | 21.86 | | | R-squared =0.394 |
| | | | | | | Adj R-squared =0.393 |
| Total | 66662 | 2921 | 743.92 | | | Root MSE =4.676 |
| | | | | | | |
| Deaths (y) | Coefficient | Sd. error | t stat | P value | 95% Confidence interval | |
| Ozone | -0.03 | 0.003 | -9.83 | 0 | -0.039 | -0.026 |
| Avg_Temp | 0.05 | 0.014 | 4.01 | 0 | 0.028 | 0.081 |
| Avg_Humidity | -0.01 | 0.005 | -1.79 | 0.074 | -0.019 | 0.001 |
| Precipitation | 0.11 | 0.034 | 3.21 | 0.001 | 0.042 | 0.175 |
| intercept | 10.72 | 0.613 | 17.48 | 0 | 9.518 | 11.923 |

The results of linear regression (Table 8) show (F (4, 2917) =33.027, P =0.00) that the model is a good fit. The F statistics is 33.027 (P<0.00) explains that there is a linear association between the dependent variable and independent variables. The co-linearity test with Variance influence factor indicates that there is no multi-co-linearity among the variables. The adjusted R square shows that 39% of variance in Deaths due to chronic known disease is explained by the predictor variables. The beta values explain that for every one unit increase in the predictors there will be an increase in Deaths. It explains that Average temperature ($\beta$ = 0.05, P<0.05), the precipitation ($\beta$ = 0.11, P<0.05) has a positive association with Deaths due to chronic know disease whereas Ozone ($\beta$ = -0.03, P< 0.05) and average humidity ($\beta$ = -0.01, P<0.05) has a negative association with Deaths due to chronic known disease, which is unexpected.

## V. DISCUSSION AND COCLUSION

The changing scenario of climate conditions around the globe is leading to adverse impact on human health and well-being. Climate change can affect human health in both direct and indirect ways. It can affect directly through natural disasters like floods, drought, and storms and indirectly through the range of changes in vector borne diseases (through mosquitoes), infectious diseases, water quality, food quality and living conditions. Infectious diseases are due to socio demographic factors like housing type and location, density of human population, land use and irrigation system, deforestation, etc. The report of IPCC fourth assessment says that in the coming years there is an increasing threat to human health due to the overall changing patterns of climate, particularly in lower income populations mainly the countries which fall under tropical/sub-tropical.

The primary objective of the study is to understand relationship between climate change and health effects from an epidemiological and public health perspective and to examine the loss economic value lost due to climate change in context of Delhi from the period 2010 -2017. The data for the study is based on the secondary data which is been collected from sources of Health Management Information System (HMIS) which gives data on mortality and Central Pollution Control Board (CPCB) which collects data on pollution and environment. For measuring the effect of climate change on health variables like Ozone, temperature, precipitation, humidity and mortality were taken. ). The data available on monthly basis was converted into daily averages for the study. Data on meteorological variables like daily minimum, maximum and mean temperature, pollution, ozone precipitation and relative humidity are gathered from the Indian Meteorological Department and Central Pollution Control Board.

For temperature, cold spells are defined as mean temperature ≤5th percentile and Heat waves as ≥95th percentile. The data on mortality was collected on the basis of diseases, which is subdivided into diaarreahal disease, reparatory disease, and heart disease, neurological, acute known and acute chronic disease. Linear regression was applied to access the impact of temperature on the death. From the analysis of environmental epidemiology investigating the linkage between temperature and daily number of deaths in Delhi it is found that the linear regression results of climate variables on all causes death shows linear relationship between the dependent (daily number of deaths) variable and independent variable (temperature, ozone, humidity and precipitation) and no multi-co-linearity exists. 63% of the total death is caused by the predictors. Every one unit increase in the predictors result in an increasing death toll. Further it also found that average temperature and precipitation has a positive association with death while ozone and average humidity has a negative association with death.

Average temperature and average precipitation has significant role in causing daily mortality in Delhi. In all analysis, all causes death, death caused due to respiratory diseases, death due to heart related diseases, death due to neurological diseases, death due to known acute diseases, and death due to known chronic diseases, average temperature and average precipitation showed positive influence while the other two variables considered- average humidity and ozone showed unexpectedly negative influence on the death causes.

The developmental program undertaken for alleviation of poverty and hunger will aid significantly towards mitigation of health impact of climate change. Though interventions had been made at the state level but the geographical, administrative and financial implications of disease control and treatment have been overlooked in summary policy conclusions. Regional variation and funding for health system remains ignored and a major issue. Health system strengthening is another important thrust area which deserves special attention since the inefficiencies and bottlenecks in the health system of the country are so prominently visible. On a priority basis the effectiveness of the current programs need to be improved than merely scaling up without addressing the current inefficiencies. Initiation of globally proven interventions is needed for the improvement of reach, efficacy and effectiveness of current health interventions. It is high time for serious work on the functioning of how, what and why of basic health sector interventions. There is pressing need to move ahead for solutions on how to combat diseases like malaria, diarrhea and hunger in a swift and cost effective manner.

## REFERENCES

[1]. Alkire, B. C., Shrime, M. G., Dare, A. J., Vincent, J. R., & Meara, J. G. (2015). Global economic consequences of selected surgical diseases: a modelling study. The Lancet Global Health, 3, S21-S27.

[2]. Campbell-Lendrum D, Woodruff R (2007) In: Prüss-Üstün A, Corvalán C (eds) Climate change: quantifying the health impact at national and local levels, WHO environmental burden of disease series No. 14. World Health Organization, Geneva.

[3]. Curriero, F. C., Patz, J. A., Rose, J. B., & Lele, S. (2001). The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948–1994. American journal of public health, 91(8), 1194-1199.

[4]. Dogra, N., & Srivastava, S. (Eds.). (2012). Climate Change and Disease Dynamics in India. The Energy and Resources Institute (TERI).

[5]. Guy Hutton, 2011, The economics of health and climate change: key evidence for decision making

[6]. Haines A, Kovats RS, Campbell-Lendrum D, Corvalan C (2006) Climate change and human health: impacts, vulnerability, and mitigation. Lancet 367(9528):2101–2109.

[7]. Kumar, A., & Sharma, M. P. (2014). GHG emission and carbon sequestration potential from MSW of Indian metro cities. Urban Climate, 8, 30-41.

[8]. Last, J., & Logan, H. (1999). Monitoring, surveillance and research needs: Public health planning priorities and policy options. Canadian Journal of Public Health, 90(6), I3.

[9]. Marimuthu, P., Meitei, M. H., & Sharma, B. B. L. (2009). General morbidity prevalence in the Delhi slums. Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine, 34(4), 338.

[10]. McMichael, A. J., Friel, S., Nyong, A., & Corvalan, C. (2008). Global environmental change and health: impacts, inequalities, and the health sector. BMJ: British Medical Journal, 336(7637), 191.

[11]. Murray, C. J. (1994). Quantifying the burden of disease: the technical basis for disability-adjusted life years. Bulletin of the World health Organization, 72(3), 429.

[12]. Nordhaus, W. D. (2013). The climate casino: Risk, uncertainty, and economics for a warming world. Yale University Press.

[13]. Parry, M., Parry, M. L., Canziani, O., Palutikof, J., Vander der Linden, P., & Hanson, C. (Eds.). (2007). Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge University Press.

[14]. Ravi, S., Ahluwalia, R., & Bergkvist, S. (2016). Health and Morbidity In India (2004-2014). Brookings India, at, 41.

[15]. Stern, N. H., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., & Garbett, S. L. (2006). Stern Review: The economics of climate change (Vol. 30, p. 2006). Cambridge: Cambridge University Press.

[16]. World Health Organization. (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization.

Shailesh Kumar. "The Health Impacts of Climate Change: A Case Study of Delhi During 2010-2017." *International Journal of Humanities and Social Science Invention (IJHSSI),* vol. 09(10), 2020, pp 53-61. Journal DOI- 10.35629/7722