A Comprehensive Review on the Climate Change and Its Impact on Health

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Abstract: Anthropogenic activities are the main cause of climate change globally. The World Health Organization (WHO) recognized that heating and precipitation are the reason for climate change due to anthropogenic actions over the past 30 years and claim 150,000 lives annually. Climate change is also affecting the atmospheres of polar regions. Numerous diseases are linked with climate change like cardiovascular mortality and respiratory illnesses. Due to climate change, lack of long-term and high-quality data sets, variations in drug resistance and immunity, the amplification or the resurgence of diseases, as well as many socio-economic factors, are uncertain.

Potentially susceptible regions consist of the temperate latitudes, the regions near the Indian and Pacific oceans are affected due to the heavy rainfall where the heat of the cities could increase life-threatening climatic proceedings. The association between climate and health poses a risk to health under future guesses. Over the current decades, warming has contributed to increased mortality and morbidity in various provinces of the globe. The current study reviews the potential effects of climate change on temperature, human health, air quality, food & nutrition, livelihoods, and livestock & fisheries in detail.

Keywords: Climate change; Human health; World Health Organization (WHO); Anthropogenic activity.

1. **Introduction:** Climate change is the long-term change in the weather situations of a specific location. These changes may be due to natural or anthropogenic causes. Since the 1800s, the burning of fossil fuels has been the main trigger of climate change and emitting greenhouse gases into the environment. Human activities like deforestation and agriculture are also the cause of climate change which proliferates greenhouse gases. These

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gases such as methane (CH_4) and carbon dioxide (CO_2) are emitted from the burning of oil and coal to provide energy for manufacturing, transport, electricity, and heating. Mikhaylov et al. (2020) reported high concentrations (400 ppm) of CO_2 in the atmosphere and stated that it is due to the greenhouse effect. After release into the air, these gases act as a blanket in the atmosphere. Additional CO_2 comes from deforestation and industrial processes while methane comes from manure, livestock, wastewater, coal mining, rice cultivation, oil & gas extraction, and landfills (Olivier and Peters 2020).

These gases are apparent to sunlight and admit it to heat the surface of Earth. When the Earth emits heat, then the gases absorb it, and it is the main cause of global warming. An upsurge in the sea surface temperature and a decrease in air quality are the major effects due to an increase in greenhouse gas emissions. Clearing forests, cement production, and landfills for garbage are the main sources of these gases. Forests and oceans serve as significant carbon sinks. The environment of the Arctic and Antarctica is also affected due to climate change. Lots of data are existing on glacier melting and the presence of toxic pollutants. These volatile toxic pollutants are reaching the polar region through long-range atmospheric transport mechanisms (LRATM) or human activities. After reaching, these pollutants can be buried in ice for several years. At the time of glacier melting, these pollutants can affect the environment of the polar region. The researcher reported these pollutants in his studies (Bhardwaj and Jindal 2019; Bhardwaj and Jindal 2020; Bhardwaj et al. 2021; Bhardwaj and Jindal 2022a; Bhardwaj et al. 2023).

As per the study by IPCC (Inter-Governmental Panel on Climate Change), the temperature of the Earth will rise by 1.4 to 5.8 ^{o}C by 2100. Climate change is the biggest danger to universal health in the 21st century (Pachauri et al. 2014; WHO 2015). The increase in the temperature will be greater at higher latitudes. Most of the effects are experienced at the current 1.2 ^{o}C level of warming. In the future, further warming will enhance these effects and may initiate the melting of the Greenland ice sheet. In Paris Agreement (2015) 196 countries agreed to maintain warming under 2 ^{o}C (UNEP 2021). Rogeli et al. (2018) stated that warming will require halving emissions to reach 1.5 ^{o}C by 2030 and will require reaching net-zero emissions by 2050.

2. **Impacts Due to Climate Change:** There are several impacts of climate change such as warming temperatures, decrease air quality, increases in the intensity of some extreme weather measures, and rising sea levels (figure 1). These effects are affecting our food, drinking water, air, and surrounding weather and threaten our health. The severity of these impacts depends on several components such as gender, age, and behavior of the individual as well as the safety systems.

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These impacts vary from person to person and area to area. These impacts may be based on the locality of the person, the sensitivity to health threats, and exposure to climate change. Older men, pregnant women, children, out workers, sportspersons, and people with low income are most vulnerable to these impacts. Cattaneo et al. (2019) studied the effects of climate change and stated that migration may be the result of climate change. Migration may be within and between the countries and affected by changes in temperature and seasons. As per the study by Lead (2008), climate change may lead to quicker flowering, additional flowers, and boosted pollen levels in ragweed. Cramer et al. (2014) reported that effect of the climate change can now be observed on all oceans and continents.

(i) **Temperature Impacts:** Due to climate change, the temperature in the daytime and death rate in the summer months will increase (Luber et al. 2014). Respiratory and cardiovascular diseases may be the result of exposure to heat (Arbuthnott and Hajat 2017). However, the wider use of air conditioners (AC) is assumed to decrease the death rate. But people of low income may not have access to air conditioners which also raises exposure to maximum heat. Extreme heat may be the cause of heat stroke, and dehydration (Karl et al. 2009). The high temperature is more likely to affect the people of the northern latitudes where peoples are less prepared to fight the impact of heat (Lead 2008).

Workers, farmers, students, roadside vendors, and sportspersons are more vulnerable than others because they spend more time in high temperatures. Extreme heat can affect more children and older people (Watts et al. 2019). Old-age people, infants, and people with medical conditions are more in danger of high temperatures because they are less capable to adjust their body temperature (Oikonomou et al. 2012; USGCRP 2018). Due to limited financial resources, older people are more vulnerable to heat and are difficult to adapt to climate change. Due to an increase in temperature and CO_2 levels, the oceans of the world are also becoming extra acidic. Exposure to heat is greater in people, which are living in urban areas because urban areas are heater than rural areas. As per the study by the USEPA (2006), urban areas are expanding, and an estimated 67 million people per year and 1.3 million people every week are coming. Luber et al. (2014) and Hajat (2017) reported a high death rate in Chicago, Philadelphia, St. Louis, and the UK due to exposure to heat. While Haines et al. (2006) reported that an estimated 29,817 to 30,617 people were killed in Europe in 2003 due to the heat waves.

(ii) **Air Quality Impacts:** Climate change influences indoor and outdoor air quality. Heatwaves may lead to increase air pollution and associated health effects. The population of urban areas is mostly concerned by the Urban Heat Island (UHI) effect, and this effect can increase the temperature (2 to 10 °F) of the air (Vose et al.

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2004; Luber and McGeehin 2008). UHI absorbs the temperature during the daytime and releases it at night and it is the cause of rising the temperature at nighttime (USEPA 2006). Both UHI and CO_2 can affect the air quality of urban areas. While in rural areas, a forest fire is a major threat to air quality.

Forest fires due to high temperatures can create smoke and other unhealthy air pollutants (USGCRP 2018). The main sources of the worst air quality in urban areas are industrial activities, road traffic, and the use of fossil fuels for energy production and heating. Air pollution can lead to respiratory diseases like asthma, etc. People with respiratory and cardiac diseases are mostly affected by poor air quality. Ziska et al. (2003) stated that airborne allergens like ragweed pollens are the main cause of respiratory disease and increase with the increase in temperature and CO_2 level.

Increases in Ozone: High temperatures may increase the unhealthy ozone level, which may damage lung function (Kim 2016). People exposed to unhealthy ozone are in danger of dying or being admitted to the hospital with respiratory diseases. Older people, children, workers, students, and patients with chronic lung infections are at higher risk (Lead 2008). The warm air tends to expand the creation of ozone.

Changes in Particulate Matters (PMs): Particulate matters (PMs) are fine particles that are small in size (1-10 µm) and may be suspended in the atmosphere. Some particles are formed naturally from wildfire smoke, sea spray, and dust while some are formed due to anthropogenic activities like the burning of fossil fuels. These particles may be produced directly into the atmosphere or created by the reaction of some gases like nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Inhalation of these particles through breath can cause several health problems such as lung cancer, cardiovascular disease, and chronic obstructive pulmonary disease (COPD). Climate change may trigger allergic illnesses.

Climate change is responsible to raise the number of wildfires and the particles which are emitted from the wildfire can also affect the people who live far from the fire. Recently, we have seen many cases of forest fires e.g. Uttarakhand (April 2016), Amazon Forest fire (January 2019), Australia forest fire (September 2019), and Simplipal forest fire in Odisha (March 2021). Older people and people with respiratory diseases may be sensitive to these particles with exposure for a short time. Firefighters may also be affected because they always live with high exposure to these particles. The level of PMs depends on wind patterns, the chemistry of pollutants, changes in the stagnant air, and precipitation. Any fluctuations in the different causes due to climate change may lead to changes in the level of the pollutants. The maximum percentage of these particles can be eliminated from the air by precipitation.

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(iii) Impacts of Extreme Weather Events: Some risky weather conditions such as flooding, precipitation, storms, and droughts may threaten people worldwide. The effect on human health is mainly due to shifts in precipitation and warming. Continued warming has potentially served irreversible and pervasive impacts on ecosystems and people. Several extreme conditions due to climate change such as reducing the availability of drinking water and safe food, damaging bridges and roads, interrupting communication, disrupting access to health care services and pharmacies, and increasing intestinal and stomach illnesses can affect human health. The risk due to climate change is uneven and is larger for deprived people in developed and developing nations.

Old age people and people with severe medical conditions may be at high risk because they may have difficulty in understanding the warning signal of danger. Children and pregnant women are more susceptible to heat waves, drought, and flooding. Disabled people are more vulnerable to extreme weather conditions. They can face difficulty in traveling and emergency evacuation. The transportation of medical facilities such as medicines, equipment, ambulance, etc. may be difficult at the place of requirements and the needy people can suffer. Costello et al. (2009) and Smith et al. (2014) reported that severe weather condition leads to injury and death. Parry et al. (2007) stated that floods, landslides, and mudflows are associated with the increased frequency of intense rainfall. This has been watched in India, Nepal, and Bangladesh. The height of storm surges has increased with the increase in cyclone intensity and sea surface temperature. Patz et al. (2008) stated that an increased frequency of precipitation can bring the risk of waterborne disease in the future. Extreme weather conditions can contaminate the ecosystem of water bodies and increase the risk to the peoples which live near water bodies.

(iv) Impact on Human Health: Climate change poses threats to the health of people globally. Heat waves, rainfall, floods, and drought have direct effects on the health of humans (Haines and Patz 2004). Oppenheimer et al. (2015) stated that humans in the least developed area are facing the highest risk. The harmful algal blooms thrive in warm water because high temperatures and high CO_2 concentrations are suitable habitats for them. They produce toxins and contaminate the drinking water. Exposure to the toxin may cause hepatic cancer. Ciguatera fish poisoning is caused by the consumption of fish that are exposed to toxins. These algal blooms disrupt the existing ecosystems. Many weeds, fungi, and pets also thrive under increased CO_2 levels and warmer temperatures. Due to climate change, the range of potential health consequences varies from the direct effects of temperature increases to the indirect effects of population movement and mental health concerns. Due to decreasing air quality, there are several indirect and direct health results such as vector- and waterborne

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diseases, increased exposure to environmental toxins, heat-related illnesses, and exacerbation of cardiovascular and respiratory diseases.

Mental Health: Due to climate change, any changes in the physical health of persons can have serious impacts on their mental health. When the persons lose loved ones, then they can suffer from stress and other mental health diseases. There are several examples of extreme weather conditions in which people lost their relatives, e.g.: a cloudburst in Kedarnath, Uttarakhand (June 2013), the tsunami (December 2004), etc. Peoples with mental diseases are at higher risk of death because they cannot regulate their body temperature properly. News related to extreme events can increase stress levels. Old-age peoples, people with pre-existing mental diseases, pregnant women, and people with low income are at high risk of mental health impacts.

Diseases: Climate change can cause more diseases in people and the threat of economic loss. Luber and Prudent (2009) studied climate change and reported several vectors and waterborne diseases. Infectious diseases like dengue fever and malaria are more easily transmitted in warmer conditions (Watts et al. 2019). As per the study by WHO (2014, 2021), there is an assumption that approximately 2,50,000 people will die from malaria, diarrhea, dengue, heat stress, malnutrition, and coastal flooding during the period 2030 to 2050. Springmann et al. (2016) stated that nearly 5,00,000 people will die by 2050 due to the unavailability of food and water.

Vector-borne Diseases: These diseases are spread by vectors such as ticks, mosquitoes, fleas, etc. and the spread of diseases depends on climatic and non-climatic factors. The possibility of diseases can be much greater in poor nations which have less ability to treat and prevent diseases. Outdoor workers, sports persons, and workers in hot indoor environments are more likely to be susceptible to extreme temperatures and exposure to vector-borne diseases. Vectors can transfer transmittable pathogens like bacteria, viruses, and protozoa from animals to humans (Bhardwaj and Jindal 2022b). They act as bridges between animals and humans. Due to climate change, vector-borne diseases can be spread in a large geographic area. Recently, the world was suffering from the viral disease “Covid-19”. It was spread in humans from the bat. Lyme disease is caused by ticks (Ogden et al. 2006). The ticks are more active in high temperatures, and the geographic area of ticks is increasing as temperature increases. Fever, fatigue, headache, and skin rash are the symptoms of Lyme disease. Diseases such as dengue, malaria, and West Nile Virus are caused by mosquitoes in certain climatic conditions.

Gage et al. (2008) studied the transmission of diseases and stated that several other factors are also responsible for the transmission of diseases like changing economic, social, and epidemiological landscapes. The variability in climate conditions may affect the abundance and distribution of vertebrate host species, leading to a surge of

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zoonotic and vector-borne diseases. As per the study by USGCRP (2018), more than 3 million people were diseased with West Nile Virus in the United States in the period of 1999 to 2010.

Water-Related Illnesses: The risk of waterborne diseases is increased by increasing the temperature of water bodies because high temperature is fava rouble for some bacteria/viruses. The high temperature of water bodies acts as an indicator of the presence of Vibrio bacteria and other toxins. Contaminated water can cause diarrhea, and other intestinal diseases, and also affect the liver and kidneys. Climate change can affect the exposure to waterborne pathogens, toxins released from harmful algae, and chemicals disposed of in the water bodies from anthropogenic activities.

Other Health Impacts: There are other impacts of climate change that can affect human health indirectly. Floods, drought, higher temperatures, and precipitation can affect the yields of crops and their production (Brown et al. 2015). In high temperatures, the yields of the crops can decline. Pachauri et al. (2014) studied malnutrition, food poisoning, and infectious diseases and stated that these may be the result of the climate impact in some developing countries. While in developed countries trade, migration, and immigration can affect the health of humans (Lead 2008).

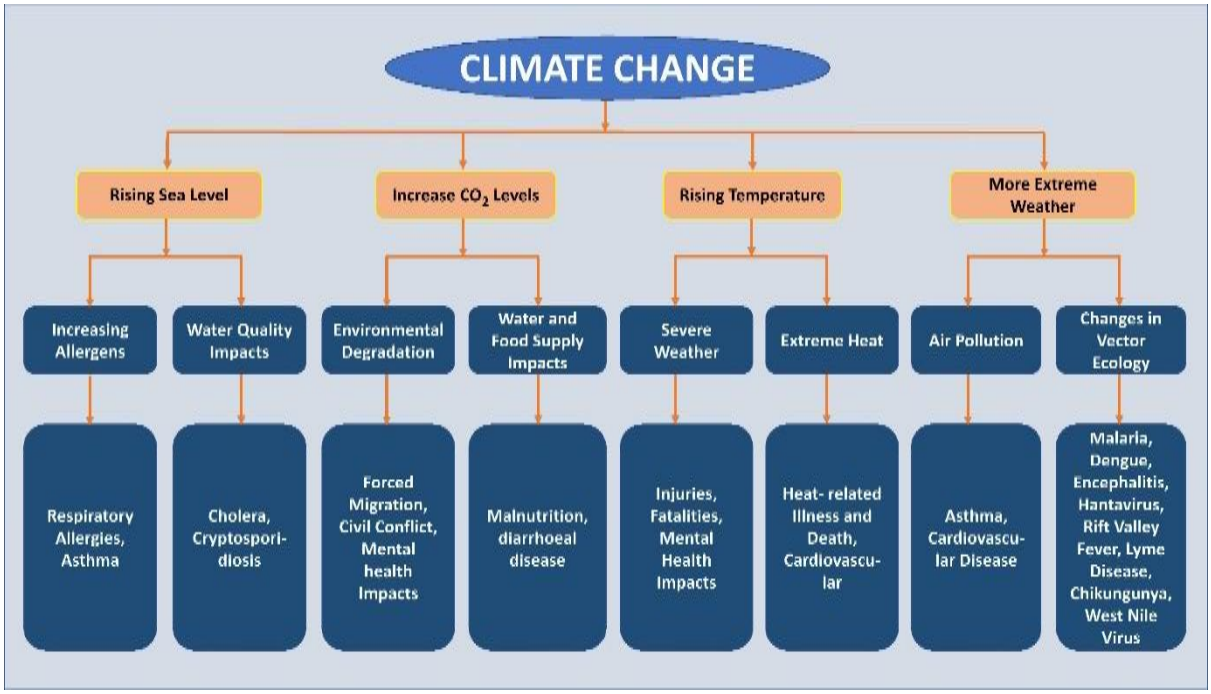

Figure 1: Impacts of Climate Change and Their Effects on Human Health

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(v) **Impact on Food and Nutrition:** Climate change affects food security. Porter et al. (2014) reported that crop production may be affected negatively in low-latitude territories, while in northern latitudes it can be affected negatively or positively. Approximately 183 million people worldwide are at high risk of hunger (Mbow et al. 2019). The global yields of maize, wheat, and soybeans have been reduced from 1981 to 2010 and it will also reduce more in the future due to high temperatures (Zhao et al. 2017). Children are vulnerable to disease due to food shortages because they are more susceptible.

The high concentration of CO_2 decreases the protein contents in rice, wheat, potatoes, etc., and makes the food less nutritious. While it acts as a fertilizer for some crops and can increase the yield of wheat and soybeans by up to 30 %. The high temperature of the air can increase the number of Salmonella and other bacteria and can contaminate the food. Because microbes grow more quickly in warm conditions. Contaminated food is the major cause of gastrointestinal diseases (Bhardwaj and Sharma 2021; Bhardwaj 2022). Practices to safeguard food can avoid several diseases. Drought and flood can disrupt the distribution of food due to the blockage of roads and waterways. The high temperature of the sea surface can lead to higher concentrations of mercury in seafood.

(vi) **Impact on Livelihoods:** Livelihood is also affected due to climate change. DeFries et al. (2019) stated that climate change may be the cause of economic damage and it also may be a risk of disastrous concerns. Inequality in the global economy has increased, and it may continue in the future (Diffenbaugh and Burke 2019). The function of climate change in armed conflict has been minor compared to state capabilities and socioeconomic inequality (Mach et al. 2019).

People who have fewer limitations over resources are facing more difficulties in mitigation and adaptation to climate shock (Resurreccion et al. 2019). People who are dependent on the land may face several problems related to their lifestyle and wellness. Most of the effects are projected in South-East Asia and Africa, where the inhabitants are dependent upon agricultural and natural resources (Olsson et al. 2014). According to the report of the World Bank, climate change can affect over 120 million people by 2030 (Hallegatte 2016).

Oppenheimer et al. (2019) studied the sea level and stated that the rising level is the main cause of the threat to coastal communities and islands. The melting of the polar ice caps is the main cause of the rising sea level. The people of several islands such as Maldives and Tuvalu may be stateless (Park 2011). In other provinces, the rise in humidity and temperature may be too serious for humans to adapt (Mattews 2018). Balsari et al. (2020) reported that one-third of humans reside in particularly hot climates like Sahara. Due to rising sea levels,

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excessive weather conditions, and increased competition for natural assets, most people are assumed to be shifted from one place to another place. Climate change may enhance liability in stuck populations who are not able to relocate due to a deficiency of resources (Flavell 2014).

(vii) **Impact on Livestock and Fisheries:** Climate change affects animals directly and indirectly. Heat waves directly threaten the animals while heat stress influences creatures indirectly and directly. Over time, heat stress can decrease milk production and potency. Climate change can upsurge vulnerability and may improve the prevalence of diseases and parasites. Climate change can also affect fisheries. Numerous fisheries face multiple stresses like overfishing and water pollution. Climate change may worsen these stresses. High temperatures may change the ranges of many fishes and shellfish of different species. For example, cod require water temperatures below 12.22 ºC in the North Atlantic to survive while krill requires below 2.0 ºC. High temperatures may affect the lifecycle of aquatic animals.

(viii) **Other Impact:** Some people are more susceptible than other people to health risks that arise due to climate change. Susceptibility depends on sensitivity, exposure, and adaptive capacity. Sensitivity mentions to the degree to which people are influenced by a higher temperature. Exposure indicates physical interaction between an individual and a stressor. Adaptive capacity mentions to an ability to avoid possible hazards. For example, older people are sensitive to dangerous heat. They are not exposed to temperature as long as they stay inside the room, and as long as they can have enough money to pay the energy bill to run the air conditioner (AC). Their capacity takes these actions is an evaluation of their adaptive capability. Some peoples are susceptible to health consequences due to the high probability of exposure, particular sensitivities, and low adaptive capacity. Societies of low income, color, and immigrants face susceptibilities due to a higher danger of exposure, educational factors, and socioeconomic factors that distress their adaptive capacity, and a complex prevalence of medical conditions that disturb their sensitivity.

3. **Mitigation:** The mitigation of climate change refers to reducing the emission of greenhouse gases by using renewable energies and new technologies, making older equipment more energy-competent, or changing management practices or user behavior. Frumkin et al. (2008) described the climate change mitigation programs and said that they provide opportunities to decrease greenhouse gas emissions with benefits to humans at the same time. It can be a simple as well as complex process. Efforts underway around the world range from high-tech subway systems to bicycling paths and walkways.

All strategies for the mitigation of climate change made by the government should include observation of environmental and health data which are already present. Mitigation strategies should focus on the minimization of health-related burdens due to climate change. Strategies should be regional because the health of populations to climate change varies by location. The assessment of regional and citywide needs with public health services is required because they provide effective responses. Co-benefits or synergies are an important principle between mitigation attempts and health in the form of modification measures.

4. **Conclusions and Recommendations:** At the present time, climate change is the main issue that affects drinking water, clean air, appropriate food, and protected shelter. It also affects the yield of cereal grains, and the yield increases at higher latitudes but decreases at lower latitudes. Scientists and researchers are focusing on this issue because they have concerns about public health. Understanding the threats due to climate change and its impact on the health of humans is the first step to lowering the risk. Action on climate change is required on time otherwise the costs will be high. In the future, it will be very difficult for states to meet air quality standards due to climate change. By increasing forests, carbon can be removed from the atmosphere. Health can improve with the reduction of the emissions of greenhouse gases through better energy, and transport use.

- Different agencies which are working on climate change should be aware of people through the conducting of several national and international programmes.

- The government body should establish early warning approaches for heatwaves.

- People should prepare against the changes due to climate change or should adapt to these changes.

- A well-developed infrastructure and programs should be established for the monitoring, managing, and preventing the spread of many diseases.

- Public health safeguards should be provided by national agencies to decrease the risk of exposure and diseases.

- Coal-fired power plants should be closed and the use of solar, wind, and other techniques of renewable energy should be increased.

- People should encourage to use electric vehicles instead of fuel vehicles.

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