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Effects of Carbon Dioxide and Nitrogen Oxides on Climate Change in Afghanistan

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ABSTRACT

Climate change is a global threat to the environment and human health. Two of the main greenhouse gases that cause the greenhouse effect and raise global temperatures are carbon dioxide and nitrogen oxides. In this review paper, we investigated the effects of carbon dioxide and nitrogen oxides on climate change and the effects of climate change on Afghanistan. We found that high concentrations of carbon dioxide, which is now CO_2 levels, have increased by 50% than before the Industrial Revolution, contributing to a rise in global temperature and precipitation. At the same time, Nitrous oxide is an important greenhouse gas, with 310-fold higher potential for global warming than CO_2 and leads to the depletion of stratospheric Ozone and other Nitrogen oxides, has a significant impact on plant health, including effects on chlorophyll levels, oxidative stress, and antioxidant responses. Afghanistan's climate change is predicted to increase the country's prevalence of illnesses linked to dust storms and poor air quality, especially in Kabul, the nation's capital. In addition, air pollution in Kabul is also likely to increase as a result of climate change. The alarming impacts of air pollution, with more than 3,000 deaths attributed to air pollution annually.
Additionally, at least 700,000 individuals in Kabul have experienced various respiratory diseases. Due to climate change, Afghanistan's total glacier area has shrunk by 13.8%. In 2023, Afghanistan experienced early snow melt and below-average precipitation, causing second-season and irrigated crops to have less access to water. Reducing emissions and coping with the changing climate are essential steps towards tackling the complex issues these gases present and their wider effects on the environment and human health.

INTRODUCTION

The change in temperature, rainfall, wind, and other elements with time is known as climate change (MacCracken 2019). Many gases pass the incoming sunlight through them and heat the land and oceans. This heat is released by the Earth in the Infrared region of radiation to space. These gases absorb the Infrared radiation and do not allow the infrared radiation to pass to space and radiate it back to the Earth, and the temperature of the Earth rises. This effect is called the Greenhouse effect (Doll et al. 2011). The Earth is heated by the greenhouse effect, which causes it to be warmer than it would be if sunlight were straight overhead. The proof for the greenhouse effect is the 33°C difference between the actual average temperature of 14°C and the effective temperature with sunlight, which is -19°C. The major gases that impart the Greenhouse effect are CO_2, N_2O, CH_4, Water vapors, and CFC. These gases have more than two atoms, joined together loosely, and can vibrate by absorbing the heat (Kweku et al. 2018). The Greenhouse Effect is shown in Fig. 1.

Earth's average temperature has increased by 1°C since 1900. Since 1850, the previous four decades have continuously been warmer than any other, despite trend variations, as shown in the instrumental record Fig. 2. Other evidence like reduction in Arctic sea content, elevation in ocean heat content, and evidence from the natural world show strong proof of the Earth's warming (National Academy of Sciences 2020).

Since about 1750, human activity has increased the concentration of greenhouse gases. Both the atmospheric CO_2 and N_2O concentrations in 2019 were higher than they had been in at least 2 million years and 800,000 years, respectively. Climate extremes such as heat waves, intense precipitation, droughts, and tropical cyclones are being impacted by climate change brought on by human activity. Human health is impacted by climate change in both direct and indirect ways. Direct effects include injury and even death from hurricanes and heat waves. In contrast, indirect effects include changes in temperature and precipitation that can disrupt the life cycles of insects that spread the West Nile virus and Lyme disease, resulting in a variety of new outbreaks. Climate change frequently coexists with additional health stressors such as poverty, social hardship, and linguistic impairment, causing heightened susceptibility

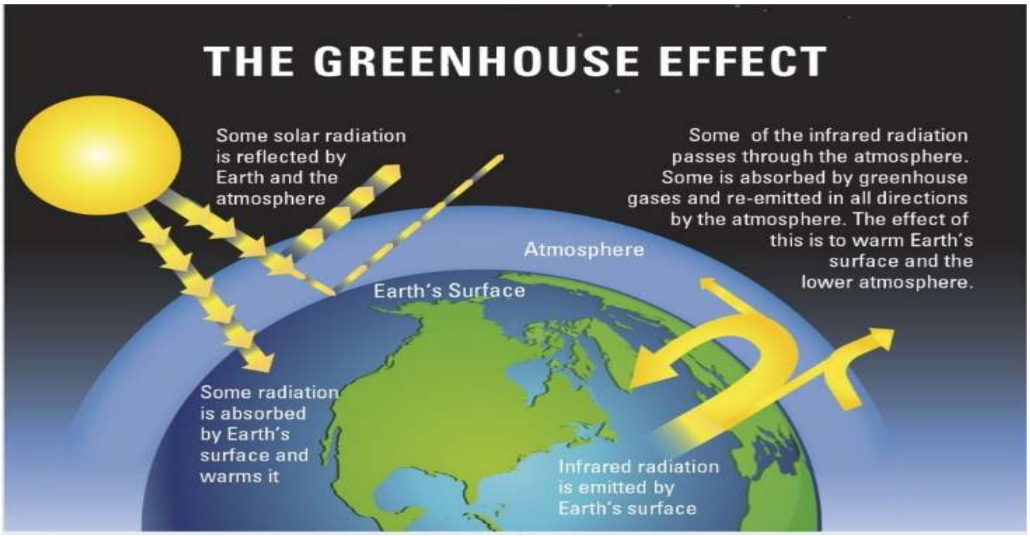

Fig. 1: The greenhouse effect.

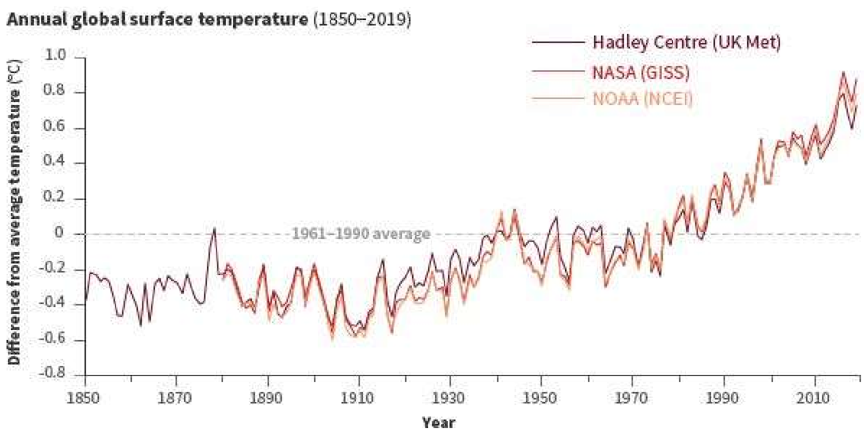

Fig. 2: Annual global surface temperature (1850-2019).

(McMichael & Woodruff 2005). The consequences of climate change on water resources have been well-documented, and it is expected that these resources will be seriously threatened in the future on a regional and worldwide scale. (Shokory et al. 2023).

The expected effects of climate change in Afghanistan are concerning. Raising temperatures are predicted to have a major effect on the country's ecosystems, agriculture, economy, biodiversity, and food security. Even with limited greenhouse gas emissions, Afghanistan will face significant challenges in adapting to these changes. However, if GHG emissions are not curbed, the effects of global warming are probably going to be considerably more extreme and unpredictable, exacerbating the existing adaptation deficit in the country areas (Aich & Khoshbeen 2016). According to the World Health Organization (WHO), in Afghanistan, 26% of total mortality is attributed to environmental risks and pollution (Masood et al. 2022). Based on the INFORM 2019 Index, Afghanistan is ranked as the fifth most at-risk country globally, meaning it faces the highest levels of natural disaster hazards. (Climate Risk Country Profile Afghanistan 2021). Climate models suggest that Afghanistan will experience an array of novel and amplified climate-related risks. In Afghanistan, drought is the most likely negative effect of climate change. By 2030, drought will no longer be considered an isolated or cyclical occurrence but rather the standard. (Savage et al. 2009).

In this review paper, we investigated the effects of CO_2 and nitrogen oxides on climate change and the effects of climate change on Afghanistan. We reviewed most of the reports, research articles, authenticated web pages, and books section for this purpose.

EFFECTS OF CARBON DIOXIDE ON CLIMATE CHANGE

Without CO_2, the Earth's natural greenhouse effect would be insufficient to keep the global average temperature above freezing. As individuals release more CO_2 into the atmosphere, the global temperature rises (Lindsey 2023). For the previous 800,000 years up until the 20th century, the atmospheric CO_2 content varied between 170 and 300 ppm (National Academy of Sciences 2020). According to the NOAA Monitoring Lab annual report, the global average CO_2 was 417.06 ppm in 2022, setting a new high record. Compared to before the Industrial Revolution, atmospheric CO_2 is currently 50% greater (Lindsey 2023). CO_2 is the largest contributor to global warming, emitted from various sources to the environment like, the combustion of fuels, transportation, and industrialization processes (Thiruvenkatachari et al. 2009). The major sources of CO_2 have been given in Table 1 (Yoro & Daramola 2020).

To keep atmospheric CO_2 levels in equilibrium, the Earth's natural mechanisms for absorbing and storing CO_2 are crucial. These procedures, including photosynthesis in plants and absorption by the ocean, have been a component of the carbon cycle for millions of years, which regulates CO_2 levels. However, human activities like Deforestation and the burning of fossil fuels have disrupted these processes, resulting in a persistent increase in atmospheric CO_2 concentration. This increase in CO_2 has led to global warming and climate change (Nunes 2023). For the next 1000 years, climate change caused by a rise in CO_2 concentration is largely irreversible (Solomon et al. 2009). CO_2 acts like a blanket in the air, trapping the heat, warming up the Earth, and preventing the Earth from cooling (Ali et al. 2020). Even if global average temperatures stabilize at some point, rising CO_2 concentrations have a direct impact on the climate system and may have an ongoing impact on Earth (Harvey 2018). Destructive storms intensify and increase in frequency throughout various regions as temperatures rise. Due rise in temperature, more water evaporates, which exacerbates heavy rainfall and flooding. By warming the ocean, the extent and frequency of the tropical storm are also affected. Warm water at the ocean's surface provides fuel to hurricanes, typhoons, and cyclones (UN n.d.). Many researchers have shown the inhibitory effects of different heat stresses in crop plants. It is an essential environmental pressure that restrains plant growth and development and disturbs its several metabolic and physiological activities, hence rendering yield production at the global level (Javadmohammadi et al. 2013). Due to human activities, 30% to 40% of CO_2 emitted into the atmosphere dissolves into the oceans (Millero 1995), where CO_2 reacts with seawater and has increased its acidity to 0.1 pH since the pre-industrial era. The terrestrial biosphere absorbs about 20% of the CO_2 emissions caused by human activity. Here, it combines with soil moisture to modify soil acidity, meaning that CO_2 can make the air, soil, and ocean more acidic (Mitchell et al. 2010). Numerous ocean species are already being impacted by ocean acidification, particularly those that combine calcium and carbonates from seawater to form hard shells and skeletons.

Ocean acidification reduces the amount of carbonate ions available for calcifying organisms to form their shells, skeletons, and other calcium carbonate structures by increasing the carbonate ions' link with excess hydrogen (NOAA 2020). The lower pH also affects the senses of reef fishes and reduces their survival, and might target most of the commercial fishes that produce seafood for humans (Branch et al. 2013). The start and end of growing seasons have changed due to warmer temperatures and shifting precipitation patterns. There is a high degree of confidence that this has decreased regional crop yield, freshwater availability, and biodiversity. There is a medium degree of confidence that the increase in atmospheric CO_2 has contributed to the observed increase in plant development and woody plant cover in grasslands and savannahs (Shukla et al. 2019). However, studies have found that this accelerated

Table 1: Major sources of CO_2.

Anthropogenic Sources		Non anthropogenic Sources	
Sources	CO_2 emission [Billion Mt]	Sources	CO_2 emission [Billion Mt]
Fossil fuel combustion engines	392	Plant, animal, and human respiration	7
Cement Production Plants	113	Ocean-atmosphere exchange	7
Power generation (coal-fired power plants)	279	Soil respiration and decomposition	1.54
Transportation	191	Volcanic eruptions	0.15
Industrial manufacturing	178		
Land use changes	13		

Adapted from Yoro & Daramola (2020)

growth under elevated CO_2 can lead to a dilution of essential nutrients in crops. When plants grow faster, they allocate more carbon to structural components like stems and leaves rather than to nutrients such as protein, vitamins, and minerals. As a result, the concentration of these vital nutrients in staple crops can decrease. For example, research has shown that elevated CO_2 levels can reduce the protein content of wheat and barley, making them less nutritious.

Similarly, increased CO_2 can lower the iron and zinc content in rice, which are important micronutrients for human health. Potatoes, another staple crop, may experience reduced vitamin C content when exposed to higher CO_2 concentrations (Ebi & Ziska 2018). Rising atmospheric CO_2 levels, rising temperatures, and shifting precipitation patterns cause significant effects on agriculture and agricultural insect pests. Climate change has the potential to increase the risk of invasion by migratory pests, increase the incidence of insect-transmitted plant diseases, increase the number of generations, increase the geographic distribution, increase survival during overwintering, change plant-pest synchrony, and alter interspecific interaction. It can also decrease the efficacy of biological control of agricultural pests. As a result, there is a significant chance that the crop will suffer financial losses, which poses a threat to global food security for humans (Skendžić et al. 2021). CO_2 also causes acidic rain, which physically harms the trees and builds the environment (Ali et al. 2020).

Along the glacial to interglacial cycles when humans first appeared, CO_2 concentrations in the atmosphere ranged between 135 and 280 ppm. Human blood's pH during this time narrowly varied between 7.35 and 7.45 for arterial and venous blood, respectively. Humans are now exposed to atmospheric CO_2 concentrations that have never before been experienced by mammals or humans due to the recent increase in CO_2 concentration, which is currently over 400 ppm. Similar to the pH drop in the ocean that happened during the Industrial Revolution, this suggests a minor drop in blood pH below the 7.35-7.45 typical performance range for the human proteome. (Duarte et al. 2020). High CO_2 concentrations may have negative effects on human health that are more frequent and persistent due to higher indoor air concentrations and longer indoor exposure times (Jacobson et al. 2019). There were noticeable immediate physiological alterations in the circulatory and autonomic systems with exposure to CO_2 at concentrations between 500 and 5000 ppm. (Azuma et al. 2018). People's decreased lung gas transport in response to CO_2 retention is strongly suggested to be the cause of the decline in cognitive function. (Shriram et al. 2019). It is unclear if CO_2 by itself is a pollutant and whether it can be harmful to health at low concentrations ($\leq$ 5000 ppm). However, according to current criteria, CO_2 levels can be used to measure the quality of indoor air; values below 1000 ppm are deemed good, while levels above 1500 ppm are deemed poor. High CO_2 levels can cause discomfort and reduced cognitive function and can also indicate poor ventilation and the accumulation of other pollutants. Therefore, it is important to monitor and control CO_2 levels to ensure healthy indoor environments (Lowther et al. 2021).

EFFECTS OF NITROGEN OXIDES ON CLIMATE CHANGE

Nitrogen, a chemical element, can exist as a diatomic molecular (N_2) nitrogen gas, which is mostly inert and makes up 80% of the air we breathe. However, as a single atom, nitrogen can be reactive and have several valence states from +1 to +5, resulting in the formation of multiple oxides of nitrogen (NO_x), including N_2O, NO, N_2O_2, N_2O_3, NO_2, N_2O_4, and N_2O_5 (Cox 1999). Climate, air quality, and atmospheric chemistry are all significantly influenced by Nitrogen oxides. Both human activities and natural processes emit them into the atmosphere. Naturally occurring wildfires, microbial activity in soil, and lightning are among the natural sources of Nitrogen oxide emissions. Fossil fuel combustion, home heating, cooking, industry, and the energy sector are the primary producers of NO_x. (Lange et al. 2022). In the air, the most abundant nitrogen oxides are N_2O, NO, and NO_2 (Cox 1999).

It is considered that NO_x is an indirect greenhouse gas, while N_2O is a direct greenhouse gas (Lasek & Lajnert 2022). Nitrous oxide is a significant greenhouse gas with a global warming potential 310 times larger than CO_2 (Aryal et al. 2022). The use of nitrogen fertilizers and manures in agricultural soils has raised the concentration of N_2O over the past century, and these activities are the primary human sources of N_2O (Skiba & Rees 2014). Over time, the amount of N_2O in the atmosphere keeps rising. Furthermore, it has increased annually during the past decade, averaging 1.1 $ppb.yr^{-1}$. The N_2O values for 2020, 2021, and 2022 represent some of the fastest annual rises yet noted. Between 1990 and now, N_2O has increased radiative forcing by 0.086 to 0.81 $Watts.m^{-2}$, or almost 7.5% (NOAA 2022). In the troposphere, N_2O is an inert gas with no substantial sinks near the Earth's surface. However, N_2O is carried into the stratosphere where it is primarily broken down by short-wavelength photolysis to produce atomic Oxygen (O) and molecular Nitrogen (N_2). The primary source of nitrogen oxides in the stratosphere is the dissociation of N_2O to a lesser extent into nitric oxide (NO), yet the proportion is less than 10%. (Müller 2021). In the stratosphere, NO reacts with Ozone (O_3) and forms

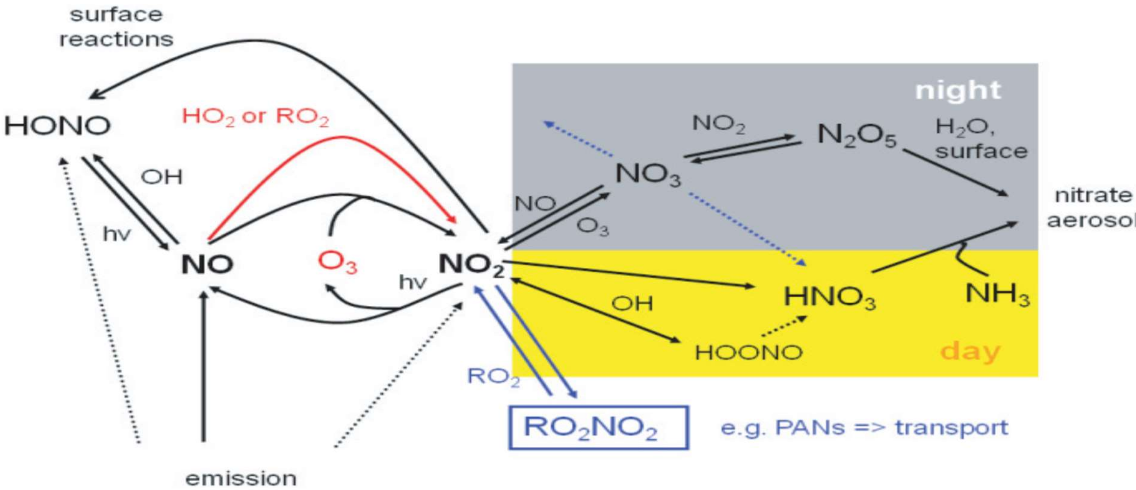

Fig. 3: Chemistry of NO_x in the troposphere (Richter 2009).

nitrogen dioxide (NO_2) and (O_2). NO_2 is photolyzed and forms NO and an oxygen atom (O) again (Lange et al. 2022). A greater concentration of N_2O leads to an increased concentration of NO_x, which destroys the stratospheric ozone layer. Due to this ozone depletion, UV radiation enhances and photolyzed more N_2O (Ehhalt & Prather 2001). The Ozone layer acts as a natural filter, collecting UV radiation from the Sun and keeping it from reaching the surface of the Earth. However, alterations to the ozone layer have led to a rise in the percentage of UV-B radiation that reaches the surface. This increase can have negative effects on biological life and processes, as well as on non-living things like building materials made of polymers. (Umar & Tasduq 2022). Additionally, the release of nitrogen oxides into the atmosphere leads to a rise in tropospheric Ozone (O_3) and Particulate Matter (PM). The emissions of NO_x play a significant influence in the generation of (O_3), one of the most important air pollutants impacting human health. Since 1900 the increase in O_3 is 60% due to an increase emission of NO_x (de Vries 2021). PM precursors include NO_x, NH_3, and SO_2 pollutants that have a direct impact on human health and are partially converted into pollutant particles in the atmosphere by photochemical processes (Lovarelli et al. 2020).

Nitric acid (HNO_3) is produced when NO_2 combines with hydroxyl ions (OH^-); aerosols and droplets can readily absorb this compound. HNO_3 is a strong acid and can readily dissociate in water to release H^+ ions, contributing to the acidity of aerosols and cloud droplets. Through this pathway, these acidic particles are deposited on land or water surfaces. They can disrupt the pH balance and harm sensitive ecosystems through the formation of acid rain. The reduction in SO_2 emissions has led to a decrease in sulfate aerosols, which were previously the dominant contributor to acid rain, so the relative importance of HNO_3 has increased in most industrialized countries. A simplified picture of the chemistry of NO_x in the troposphere is shown in Fig. 3.

Plant species diversity often begins to decline when nitrogen deposition levels rise over 5-10 $kgN.ha^{-1}.yr^{-1}$. The dominance of nitrophilic species, which outcompete species adapted to nitrogen deprivation in oligotrophic settings, is blamed for this decline. Indirect soil-mediated effects, such as soil enrichment, eutrophication, and acidification, primarily cause the loss of plant species diversity due to increased nitrogen inputs. These effects can alter soil microbial communities and nutrient cycling processes (Environmental Protection Agency (EPA) 2018). There are many ways in which nitrogen oxides (NO_x) can affect plant health, both directly and indirectly. NO and NO_2 are phytotoxins that can cause direct damage to plant growth and yield reduction. Indirectly, NOx may aid in the production of Particulate Matter (PM) aerosols and Ozone (O_3), both of which may be harmful to crops. NO_x is a crucial precursor to the generation of Ozone in the troposphere. Elevated quantities of O_3 can harm plant tissues, hinder photosynthesis, and lower agricultural output. In addition, N_{Ox} can take part in atmospheric reactions that result in the production of (PM) aerosols. Ammonium nitrate aerosols (NH_4NO_3) and ammonium sulfate aerosol [$(NH_4)_2SO_4$] can be more concentrated when NO_x is present in the presence of ammonia, which is frequently found in agricultural regions due to the usage of nitrogenous fertilizers. By reflecting and dispersing incoming sunlight, these aerosols can lower the quantity of photosynthetically active radiation that reaches crops, thus hindering photosynthesis (Lobell et al. 2022). Exposure to nitrogen dioxide (NO_2) can indeed have significant impacts on plant health, including effects on chlorophyll levels, oxidative stress, and antioxidant responses. NO_2 exposure can also induce oxidative stress in plants, leading to lipid peroxidation and protein dissolution. In response to NO_2-induced oxidative stress, plants often increase the activity of enzymes such as peroxidase (POD), which helps to detoxify reactive oxygen species. Despite the negative impacts of NO_2 exposure, plants can recover and resume normal growth after the removal of the pollutant. This recovery process can involve the repair of damaged cellular components and the restoration of normal physiological functions (Sheng & Zhu 2019).

The 1-Hour Standard and the Annual Standard are the two main standards for Nitrogen oxides. The 2010 establishment of the 1-Hour Standard established a limit of 100 parts per billion (ppb). Its foundation is the 98th percentile of the daily maximum 1-hour NO_2 concentrations' annual distribution. To determine compliance with this requirement, the maximum per day's 1-hour NO_2 values are taken as an average over three years. The Annual Standard was first established in 1971 and is now maintained at 53 parts per billion. It is based on the average annual concentrations of NO_2. Compliance with this standard is determined by calculating the average NO_2 concentration over a full year (Environmental Protection Agency (EPA) 2018). The majority of the public's exposure to nitrogen oxides comes from breathing in air. Individuals who live close to sources of combustion, such as power plants powered by coal, or in places with a lot of traffic may be more exposed to nitrogen oxides. Within homes where wood is burned extensively or kerosene heaters and gas stoves are used, nitrogen oxide levels tend to be higher compared to homes without these appliances.

Additionally, tobacco smoke contains nitric oxide and nitrogen dioxide. Thus, individuals who smoke or come into contact with secondhand smoke could potentially be exposed to nitrogen oxides (ATSD 2014). Depending on the concentration and length of exposure, nitrogen dioxide (NO_2) exposure can have both short-term and long-term health impacts. Prolonged exposure to low NO_2 concentrations can aggravate respiratory disorders, including asthma and chronic obstructive lung disease, and cause respiratory problems like sneezing, coughing, and shortness of breath (COPD). Severe exposure to elevated NO_2 levels, which is rare but can occur during industrial events or in heavily polluted areas, can cause severe damage to the respiratory system, leading to respiratory distress, lung inflammation, and even respiratory failure. Even individuals without pre-existing conditions can experience respiratory symptoms and decreased lung efficiency in the presence of elevated NO_2 levels. Even at low doses, those with respiratory disorders are more susceptible to the effects of NO_2. It is important to reduce NO_2 emissions and limit exposure to protect public health, especially for those with respiratory conditions. This can be achieved through regulations, emission control technologies, and sustainable practices in transportation and industry (Javadmohammadi et al. 2013).

Effects of Climate Change on Afghanistan

Afghanistan is a mountainous nation that lies in the subtropical zone and stretches from 29°21′ to 38°30′N latitude and from 60°31′ to 75°E longitude. Its climate is primarily dry and semi-arid, with traits of steppe, highlands, and deserts with regard to precipitation and temperature patterns (Shokory et al. 2023). With a population of over 4.6 million people, Kabul stands as the most populous city in Afghanistan. The city has experienced rapid urbanization, making it the fifth fastest-growing city globally. At present, its population is growing at a pace of 2.71% annually, and by 2035, it is expected to surpass 6.7 million (Masood et al. 2022). While conflict-related deaths in Afghanistan have significantly decreased in 2022, the country still faces challenges due to climate and environmental stressors. These stressors not only hinder development but also have a negative impact on community resilience and worsen social divisions (Jiayi & Seyuba 2023).

Table 2: Afghanistan's CO_2 emissions from 2015 to 2019.

Sector	2015 CO_2 emission [Mt]	2016 CO_2 emission [Mt]	2017 CO_2 emission [Mt]	2018 CO_2 emission [Mt]	2019 CO_2 emission [Mt]
Agriculture	15.53682	15.2975	15.20713	14.83939	14.48123
Energy	12.19827	11.41276	12.18425	13.13404	13.43123
Waste	3.28	3.365385	3.448441	3.531498	3.614555
Industrial Processes	0.60166	0.789337	0.910724	1.07556	1.209746
Land-Use Change and Forestry	- 0.24622	0.154657	0.154657	0.154657	0.154657
Total	31.3637	31.01964	31.90521	27.84	32.89143

Note: Adapted from Climate Watch Historical GHG Emissions (2022).

In Afghanistan and other countries, the fundamental cause of climate change is the release of greenhouse gases, especially CO_2. Table 2 presents the yearly CO_2 emissions in Afghanistan and the associated sectors from 2015 to 2019.

Table 2 gives the CO_2 emissions in a million tons in Afghanistan from 2015 to 2019, attributing these emissions to sectors such as agriculture, energy, waste, industrial processes, changing land uses, and forestry. In 2019, Afghanistan's emissions totaled 28.79 million tons of CO_2 equivalent, representing only 0.06% of global emissions and ranking the country as the 116th largest producer of greenhouse gases worldwide (Zaki & Lederer 2023). In Afghanistan, climate change is primarily characterized by increasing temperatures. The country has observed a significant temperature rise, surpassing the global average, with an increase of 1.8°C between 1951 and 2010. This upward trend in temperatures is expected to continue from 2006 to 2050, with a projected rise of 1.7- 2.3°C. Subsequently, temperatures are anticipated to increase further, ranging from 2.7-6.4□ until 2099 across the entire country (Přívara & Přívarová 2019). Afghanistan's water supplies have been impacted by climate change, especially in the Kabul River watershed. Due to the changing climate, there has been a noticeable impact on the glaciers and snowmelt that feed the river, increasing their melting trend. Additionally, this trend has been further supported by a change in the seasonal monsoons in the river basin (Qutbudin et al. 2019). In the twenty-five years between 1990 and 2015, Afghanistan's total glacier area shrank by 13.8%, and the country's projected ice reserves shrank by 14.4%. Moreover, there have been 3.1% fewer glaciers in the 25 years between 1990 and 2015 and 1.7% fewer between 1990 and 2010. Most likely, the consequences of climate change are to blame for this decrease in glacier area and ice storage. The reduction and retreat of glaciers, which act as vital freshwater reservoirs, will negatively affect the future availability of freshwater downstream and the coordinated management of water resources (Maharjan et al. 2021). The majority of models indicate a notable reduction in precipitation in the spring, which is essential for agricultural production that depends on rainfall. These anticipated precipitation declines are between around -30% and almost -40% in the relevant East, North, and Central Highlands regions relative to historical levels. This decrease in precipitation poses a significant challenge for agricultural activities in these areas (Aich & Khoshbeen 2016). Over two-thirds of Afghanistan's provinces were directly impacted by the country's catastrophic drought in 2018, which affected about 10.5 million people. 2018's drought emphasizes how urgently the nation must solve issues related to food security, climate change, and development that is sustainable (FAO 2020). In 2022, Afghanistan's agricultural sector, which contributes around 36 percent to the GDP, experienced a contraction of 6.6 percent. This decline was primarily caused by widespread drought conditions and below-average precipitation, leading to a significant reduction in the wheat crop. Moreover, certain regions of the country faced inadequate rainfall, negatively impacting the livelihoods of pastoralists who were already struggling due to limited pasture availability in the previous years (Muhammad et al. 2023). In 2023, Afghanistan experienced early snow melt and below-average precipitation, which means that there is now less water available for irrigated and second-season crops. As a consequence, the prospects for the second-season harvest are expected to be below normal. Rice and maize are particularly major second-season crops in the country's northern and eastern areas. Additionally, fruits like melons and oilseed crops are also cultivated during this season, primarily in the Northern provinces. Many farmers extensively rely on deep boreholes to obtain water for farming crops like rice, sesame, and maize in order to deal with the restricted supply of water. The recurrent drought in Kabul Province is causing a severe impact on surface water sources and groundwater levels. This is evidenced by the fact that almost half of the boreholes assessed in the province are dry, and the remaining ones are operating at significantly reduced efficiency (OCHA 2023). It is anticipated that the lower yields from the 2022 crops and the shortages in 2023 will significantly affect food security in 2024. As of 2023, an estimated four million individuals who are considered vulnerable are suffering from acute malnutrition. This comprises about 2.3 million children with moderate acute malnutrition (MAM), 840,000 pregnant and lactating women (PLW) with acute malnutrition, and about 875,000 children with severe acute malnutrition (SAM) (UNICEF 2023). Afghanistan, a nation plagued by prolonged conflict, is also susceptible to natural calamities. Earthquakes, droughts, floods, and heavy snowfall have a significant influence on many Afghans' lives. In 2005 and 2006, severe flooding left thousands homeless and destroyed agricultural land, livestock, and infrastructure (Hagen 2009). In Afghanistan, there are two primary types of floods: those resulting from intense rainfall over a brief period, leading to river overflow and heavy surface runoff in surrounding areas, as well as those brought on by the swift melting of snow and ice in highland regions in the spring, which overflows downstream rivers and stream. Afghanistan saw severe flash flooding in its central, eastern, and southern regions in August 2022. Approximately 15,875 people were affected by the floods, which destroyed or damaged over 5,600 homes in provinces including Kunar, Laghman, Logar, Maidan Wardak, Nangarhar, Nuristan, Paktiya, Kandahar, Zabul, Uruzgan, and Parwan (UNICEF 2022). Heavy rains continued in July 2023, resulting in flash flooding that harmed around 6,193 people across eight provinces in Afghanistan, including Kabul, Kunar, Laghaman, Maidan Wardak, Nangarhar, Nuristan, Parwan, and Zabul. This event tragically led to the loss of 40 lives, with 30 others sustaining injuries. Furthermore, the flooding caused damage to 551 houses and the destruction of 121 others (UNICEF 2023).

Afghanistan's impoverished population is especially susceptible to the effects of climate change. It is anticipated that climate change will make the problems with food security worse and have a big effect on people who depend on agriculture for their livelihoods. The adverse effects are likely to disproportionately affect women, children, and individuals engaged in subsistence agriculture or pastoralism. Changes in the climate have the potential to drive a sizable fraction of the Afghan people into poverty, as a sizable portion currently lives barely over the poverty line (Savage et al. 2009). Poverty and food insecurity are widespread issues in Afghanistan, particularly in rural areas. Events like the 2011 drought, which caused over 100,000 children to go malnourished, and the 2018 and 2019 drought, which forced over 400,000 people to relocate, demonstrate the dangers that climate change poses. These risks also have a big impact on the economy. For example, the 2018 drought reduced wheat production by more than 60%, necessitating a deficit of $550 million to feed the country's livestock. The drought crisis in Afghanistan in 2019 was aggravated by severe floods, exacerbating the humanitarian situation. The flooding resulted in the displacement of 42,000 people and tragically led to at least 63 deaths. There is growing evidence to suggest that human-induced climate change has made natural hazards, such as droughts and floods, more likely and more intense in Afghanistan (Climate Risk Country Profile Afghanistan 2021). The complex humanitarian crisis in Afghanistan is becoming more severe due to a combination of factors, including the contraction of the economy, environmental pressures, and climate change. Nearly three-quarters of the predicted total population, or around 28.3 million people, are expected to need direct humanitarian aid in 2023. According to a May 2022 food security assessment, by the end of 2022, 47% of the population will be experiencing emergency or crisis shortages of food (Jiayi & Seyuba 2023).

Evidence from various regions globally indicates that climate change and global warming are having negative impacts on essential elements of life, including water, air, food, and human habitats, leading to health security risks. Malnutrition, diarrhea, and malaria are particularly sensitive to climate change and are currently significant contributors to the global burden of disease. Estimates suggest that malnutrition causes 3.5 million deaths annually, while diarrhea and malaria cause 1.8 million and 0.9 million deaths, respectively (World Health Organization 2008). In developing nations, the issue is exacerbated by rapid population growth, unregulated urban expansion, and the growth of industrialization. This results in inadequate air quality, particularly in countries with social inequality and a lack of information regarding long-term environmental management. People who depend on inexpensive fuels like wood or solid fuel for domestic needs due to financial constraints are at risk of breathing in tainted indoor air. It's important to note that almost three billion people worldwide depend on these sources of energy to meet their everyday heating and cooking needs (Manisalidis et al. 2020). Conditions brought on by climate change, such as more frequent droughts, intense rainfall, floods, and elevated temperatures, are influencing the environment and aiding in the development of vector-borne and water-borne illnesses. Children in Afghanistan are particularly vulnerable to the health risks associated with diarrheal disease; according to UNICEF estimates, in 2016, 7,300 deaths in this age range occurred in Afghanistan due to diarrheal disease, which makes up around 9% of all disease deaths in this group. The incidence of diseases linked to dust storms and air quality in Afghanistan is predicted to increase due to climate change. During an extended drought in the early 2000s, dusty storms were especially common around Lake Hamun on the Iran-Afghanistan border, and they were associated with a rise in hospital admissions for asthma and chronic obstructive pulmonary disease in that region. Usually, when the lake beds dry out, these dust storms happen. Consequently, because of the anticipated rise in the frequency of droughts in Afghanistan, climate change may make dusty storms more likely in this western border region in the ensuing decades. Moreover, the situation could worsen in the long run if the predicted decline in glacier mass in the Hindu Kush limits the amount of snowmelt that replenishes Lake Hamun (Climate Risk Country Profile Afghanistan 2021). In the near to medium future, there will be a heightened risk of malaria and dengue fever due to the anticipated rise in temperature and precipitation brought on by climate change. This will include an extended transmission season and the expansion of mosquito habitats into highland areas. Furthermore, temperature fluctuations due to climate change may increase the prevalence of neglected tropical diseases like Leishmaniasis. Eastern Afghanistan bears the highest burden of Malaria cases, but roughly 76% of the country's population is exposed to Malaria-causing mosquitoes. The increase in temperature resulting from climate change may lead to higher transmission of Malaria due to faster vector development (Aditi et al. 2021). The study discovered that measles appeared in late spring, pneumonia occurred in the winter, and diarrhea and typhoid fever peaked in the summer. Acute viral hepatitis and meningitis, however, did not exhibit any discernible seasonal trends. While rates of pneumonia and diarrhea remained consistent over the years, the incidence of Typhoid fever, acute viral hepatitis, and meningitis declined. (Wagner et al. 2017). The results show that Afghanistan's incidence of diarrhea is positively correlated with both mean daily temperature and aridity. Specifically, the risk of diarrhea increased by 0.70% and 4.79% for every 1°C increase in the mean daily temperature and 0.01 units in the aridity index, respectively. In contrast, there was a negative correlation found for the average annual temperature, with a 3.7% reduction in risk for each degree Celsius that the average annual temperature increased. It was also observed that, except for the eastern region, where variations in climatic patterns and population density may be linked to high rates of diarrhea all year round, most districts showed comparable seasonal tendencies, with the frequency of diarrhea peaking in the summer. These findings highlight the important influence of climate on Afghanistan's diarrheal patterns (Anwar et al. 2019). Kabul's polluted air condition has certainly deteriorated dramatically over time. In autumn and winter, the World Health Organization's (WHO) recommended levels of sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate Matter ($PM_{2.5}$ and PM_{10}) are frequently exceeded. The average $PM_{2.5}$ concentration in Kabul was measured at 92.2 $\mu g.m^{-3}$ over 24 h, exceeding the World Health Organization's (WHO) recommended limit of 25 $\mu g.m^{-3}$ for the same duration. Additionally, the average PM_{10} concentration in Kabul was recorded at 120.6 $\mu g.m^{-3}$ over 24 h, surpassing the WHO's recommended limit of 50 $\mu g.m^{-3}$ for the same duration. The average NO_2 concentration in Kabul was recorded at 305.4 $\mu g.m^{-3}$, which indeed exceeds the World Health Organization's (WHO) recommended limit of 200 $\mu g.m^{-3}$ for a 1-hour measurement. The average SO_2 concentration in Kabul was measured at 63.7 $\mu g.m^{-3}$ over a 24-hour period, which is indeed higher than the World Health Organization's (WHO) recommended limit of 20 $\mu g/m^3$ for the same duration (Mehrad 2020). One major concern in Afghanistan is the effect of air pollution on public health, especially in Kabul, the country's main city. The Ministry of Public Health's spokesperson claims that the effects of air pollution are alarming, with more than 3,000 deaths attributed to air pollution annually. Additionally, at least 700,000 individuals in Kabul have experienced various respiratory diseases, with this figure reflecting only those who sought treatment at government hospitals. It's important to note that many others may have sought treatment at other medical facilities, indicating that the actual number of people affected by respiratory issues due to air pollution could be even higher (Jahed & Fang 2023).

CONCLUSION

In conclusion, the impact of carbon dioxide and nitrogen oxides on climate change is undeniable, with these gases contributing to rising global temperatures through the greenhouse effect. This has led to a range of consequences, including the melting of glaciers, rising sea levels, shifts in precipitation patterns, and disruptions to plant yields. Furthermore, the resulting air pollution from these gases has had detrimental effects on human health, potentially leading to various diseases. Afghanistan has experienced severe repercussions from climate change, including alterations in precipitation patterns, drought, food insecurity, floods, and a rise in serious human health issues. In Afghanistan and elsewhere, it is essential to address the underlying causes of these environmental issues and put policies in place to lessen the effects of climate change. In order to address the complex issues these gases present and their wider ramifications for the environment and human well-being, efforts must be made to reduce emissions and adapt to the changing climate.

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