“EXPLORING STRATEGIC MANAGEMENT CHOICES TO MITIGATE CLIMATE CHANGE EFFECTS”

by

Rajesh Srinivasan

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“EXPLORING STRATEGIC MANAGEMENT CHOICES TO MITIGATE CLIMATE CHANGE EFFECTS”

by

Rajesh Srinivasan

Supervised by

Dr.Minja Bolesnikov

APPROVED BY

Dr. Gualdino Cardoso
Dissertation chair

RECEIVED/APPROVED BY:

Admission Director

Dedication

I, Rajesh, hereby declare that the dissertation entitled "EXPLORING STRATEGIC MANAGEMENT CHOICES TO MITIGATE CLIMATE CHANGE EFFECTS” is a bonafide work carried out by me under the supervision of Dr. Minja Bolesnikov, Vice President International Affairs and Guide at Swiss School of Business and Management, Geneva. I further declare that to the best of my knowledge the dissertation proposal does not contain any part of any work which has been submitted for the award of any degree either in any college or university.

Signature -

Rajesh Srinivasan

Roll No: 48203

DATE: November 19,2024

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Signature:

Rajesh Srinivasan

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ABSTRACT

"EXPLORING STRATEGIC MANAGEMENT CHOICES TO MITIGATE CLIMATE CHANGE EFFECTS"

Rajesh Srinivasan

2024

India has a legitimate cause for worry over climate change, given that a substantial portion of its people relies on climate-sensitive industries such as agriculture, forestry, and fishing for their means of subsistence. Climate change will exacerbate the strain on natural and social systems that are already under significant pressure as a result of increasing industrialization, urbanization, and economic expansion. The study aims to consolidate limited and dispersed literature and data on "Climate Change" and "Agriculture Growth" in order to provide a comprehensive understanding of the significant issue of climate change in India. In this study, the methodology is a systematic approach used to determine the outcome of a particular problem related to a certain subject or issue. The framework describes the details of indicators of environmental degradation, climate change and Agriculture Growth along with data items, geographical unit of collection of data, periodicity, sources of data and metadata linkage. In result, the data set includes data spanning 35 years (1990-2024), with significant variability in key environmental and socio-economic indicators. CO2 emissions range from 300 to 620 Mt, averaging 460 Mt with a standard deviation of 101.71, indicating moderate variability. CO_2, CH_4, and N_2O Emissions all have extremely high correlations with Year, Agricultural Output, Energy

Consumption, and Urbanization Rate (close to 1.000), indicating consistent increases over time and a close relationship with industrial activity and urban growth. The average annual growth rate and the exponential growth rate were determined as 0.41% and 0.39%, respectively. The urban population had a consistent growth trend, with an annual average growth rate of 2.89% and an exponential growth rate of 2.53%. In conclusion, all the variables causing Environment Degradation are highly and positively correlated with each other. An only variable showing non-significant correlation with all the other variables is "Total consumption of ODS. The repercussions of environmental degradation and the determinants of climate change are so profound that even a substantial augmentation in irrigation infrastructure or intensity cannot mitigate the detrimental impacts these phenomena have imposed on the growth of India's agricultural sector.

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INTRODUCTION

1.1 Overview

The increase in trace gases such as carbon dioxide (CO_2) and methane (CH_4) in the atmosphere, mostly driven by human activities such as burning fossil fuels, is thought to be changing the earth's climate system. The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) stated that the warming of the climate system is now undeniable. This is supported by evidence of rising global average air and ocean temperatures, widespread melting of snow and ice, and an increase in global sea levels (Liu et al, 2022, pp. 217-219). India has a legitimate cause for worry over climate change, given that a substantial portion of its people relies on climate-sensitive industries such as agriculture, forestry, and fishing for their means of subsistence. The detrimental effects of climate change, such as less rainfall and higher temperatures, have led to a heightened severity of livelihood challenges in the nation. Climate change will exacerbate the strain on natural and social systems that are already under significant pressure as a result of increasing industrialization, urbanization, and economic expansion. Climate change is a significant worldwide environmental issue that has consequences for several aspects of human life, such as food production, natural ecosystems, freshwater supply, and health (Null, Ligare and Viers, 2013, pp. 1456-1472). Based on the most recent scientific evaluation, it is evident that the climate system of the Earth has undergone significant changes at both global and regional levels since the pre-industrial period. Moreover, there is data indicating that the majority of the observed warming, which amounts to 0.1 o C per decade, during the last 50 years, may be attributed to human activities (Bonger et al, 2008, pp. 11-32).

India is a vast developing nation where over 700 million people in rural areas rely directly on climate-sensitive industries and natural resources including water, biodiversity, mangroves, coastal zones, and grasslands for their survival and means of living. Moreover, the resilience of dry land farmers, forest-dwellers, and nomadic shepherds is very limited. Although the Kyoto Protocol has symbolic significance, it is commonly seen as a 'failure' since it has neither effectively launched global emission reduction efforts nor has it committed to the necessary further reductions in greenhouse gas emissions. Scientists have consistently cautioned that even complete compliance with the Kyoto Protocol will have no impact on mitigating climate change (Iwata and Okada, 2014, pp. 325-342). Nevertheless, over 15 years were dedicated internationally to crafting this ineffective strategy. The Kyoto Protocol's strong emphasis on mitigation disproportionately disadvantages poorer nations. The affluent industrialized nations exhibit unsustainable consumption practices, which directly contribute to the climate crisis. Despite comprising just 25% of the worldwide population, these countries are responsible for over 70% of the total global CO2 emissions and use a significant portion, ranging from 75 to 80%, of various global resources (Tiwari, 2011, pp. 85-122).

1.2 Climate change

Climate Change is one of the biggest threats to the nature and humanity in the 21st century, influenced by both anthropogenic activities and natural phenomenon. It was calculated that the increase fossil fuel use with enhancement global warming will lead to the extinction of civilizations as time increases (Lonngren and Bai, 2008, pp. 1567-1568). Hence the problems associated with Climate Change are one of the major obstacles to Sustainable Development. With an increasing release of Greenhouse gases (GHG), which is the major cause of global warming and a key role in regulating Earth’s temperature, it is vital to respond by achieving greater understandings on the impacts of climate change. The impacts of Climate Change have been widely acknowledged to be deteriorating ecosystems services. Climate change's consequences span several domains, including ecology, environment, sociopolitics, and socioeconomic factors, making it a complex international issue (Feliciano et al, 2022, pp. 427- 444). Due to climate change, temperatures are increasing on several celestial bodies. The climatic situation has significantly worsened since the beginning of the industrial revolution (Massey, 2023, pp. 28-81). Swift reaction and suitable intervention are believed to enhance the likelihood of preventing irreversible harm. The increasing acknowledgement and integration of climatic uncertainties in policies at both the regional and federal levels indicate that it is not feasible to accurately evaluate the consequences of climate change on individual sectors. Climate change is defined by the enduring alterations in the temperature, precipitation, air pressure, and humidity of the environment. An important global and local consequence of climate change is the escalation of severe weather phenomena, the shrinking of ice sheets worldwide, and the subsequent elevation of sea levels (Barnett et al, 2023, p. 198). Greenhouse gases (GHGs) such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and water vapor were formerly believed to originate only from natural causes such as forest fires, volcanoes, and seismic activity prior to the industrial revolution (Usman et al, 2022, p. 122515).

Figure 1.1 depict the factors of climate changes as shown below.

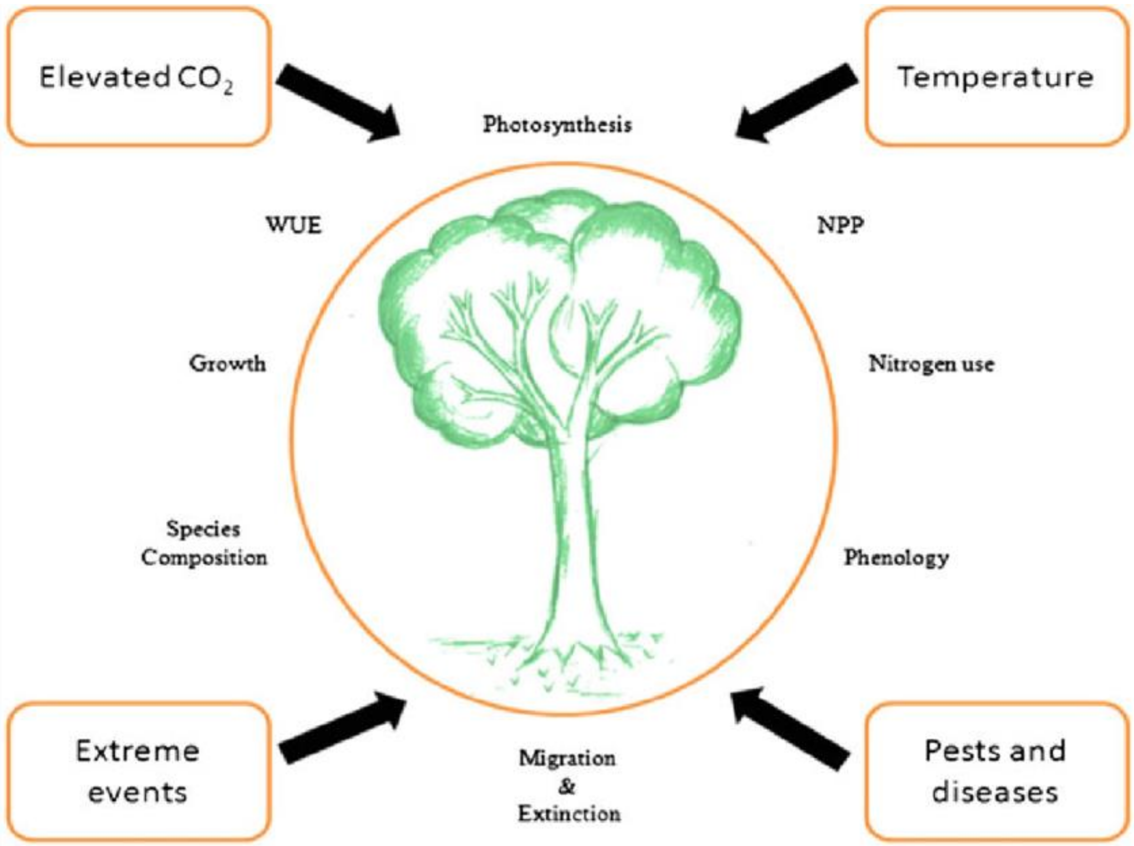

Figure 1.1 Diagram of Factors of climate changes (Source: Kallarackal and Roby, 2012, pp. 1327-1342).

1.3 Climate Variability vs Climate change

Climate variability encompasses fluctuations in the dominant condition of the climate throughout different time periods and geographical areas, beyond the scope of isolated weather occurrences. Variability in the climate system may arise from internal processes or from natural or human- induced external factors. Global climate change refers to a long-term alteration in either the average condition or the fluctuation of the Earth's climate. This encompasses changes in the overall climatic conditions on Earth, such as variations in the average global temperature, as well as shifts in the frequency with which places now suffer heat waves, droughts, floods, storms, and other forms of severe weather. Climate change may arise from natural factors such as variations in solar radiation or Earth's orbital cycle (natural climate forcing), or it can be caused by ongoing human activities (anthropogenic forcing). Examples of factors that contribute to changes in the atmosphere include the introduction of greenhouse gases, sulfate aerosol, black carbon, and alterations in land use. It is noteworthy that alterations in specific weather occurrences contribute to fluctuations in climate, and a consistent long-term pattern of climate variability is referred to as "Climate change". Figure 1.2 illustrate the Climate variability vs Climate changes

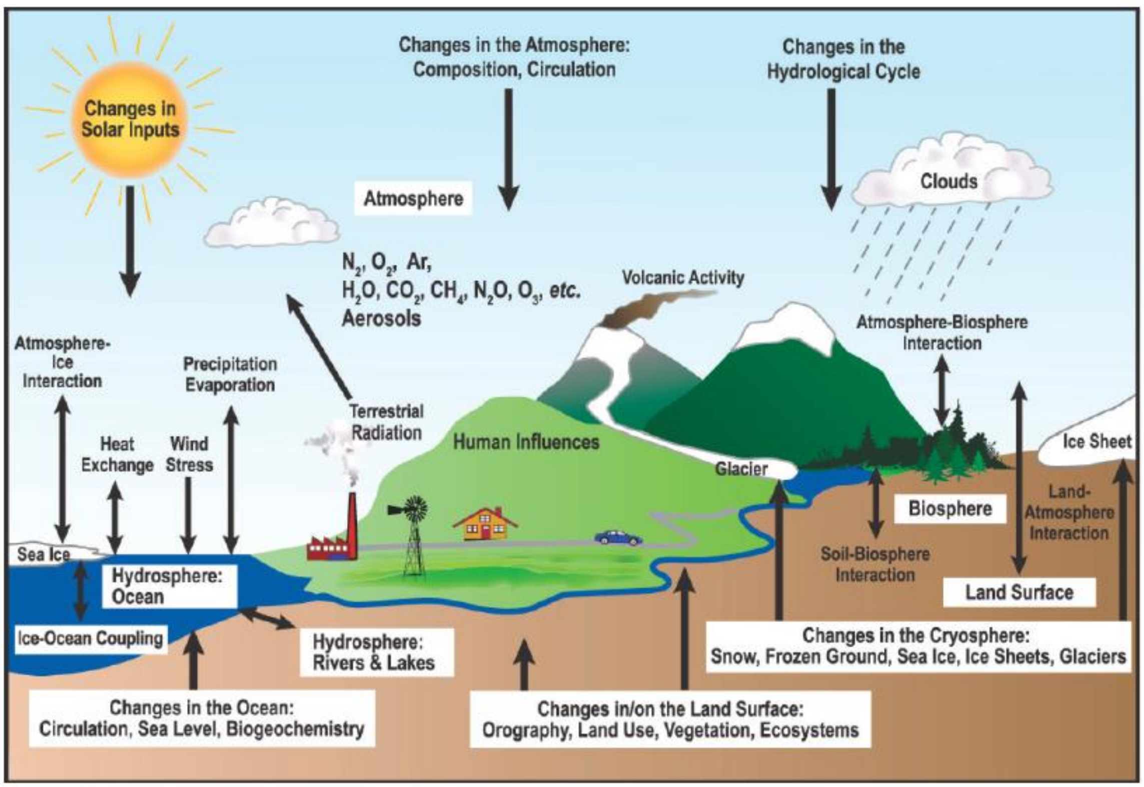

Figure 1.2 Climate variability vs Climate changes (Source: Nap.nationalacademies.org)

A statement may be made that "Climate change is a prolonged cumulative manifestation of climate variability, whereas climate variability is a brief cumulative manifestation of weather patterns." Once again, it may be said that climate change is a large- scale phenomenon, whereas climatic variability is a small-scale one. Table 1.1 depict the difference between climate variability vs climate changes as shown below.

Table 1.1 Difference between climate variability vs climate changes (Source: IGCC & https://www.weather.gov/media/climateservices/VariabilityAndChange)

S. No.	Climate Variability	Climate Change
1	It is a local/regional phenomenon	It is a global phenomenon
2	Year to year or season to season changes in rainfall and temperature are introduced as climate variability	Long term changes in rainfall and temperature over a long period are introduced as climate change
3	Examples:	Examples:
	2002 - drought year over India	Temperature increased by 0.74 °C globally during the last century (global temp. 15°C)
	2007 - Flood year over India	It is likely to increase 3-4 °C during 2100 A.D. (global temp. is likely to be 18-19 °C)
	2008 - Some regions experience floods while droughts in some regions within India	Temperature increase over India is likely to be around 3°C by 2100 A.D.
4	Short period weather changes resulting into heavy crop loss. It may be due to occurrence of floods and droughts and cold and heat waves.	Long period changes in climate lead to decline in agricultural production or changes in cropping systems. Models predict crop losses over India up to 30% by 2080 A.D.

1.4 Cause of Climate change

The fluctuation in temperature on Earth is a result of both natural occurrences and human actions, which eventually leads to the accumulation of greenhouse gases (Stern and Kaufmann, 2014, pp. 257-269). Human activities result in the release of greenhouse gases, including CO_2, methane, and nitrous oxide, as well as other compounds that contribute to the depletion of ozone in the atmosphere (Montzka, Dlugokencky and Butler, 2011, pp. 43-50). The elevated concentration of CO2 in the atmosphere can impact microbial activities in the soil, leading to changes in water content. Consequently, the increased atmospheric CO2 levels (463-780 ppm) can stimulate the release of nitrous oxide and methane from upland soil and wetlands, respectively. This counteracts the predicted 16.6% reduction in climate change effects through the expansion of terrestrial carbon sink (Van Groenigen, Osenberg and Hungate, 2011, pp. 214- 216). The agricultural industry accounts for 15% of overall emissions, mostly consisting of methane and nitrous oxide. If the dietary choices and consumption of food energy remain constant at 1995 levels, it is projected that the worldwide emission of non-agricultural greenhouse gases will continue to increase until 2055. Nevertheless, as people's tastes shift towards more valuable food options like milk and meat, it is anticipated that the emissions will increase at an even more accelerated pace. One may decrease emissions by either technology mitigation or by consuming less meat, or by using both methods (Popp, Lotze-Campen and Bodirsky, 2010, pp 451-462).

According to the IPCC, the cattle industry is the primary source of greenhouse-gas emissions, accounting for around 8-10.8% of emissions. However, depending on lifecycle analysis, it may contribute up to 18% of GHG emissions. The primary contributors to greenhouse gas emissions in the cattle industry include enteric fermentation, N2O emissions, liming, fossil fuel use, organic farming, and fertilizer manufacturing. Nitrogenous chemical fertilizers contribute to the release of greenhouse gases (Lesschen et al, 2011, pp. 16-28). By using improved agricultural production management techniques, it is possible to reduce the consumption of nitrogen fertilizer by 38%. Improved crop management practices result in a decrease of 11% in the amount of energy required for cultivation, while simultaneously increasing yields by 33%. This translates to a reduction in greenhouse-gas emissions by 20% (Soltani et al, 2013, pp. 54-61).

The causes of climate change can be divided into two categories – those that are due to natural causes and those that are created by man. Various studies made by NASA, IPCC, UNFCC etc. agree the causes of climate change to be divided in to two types as shown in Figure 1.3.

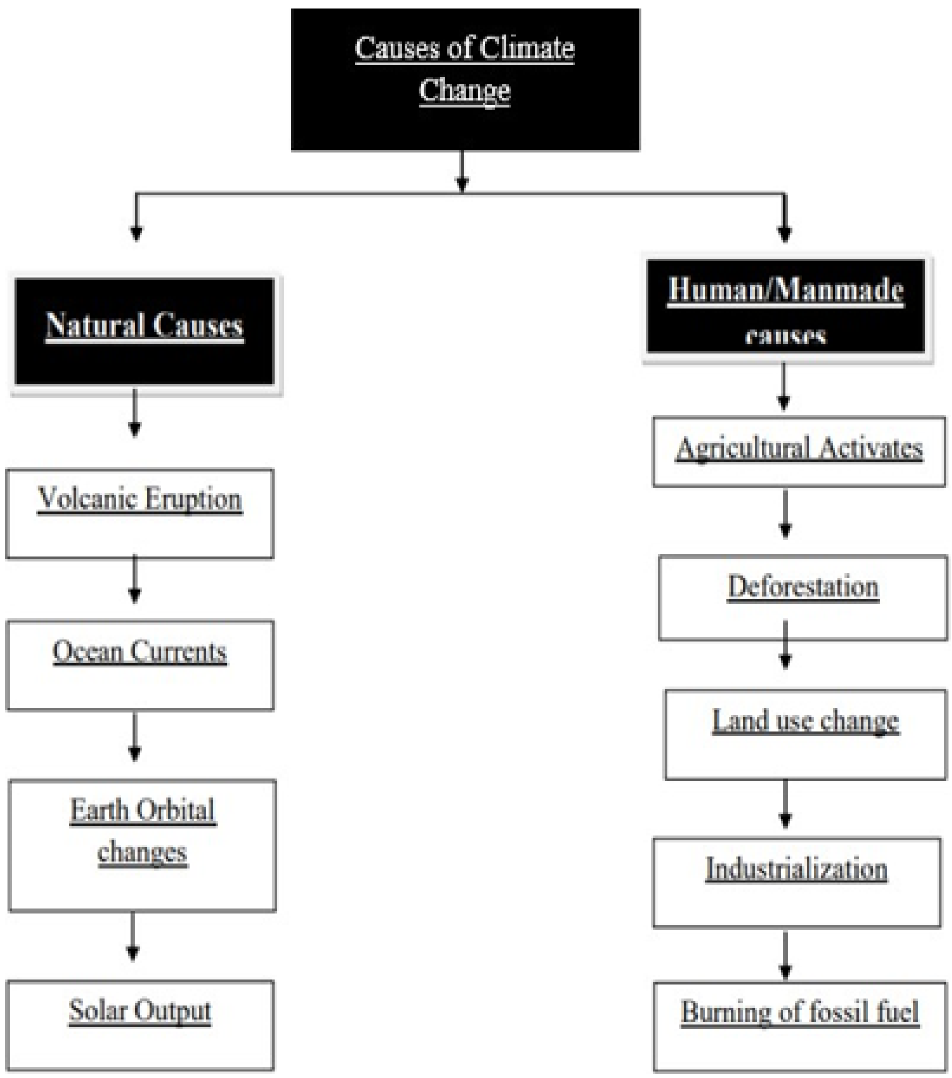

Figure 1.3 Flowchart of causes of climate change. Source: https://climate.ec.europa.eu/climate-change/causes-climate-change_en & https://www.un.org/en/climatechange/science/causes-effects-climate-change & Various other sources

A. Natural Causes

- **Continental drift**

Scientists suggest that around 200 million years in the past, the Earth did not possess its current appearance. All the continents were once contiguous and not fragmented. Evidence for this may be seen in the resemblance of plant and animal fossils, as well as the extensive rock formations discovered along the eastern coast of South America and the western coast of Africa. These regions are now divided by the Atlantic Ocean. The presence of fossilized tropical plants, found as coal deposits in Antarctica, suggests that this frozen land was once located nearer to the equator. This indicates that the climate in Antarctica was once tropical, characterized by swamps and abundant rush vegetation. The familiar continents we know today were created by the gradual separation of land masses millions of years ago. This drift also influenced the climate by altering the physical characteristics of the landmass, their locations, and the placements of water bodies. The alteration in the arrangement of landmasses resulted in a modification in the patterns of ocean currents and winds, thereby impacting the climate. The ongoing process of continental drift is supported by data indicating that the Himalayan range is gradually ascending at a rate of around 1 millimeter per year. This is attributed to the slow but steady movement of the Indian land mass towards the Asian land mass.

- **Volcanic Eruption**

Volcanic eruptions have a significant impact on the climate. During a volcanic eruption, significant quantities of sulphur dioxide, water vapor, dust, and ash are expelled into the sky. While the volcanic activity may be short-lived, the significant amounts of gasses and ash released may have long-lasting effects on climate patterns. A big eruption may release millions of tonnes of SO_2 gas into the stratosphere. The gasses and dust particles partly obstruct the incoming solar radiation, resulting in a decrease in temperature.

Sulphur dioxide reacts with water to produce little drops of sulphuric acid. These minuscule droplets have such a tiny size that a significant number of them may remain suspended in the air for several years. They effectively reflect sunlight and shield the earth from a portion of the solar radiation it would normally get. The stratospheric winds, known as upper-level winds, swiftly transport aerosols across the world in either an eastward or westward direction. Figure 1.4 depict the volcano eruptions as shown below.

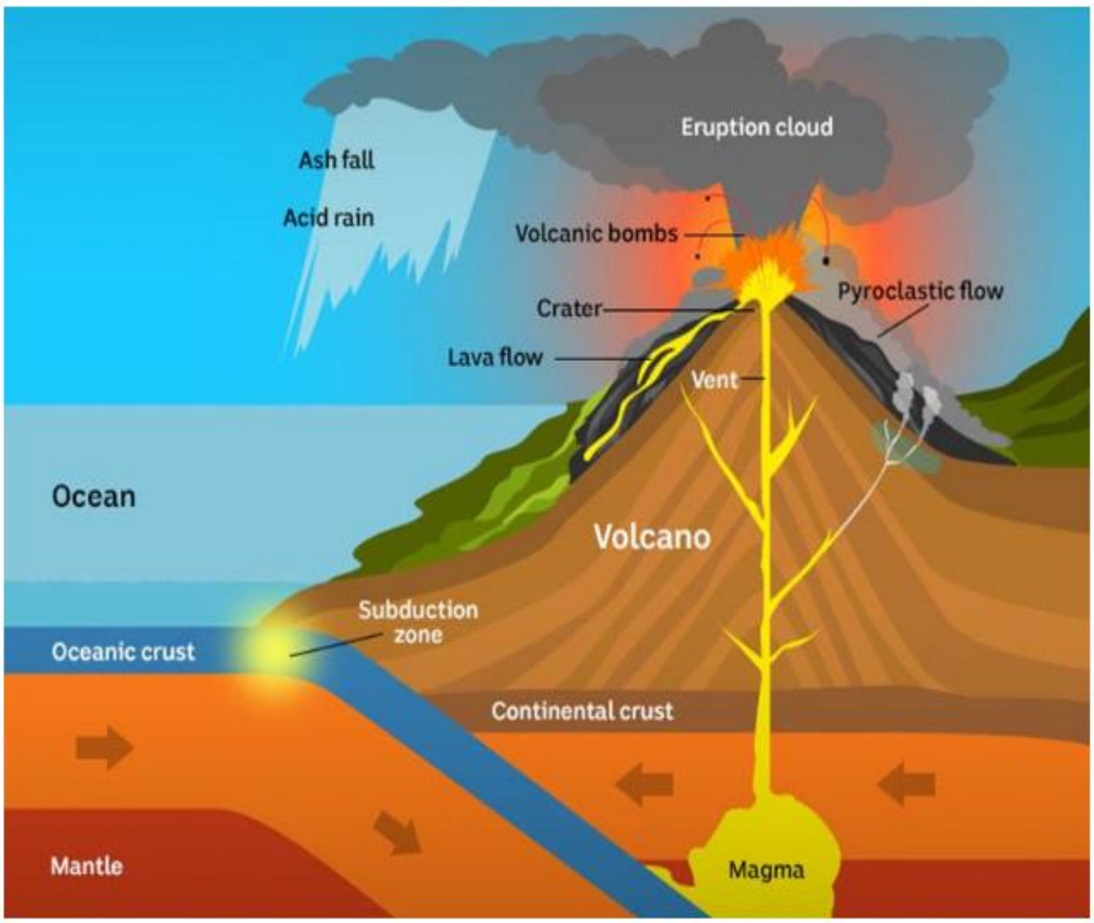

Figure 1.4 Volcano eruption (Source: www.shelterboxusa.org/disasters)

Global temperatures saw a decline of around 0.5 degrees Celsius. A volcanic eruption of this scale may diminish the quantity of solar radiation that reaches the Earth's surface, resulting in a decrease in temperature in the lower regions of the atmosphere (known as the troposphere) and altering the pattern of atmospheric circulation. Volcanoes are also a component of the prolonged carbon cycle. Over extended geological timeframes, carbon dioxide is emitted from the Earth's crust and mantle. However, according to the US Geological Survey, volcanic emissions are far smaller in comparison to the impact of present human activities, which produce 100-300 times more CO_2 than volcanoes.

- **Oceans Currents**

The oceans have a significant role in the climate system. Oceans encompass around 71% of the Earth's surface and have the capacity to absorb almost double the amount of solar energy compared to the atmosphere or land surface. Ocean currents transport substantial quantities of heat across the Earth, comparable to the quantity transferred by the atmosphere. However, due to the presence of land masses, the seas are constrained in their heat transfer, which occurs mostly via channels. Horizontal winds exert force on the sea surface, causing certain patterns of ocean currents. Some regions of the globe are more susceptible to the effects of ocean currents than others. The price of Peru and neighboring areas is directly impacted by the Humboldt Current that runs along the Peruvian coastline. The interaction between the ocean and atmosphere may give rise to events like El Niño, which typically occur at intervals of 2 to 6 years. The deep ocean exhibits a circulation pattern whereby cold-water flows from the equator towards the poles. This movement is crucial in maintaining the temperature balance between the poles and the equator, preventing the poles from becoming even colder and the equator from becoming excessively warmer. The seas have a significant influence on the atmospheric levels of carbon dioxide (CO_2). Alterations in ocean circulation may impact the climate by facilitating the transfer of carbon dioxide (CO_2) into or out of the atmosphere.

- **Earth orbitals changes**

The Earth completes one revolution around the Sun in a period of one year. It is inclined at an inclination of 23.50 degrees to the perpendicular plane of its orbital path. Variations in the Earth's axial tilt may result in subtle but significant alterations in the intensity of the seasons. A greater tilt leads to hotter summers and colder winters, whereas a smaller tilt results in cooler summers and milder winters. The gradual changes in the earth's orbit result in subtle but significant fluctuations in the intensity of the seasons over extended periods of tens of thousands of years. There are three distinct kinds of orbital variations:

Variations in earth’s eccentricity

Changes in the tilt angle of Earth's axis of rotation.

Precession of earth’s axis.

Combined together, these produce Milankovitch cycles which have a large impact on climate.

The IPCC acknowledges that the ice age cycles were driven by Milankovitch cycles. Carbon dioxide (CO2) had a delayed response to changes in temperature, occurring several hundred years later, and acted as a feedback mechanism that intensified the temperature shift. Oceanic depths exhibit a temporal delay in temperature changes. The solubility of CO2 in the ocean and the Air Sea CO2 exchange are affected by changes in sea water temperature. The Earth's orbit is elliptical, resulting in a varying distance between the Earth and the Sun throughout the year. It is often believed that the Earth's axis remains fixed, since it consistently aligns with Polaris, also known as the pole star or North Star. In reality, the axis undergoes little movement, changing at a pace of just over half a degree every century. Polaris has neither perpetually served as, nor will it indefinitely serve as, the celestial body indicating the direction of the north. The phenomenon known as precession, which refers to the progressive shift in the Earth's orientation, is responsible for climatic variations.

- **Solar variation**

The sun is the primary source of energy input to the Earth. Both long-term and short-term fluctuations in solar intensity have the potential to impact global climate. While the sun's energy output may seem consistent in our daily observations, gradual variations over a long duration might result in climatic fluctuations. Several experts hypothesize that a fraction of the temperature rise during the first half of the 20th century may be attributed to an augmentation in solar energy emissions. Given that the sun is the primary source of energy that plays a crucial role in our climate system, it is logical to infer that alterations in the sun's energy production would lead to changes in the climate. Scientific research has shown evidence that solar variations have had a significant effect in previous climatic fluctuations. For example, it was believed that a decline in solar activity was responsible for the occurrence of the Little Ice Age, which occurred roughly between 1650 and 1850. During this period, Greenland was mostly isolated by ice from 1410 to the 1720s, while glaciers progressed in the Arctic, Antarctic, and Alpine regions. The current phenomenon of global warming, however, cannot be attributed to fluctuations in solar activity. There is evidence to support the claim that since 1750, the average amount of energy derived from the sun has either stayed stable or seen a little rise. If global warming were attributed to heightened solar activity, scientists would anticipate seeing elevated temperatures throughout all atmospheric layers. However, their observations have shown a cooling trend in the 13 uppermost layers of the atmosphere, while a warming trend has been recorded at the surface and in the lower regions of the atmosphere. This phenomenon occurs as a result of greenhouse gases trapping thermal energy in the lower atmosphere.

B. Human/Manmade causes

Climate change may be attributed to several factors. A wide range of individuals, including humans, animals, and plants, are experiencing the consequences. Since the beginning of the Industrial age, human activities have had a progressively greater impact on the climate, mostly via the emission of billions of metric tons of greenhouse gases that trap heat in the atmosphere. The causes of climate change attributed to human activity are as follows:

Agricultural activities

Deforestation

Land use change

Burning of fossil fuel.

Industrialization

- **Agriculture activities**

Agriculture has been shown to have a substantial impact on climate change, mainly due to the generation and emission of greenhouse gases such carbon dioxide, methane, and nitrous oxide. Undoubtedly, CO2 is the most significant greenhouse gas present in the environment. The alteration in land use patterns, including deforestation and land clearance, as well as agricultural practices and related activities like as animal husbandry, have together contributed to an increase in carbon dioxide (CO2) emissions. Methane is a significant greenhouse gas present in the atmosphere. Approximately 25% of all methane emissions are attributed to domesticated animals, including dairy cows, goats, pigs, buffaloes, camels, horses, and sheep. Methane is also emitted by the submersion of rice fields during the planting and growing phases. When soil is submerged in water, it becomes anaerobic, meaning it lacks oxygen. In such circumstances, methanogenic bacteria and other organisms break down organic materials in the soil to generate methane. Asia accounts for over 90% of the global paddy cultivation area, mostly due to the fact that rice is a staple meal in the region. China and India together own around 80-90% of the global rice cultivation area. Methane (CH_4) is also released by landfills and other waste disposal sites. When garbage is incinerated or burned in the open, it releases carbon dioxide (CO_2). Nitrous oxide emissions, a significant greenhouse gas, are linked to the application of fertilizers. The extent of these emissions depends on the specific kind of fertilizer used, as well as the timing and methods of application, including tilling practices. Leguminous plants, such as beans and pulses, provide contributions to the soil by adding nitrogen. Agricultural activities are significant contributors to greenhouse gas (GHG) emissions, which are the primary driver of climate change.

- **Deforestations**

This valuable asset Rainforests are crucial for the functioning of our planet. They are integral components of a fragile ecosystem that has undergone millions of years of evolution. Each year, rainforests play a crucial role in absorbing around 20% of the carbon dioxide emissions caused by human activities. Hence, deforestation may be categorized as a significant factor in the origins of climate change. Accelerating deforestation beyond the rate of reforestation has a catastrophic impact on the carbon emission cycle, since trees sequester CO_2. Increased deforestation leads to a greater accumulation of CO_2 in the atmosphere. Deforestation via the process of felling and incinerating the rainforest often facilitates the establishment of agriculture and industry, which frequently results in the emission of higher levels of carbon dioxide (CO_2). Figure 1.5 demonstrate the schematic diagram of deforestation as shown below.

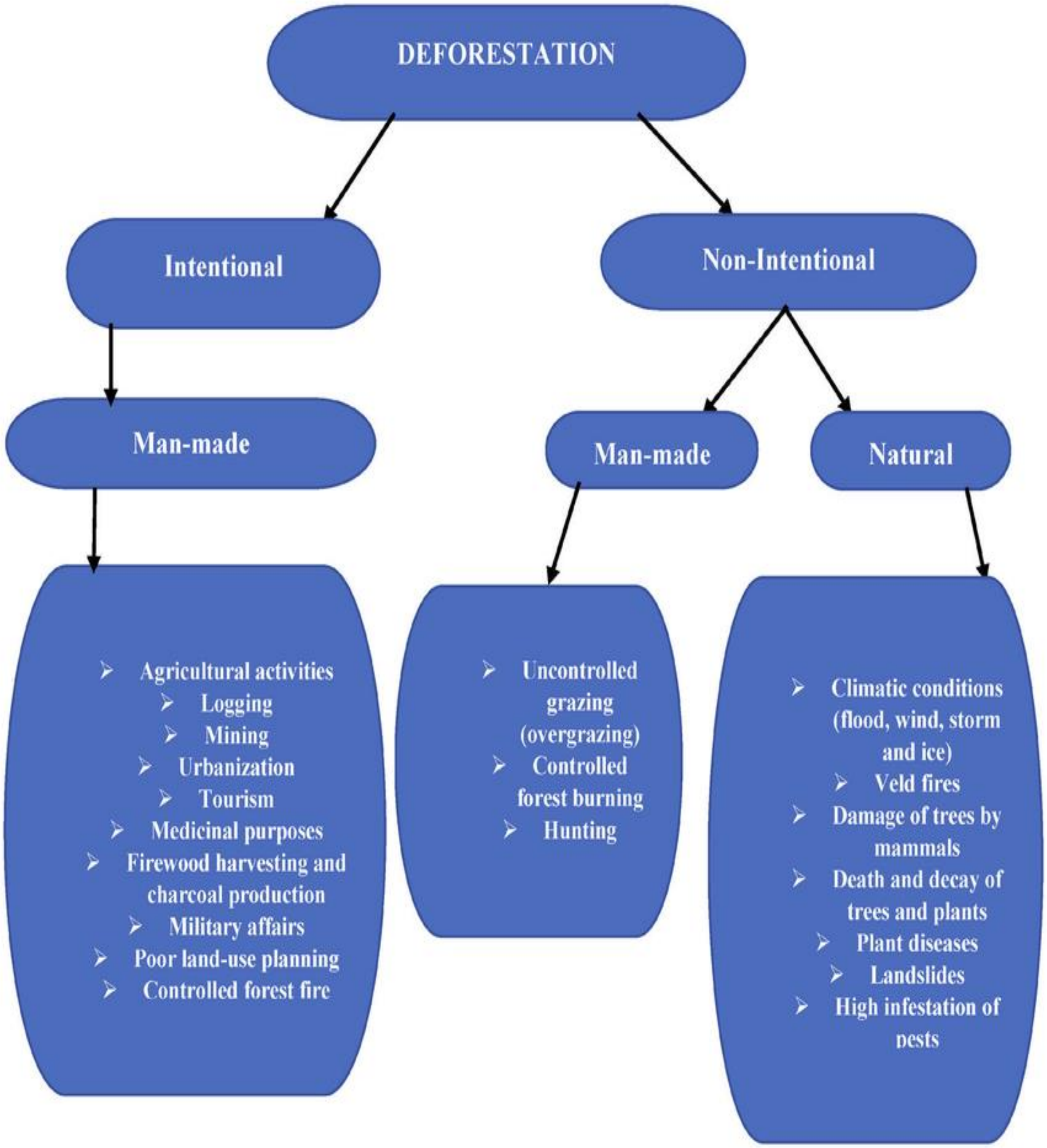

Figure 1.5 Schematic illustration of deforestations (Agholor et al, 2021)

Forests sequester and retain carbon dioxide (CO2), playing a significant role in reducing the effects of climate change. Conversely, when trees are damaged or excessively harvested and burnt, they emit the greenhouse gas CO2. Undamaged forests play a crucial role in sustaining several advantages, including as mitigating the impacts of climate change, storing carbon to offset fossil fuel emissions, and promoting the health, sustainability, and resilience of ecosystems. Forests play a crucial role in mitigating global warming by reducing greenhouse gas emissions. Approximately 20% of the world's greenhouse gas emissions are caused by deforestation and forest degradation, which is greater than the total emissions from all vehicles, trucks, ships, and aircraft worldwide. Fossil fuels emit carbon dioxide (CO_2) into the atmosphere, hence contributing to the phenomenon of global warming and climate change. The forest mitigates this shift by turning carbon dioxide into carbon via the process of photosynthesis. The global forest ecosystem comprises about 12.5% of the total carbon present in the Earth's atmosphere. Carbon sequestration is the process by which carbon is stored in the form of wood and plants. Trees contain around 20% carbon by weight, and the biomass of forests serves as a "carbon sink". The soil organic matter generated by the breakdown of deceased plant material also functions as a carbon reservoir.

- **Land use changes**

Land use change is the transformation of forested areas into agricultural land, which is a significant human activity that contributes to the production of greenhouse gases (GHGs).

The most important land use changes that result in Co_2 emission and removals are:

Change in forest and other woody biomass stocks: The primary impact of human interactions with existing forests can be categorized broadly as encompassing commercial management, extraction of industrial round wood and fuel wood, production and utilization of wood commodities, establishment and operation of forest plantations, and the planting of trees in urban and non-forest areas.

Forest and grassland conversion: The conversion of forest and grasslands to posture, cropland, or other managed uses can significantly change carbon stored in vegetation and soil.

Abandonment of croplands, posture, plantation forests or other managed lands that re-group into their prior natural grassland as forest condition.

Land use, land use change, and forestry (LULUCF) is a sector in greenhouse gas inventory that encompasses the emissions and removal of greenhouse gases caused by human activities related to land use, land use change, and forestry. The Land Use, Land-Use Change, and Forestry (LULUCF) sector plays a significant role in the global carbon cycle. The activities within this sector have the potential to either release or sequester CO2, or more broadly, carbon, from the atmosphere, therefore affecting the overall carbon balance. The use and alteration of land are of utmost significance for both climate change and biodiversity.

- **Industrialization**

Industrialization is an economic process focused on the manufacturing of commodities, extraction of resources, and supply of services. The pursuit of economic progress via industrialization has placed immense strain on the environment in emerging nations that have attempted to keep pace. However, whether intentionally or unintentionally, industrialization progressed rapidly without regard for the environment in order to achieve victory in the competition. The rate of industrialization has multiplied four times during the last decade. Industrial effluents, air pollution, noise pollution, and the greenhouse gas impact are not only detrimental to human habitats but also pose a significant threat of impending calamity. The pursuit of material wealth is causing the gradual destruction of the ecosystem. Temporary human comfort might lead to prolonged suffering. Nevertheless, due to the escalating levels of industry and urbanization, the natural ecosystem is unable to effectively manage pollutants and purify the environment by natural means. When compared to natural calamities such as volcanoes, hurricanes, and forest fires, human activities generate a far larger amount of waste that contributes to atmospheric pollution. Hence, the detrimental effects of industrialization and urbanization on the environment are severe and far-reaching. The pursuit of expansion via industrialization has placed immense strain on the environment.

Industrialization has resulted in the exploitation of certain natural resources, causing irreversible environmental degradation due to the widespread usage of factories and mass manufacturing. An instance of this reduction is the process of deforestation. Deforestation disrupts the natural habitat of forest-dwelling animals, causing them to lose their homes and be displaced. The absence of trees is further exacerbated by the issue of carbon emissions. The pollution stemming from 19 industries include not just atmospheric emissions but also contamination of land and water. Industrialization is causing the destruction of the environment in a cyclical manner by increasing carbon emissions, depleting natural resources, exacerbating air, water, and land pollution, and accelerating deforestation. Industrial activities, which are essential for our contemporary civilization, have caused a significant increase in atmospheric carbon dioxide levels from 280 parts per million to 379 parts per million during the last 150 years. The panel has determined with a confidence over 90% that greenhouse gases created by humans, such as carbon dioxide, methane, and nitrous oxide, are responsible for a significant portion of the observed rise in Earth's temperatures during the last 50 years. The evaluation concludes that the pace of global warming caused by these gases is very likely to be unparalleled in the previous 10,000 years or longer.

- **Burning of Fossil Fuel**

Fossil fuel is produced by natural processes, namely the anaerobic decay of deceased organisms that are buried. The age of the creature and the fossil fuel it produces is normally in the range of millions of years, and in exceptional cases may surpass 650 million years. Fossil fuels, such as coal, petroleum, and natural gas, have significant carbon content. These were derived from ancient flora and fauna. Fossil fuels are classified as non-renewable resources due to their lengthy formation process spanning millions of years, and the rate at which reserves are being exhausted exceeds the rate at which new ones are being created. The extraction and use of fossil fuels give rise to environmental apprehensions. The combustion of fossil fuels results in the emission of about 21.3 billion metric tons (or 21.3 gigatons) of carbon dioxide annually. However, it is anticipated that natural processes can only sequester roughly half of this quantity, leading to a net increase of 10.65 billion metric tons of atmospheric carbon dioxide per year. The amount of atmospheric carbon is comparable to 3.7 tonnes of carbon dioxide, which is calculated as 44/12. Greenhouse gases are gases that trap heat in the Earth's atmosphere, contributing to the greenhouse effect and global warming. The information was obtained from the Department of Energy in 2007-09. CO2 is a greenhouse gas that increases radiative forcing and contributes to global warming, resulting in a rise in the average surface temperature of the Earth. Figure 1.6 depict the process of fossil fuels as shown below.

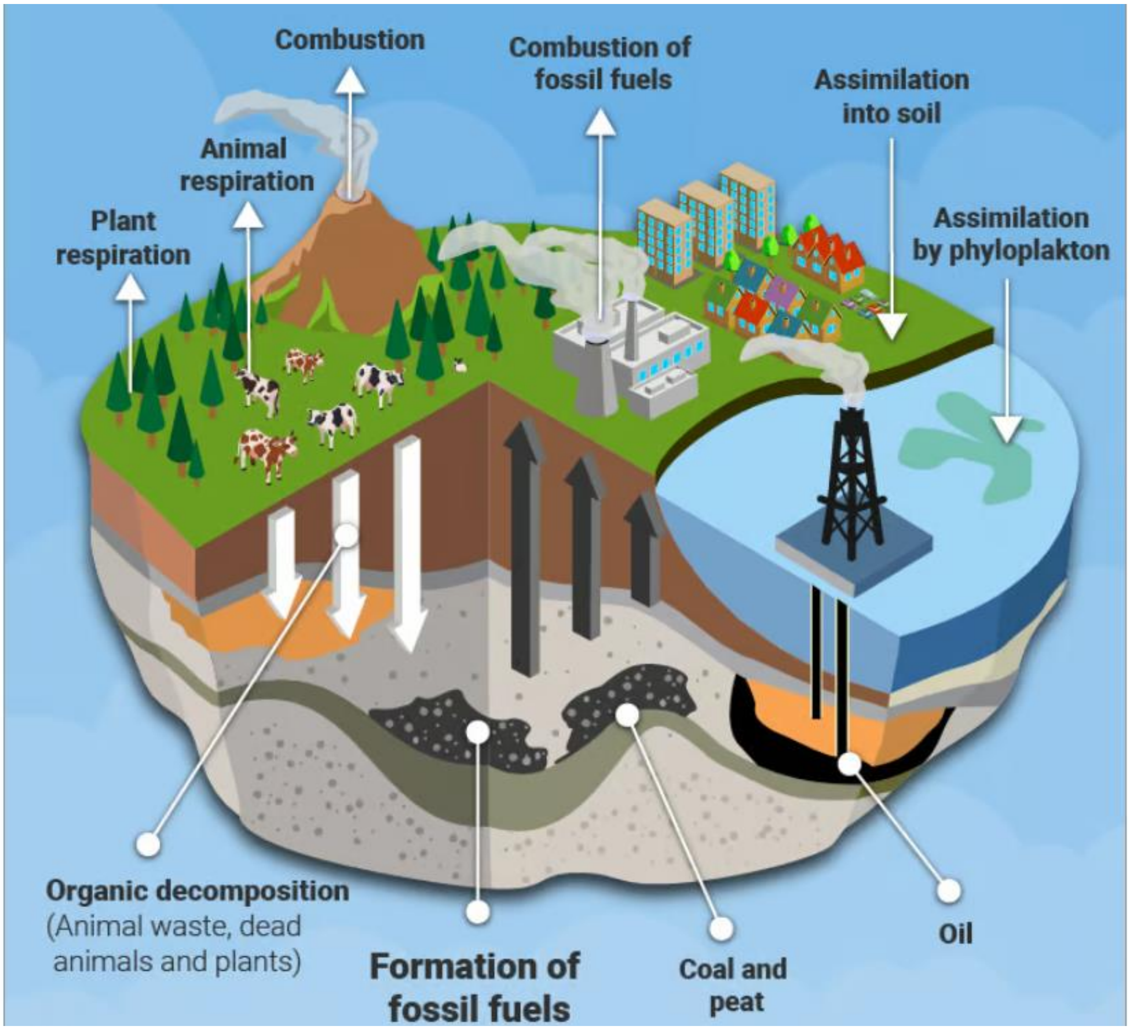

Figure 1.6 Process of fossil fuels (Source: www.greenmatch.co.uk/fossil-fuel-analysis)

The majority of climatologists think that this will have negative impacts on the environment, including changes in climate. Consequently, the combustion of fossil fuels is emitting greenhouse gases into the atmosphere at an escalating annual pace. The rapidity of the current human-induced temperature rise is more concerning than its overall amount, since adapting to such fast climate change would pose significant challenges.

1.5 Climate Change Mitigation Strategies

Two primary climate change mitigation options are extensively explored in the section. Initially, traditional efforts to mitigate climate change include the implementation of decarbonization technologies and procedures that effectively decrease the release of CO2 into the atmosphere. These include the use of renewable energy sources, switching to alternative fuels, improving energy efficiency, using nuclear power, and employing carbon capture, storage, and utilization methods. The majority of these technologies have been widely used and provide a manageable degree of risk (Ricke, Miller and MacMartin, 2017, p. 14743) (Bohringer, Garcia-Muros and Gonzalez-Eguino, 2022, 0. 105705). Another pathway encompasses a novel array of technologies and methodologies that have been lately suggested. These approaches have the ability to absorb and store CO2 from the environment. They are known as negative emissions technologies or carbon dioxide removal methods (Ricke, Miller and MacMartin, 2017, p. 14743). The primary negative emissions techniques extensively discussed in the literature comprise bioenergy carbon capture and storage, biochar, enhanced weathering, direct air carbon capture and storage, ocean fertilization, ocean alkalinity enhancement, soil carbon sequestration, afforestation and reforestation, wetland construction and restoration, as well as alternative methods for utilizing and storing negative emissions, such as mineral carbonation and employing biomass in construction.

A. Conventional Mitigation Technologies

The primary cause of the rising amounts of greenhouse gases in the atmosphere is emissions connected to energy. Therefore, it is crucial to concentrate traditional mitigation strategies and efforts on both the supply and demand aspects of energy. The literature mostly focuses on discussing mitigation efforts, which include the deployment of technology and procedures in four primary sectors: power supply, industry, transportation, and buildings. Decarbonization in the electricity sector may be accomplished by implementing renewable energy sources, nuclear power, carbon capture and storage, and transitioning to low-carbon fuels like natural gas and renewable fuels. Additionally, efforts to mitigate the demand for energy include the implementation of energy-efficient processes and sector-specific technologies that decrease energy consumption. This can also involve switching from fossil-based fuels to renewable fuels and incorporating renewable power technologies into the energy systems of these sectors (Mathy, Menanteau and Criqui, 2018, pp. 273-289). Figure 1.7 depicts the conventional mitigation technologies and techniques.

Figure 1.7 Conventional mitigation technologies (Fawzy et al, 2020, pp. 2069-2094)

As shown in Figure 1.7, these are decarbonization technologies that primarily target the reduction of CO2 emissions associated with both the production and use of energy.

Common methods for reducing the impact of climate change include the use of renewable energy, nuclear power, carbon capture and storage (CCS), carbon capture and utilization (CCU), fuel switching, and improvements in efficiency. These technologies and methods are mostly used in the power, industrial, transportation, and construction sectors.

- **Renewable energy**

In addition to the electricity sector, renewable energy may also be used in the industrial, transportation, and construction sectors. Decarbonization efforts using renewables include the use of photovoltaic and thermal solar energy, as well as the transition to renewable fuels including solid, liquid, and gaseous biofuels for combined heat and power generation in industrial settings. Buildings may also use solar and biomass-based technology to meet their electricity, heating, and cooling needs. End-use fuel switch is a crucial factor in decarbonizing the transportation industry. Solar and wind power, which are variable renewables, are crucial technologies that have significant promise for reducing carbon emissions. One of the primary technical hurdles is the intermittent and variable nature of electricity generation. This challenge has been resolved by integrating these technologies with storage, as well as other renewable baseload and grid technologies. Sinsel et al. address four specific challenges associated with fluctuating renewables, namely quality, flow, stability, and balance. In addition, they propose many solutions that primarily focus on flexibility and grid technologies for both distributed and centralized systems (Sinsel, Riemke and Hoffmann, 2020, pp. 2271-2285). The economic, social, and policy elements have a significant impact on the creation and implementation of renewable energy technologies. Figure 1.8 depict the renewable sources of energy as shown below.

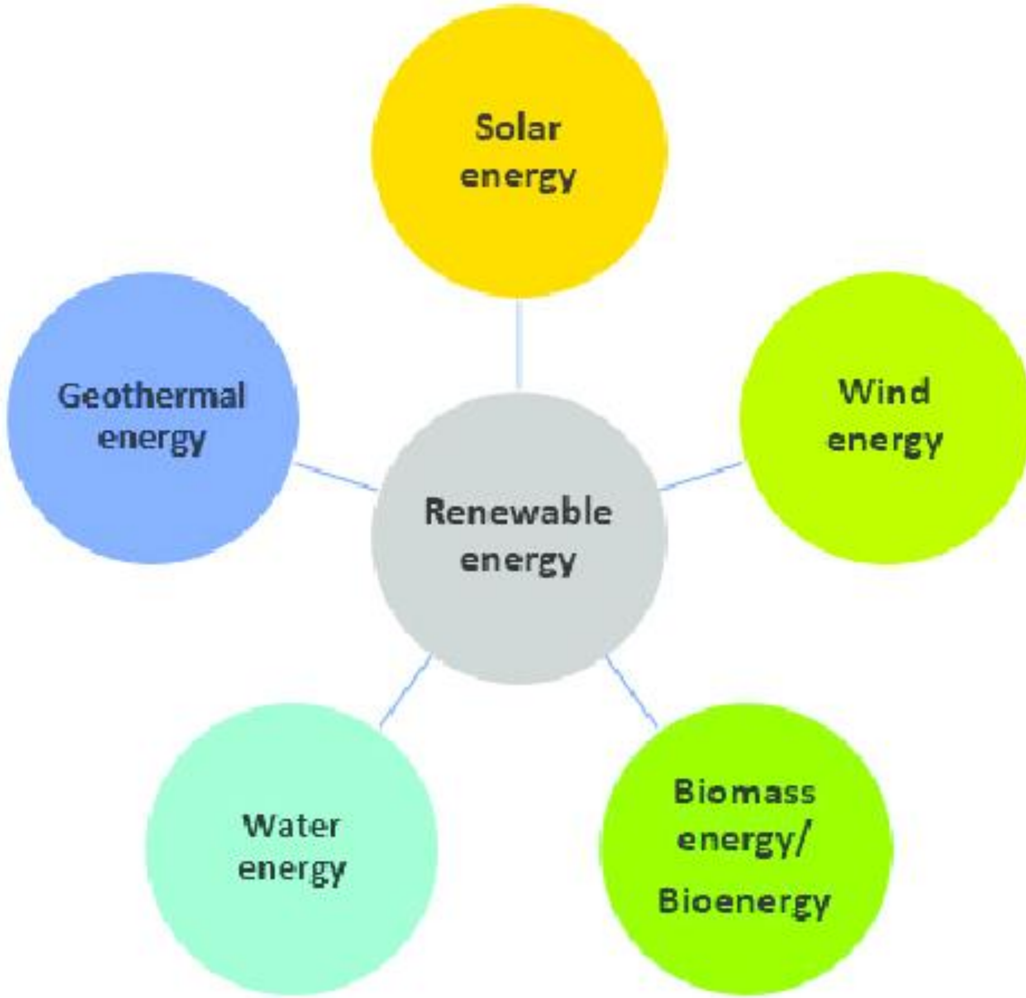

Figure 1.8 Renewable source of energy (Cristea and Andreea, 2016, pp. 132-140)

- **Nuclear Power**

While nuclear energy is often seen as a viable option for reducing carbon emissions and addressing climate change, it is important to acknowledge its significant drawbacks. Initially, the expenses related to the establishment and ongoing operation of nuclear power are very substantial. Moreover, the risk of environmental radioactive contamination is a significant concern linked with nuclear power. This risk primarily arises from the potential of reactor accidents and the hazards involved in the disposal of nuclear waste (Pravalie and Bandoc, 2018, pp. 81-92). Although there are plans to gradually eliminate traditional nuclear power plants that rely on fission, the implementation of advanced fusion-based nuclear technology might potentially play a beneficial role in reducing the effects of climate change in the latter part of the century. Fusion power is an advanced kind of nuclear power that surpasses the efficiency of traditional fission-based technologies and eliminates the potential dangers connected with waste disposal. In addition, fusion power is classified as a zero-emission technology (Gi et al, 2020, p. 100432).

- **Carbon capture, storage and utilization**

Carbon capture and storage (CCS) is a highly regarded technology that is being considered as a viable method for reducing carbon emissions in both the electricity and industrial sectors. The method involves the extraction and containment of CO2 emissions from processes that depend on fossil fuels, such as coal, oil, or gas. After being caught, the CO2 is further transported and stored in geological reserves for extended durations. The primary goal is to decrease emission levels while using fossil sources. The study discusses three capture technologies: pre- combustion, post-combustion, and oxyfuel combustion. Every technology has a distinct procedure for extracting and collecting CO2. Post-combustion capture technologies are particularly well-suited for retrofit projects and provide significant possibilities for application. After the successful collection of CO2s, it is converted into a liquid form and then transferred via pipelines or ships to appropriate storage locations. According to studies, possible storage alternatives include of depleted oil and gas fields, coal beds, and subterranean saline aquifers that are not utilized for drinking water (Vinca et al, 2018, pp. 148-159). Carbon capture and storage has many significant disadvantages, including concerns about the safety of storage and the potential for leakage.

- **Fuel switch and efficiency gains**

The short-term discussion in this section has focused on the transition in the power industry from coal to gas via fuel switching. As a possible strategy for achieving an economically viable transition to a low-carbon and ultimately zero-carbon economy in the future (Victor, Nichols and Zelek, 2018, pp. 410-425). The transition to natural gas may also be implemented in the industrial, transportation, and construction sectors. However, as said before, adopting renewable fuels offers a more sustainable strategy and has the potential to further reduce carbon emissions in these sectors. Efficiency increases are very significant in mitigation efforts, including fuel switching. Efficiency increases in the power industry are achieved by raising the efficiency of fuel combustion and improving turbine generator efficiencies in thermal power plants. In addition, the use of waste heat recovery systems to generate both thermal and electrical energy improves overall efficiency. The adoption of combined cycle technology in gas-fired power plants greatly improves efficiency. Combined heat and power units have also contributed significantly to improvements in efficiency. Technological advancements in transmission and distribution networks help improve efficiencies by decreasing losses (Wendling, 2019, pp. 235- 245).

B. Negative Emission Technologies

The Intergovernmental Panel on Climate Change (IPCC) examined various climate pathways and found that incorporating negative emissions technologies, in addition to conventional decarbonization technologies, is necessary to evaluate the possibility of meeting the goals set by the Paris agreement. The IPCC evaluations have only considered two negative emissions technologies so far: bioenergy carbon capture and storage, as well as afforestation and reforestation (Allen et al, 2018). Figure 1.9 depicts the major negative emissions technologies and carbon removal methods as shown below.

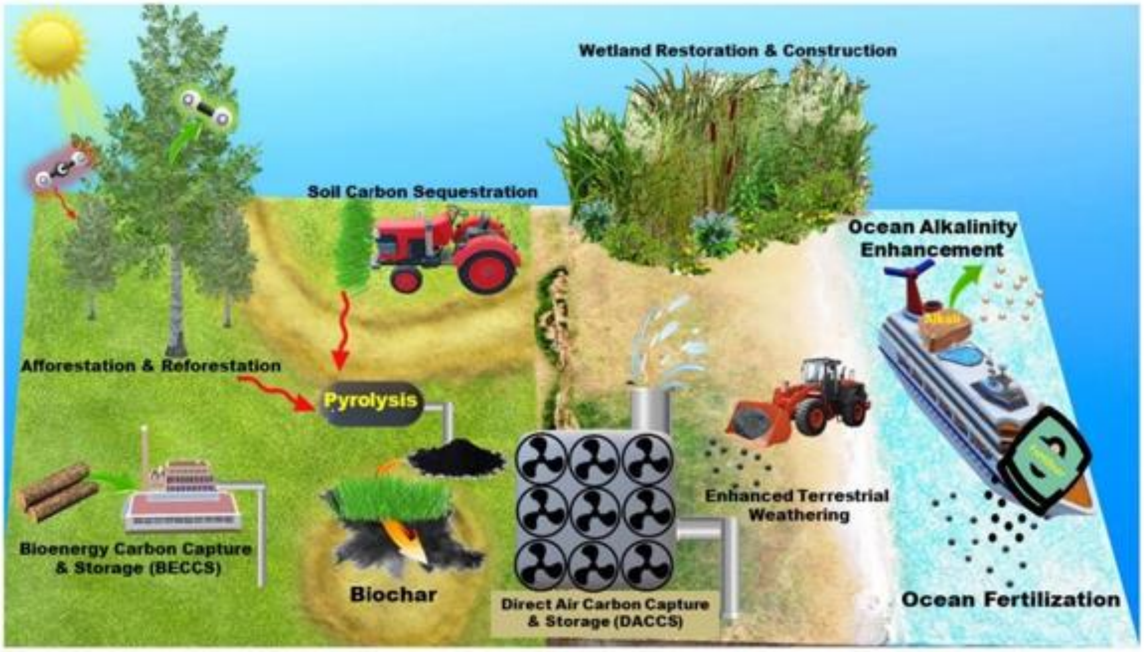

Figure 1.9 Major Negative emission technologies (Allen et al, 2018).

- **Bioenergy carbon capture and storage**

The fundamental concept behind this technique is rather simple. Biomass sequesters atmospheric CO2 via photosynthesis throughout its development, and then harnesses it for energy generation via burning. The carbon dioxide emissions produced during burning are then absorbed and stored in appropriate geological reservoirs (Pires, 2019, pp. 502-514). This technique has the potential to substantially decrease greenhouse gas concentration levels by extracting carbon dioxide from the atmosphere. Regarding technological preparedness, bioenergy technologies have reached a considerable level of development. However, carbon capture and storage are still in their early stages. The primary concern of technology risk is in the preservation of storage integrity and the possibility of leakage, as previously stated in relation to carbon capture and storage. The primary obstacle linked to this technique is the substantial quantity of biomass feedstocks needed to effectively mitigate emissions. During extensive implementation, the use of specialized crops would result in substantial resource demand, putting significant strain on land, water, and nutrient resources. An important concern arises from the direct conflict between biofuel production and the cultivation of food and feed crops for limited resources such as land, freshwater, and nutrients (Cox et al, 2018, p. 340212).

- **Afforestation and reforestation**

Throughout the process of tree development, carbon dioxide (CO2) is absorbed from the atmosphere and then stored in live biomass, deceased organic matter, and soils. Forestation is a biogenic technique that helps reduce greenhouse gas emissions and is crucial in efforts to combat climate change. Forestation may be implemented by the establishment of new woods, known as aforestation, or the restoration of previously deforested or degraded forest regions, known as reforestation. Regarding technological preparedness, the practices of aforestation and reforestation have already gained significant traction worldwide. These practices have been successfully included into climate policy via the clean development mechanism program of the Kyoto Protocol since the 1990s. In order to further efforts in mitigating the effects of deforestation, the protocol included the use of removal units, which enabled forestation operations to generate tradable credits. Although the first regulatory steps were implemented, the forest-based mitigation efforts only contributed a little portion of the total emissions during that period. Forest-based abatement programs have been implemented via both national rules and voluntary mechanisms, such as the reducing emissions from deforestation and forest degradation (REDD+) program, initiated by the United Nations in 2008. Nevertheless, the process of carbon sequestration via forestation was deemed negligible, since it represented a mere 0.5% of the overall carbon exchanged in 2013 (Gren and Aklilu, 2016, pp. 128-136).

- **Biochar**

Biochar is now widely acknowledged as a feasible method for capturing and permanently storing carbon, and is regarded as one of the most promising technologies for achieving zero emissions. Biochar is created from biomass, e.g. specific crops, agricultural residues and forestry residues, using a thermochemical conversion process. It is generated by pyrolysis, a kind of heating without oxygen, as well as via gasification and hydrothermal carbonization (Oni, Oziegbe and Olawole, 2019, pp. 222-236). To effectively alter greenhouse gas concentration levels, the manufacturing of biochar would need substantial land resources. Land is necessary for the development of feedstock and for the dissemination of biochar, which serves as a carbon sink. Although there may be concerns about rivalry for land between specialized biomass production and other agricultural and land-use sectors, similar to the case of bioenergy carbon capture and storage, there would be no such concerns about the regions needed for biochar dissemination. This condition holds true as long as the biochar is appropriately aligned with the particular crop, soil, and growth circumstances associated with the unique cropping system.

- **Soil carbon sequestration**

Soil carbon sequestration refers to the process of absorbing carbon dioxide from the atmosphere by using land management measures that enhance the amount of carbon stored in the soil. The carbon content in the soil is governed by the equilibrium between inputs, such as residues, litter, roots, and manure, and the carbon losses resulting from respiration, which are primarily influenced by soil disturbance. The process of soil carbon sequestration is driven by practices that enhance inputs and/or decrease losses (Cox et al, 2018, p. 340212). The primary concerns associated with this strategy are on durability, saturation of sinks, and the influence on other emissions of greenhouse gases.

- **Direct air carbon capture and storage**

Direct air carbon capture and storage (DACCS), also known as synthetic CO2 removal, is a promising method for capturing and storing carbon dioxide from the atmosphere. The fundamental concept behind this technique is using chemical bonding to directly extract atmospheric CO_2 from the air and then store it in geological reservoirs or use it for alternative applications, such as chemical manufacturing or the formation of mineral carbonates. Carbon dioxide (CO_2) is extracted from the atmosphere by exposing ambient air to certain compounds called sorbents. In addition, the sorbents are subsequently regenerated by the application of heat or water, resulting in the release of CO_2 for storage or usage. The primary concern linked to this method is the integrity of CO_2 storage, which is comparable to that of carbon capture and storage and bioenergy carbon capture and storage (Cox et al, 2018, p. 340212).

- **Ocean fertilization**

Ocean fertilization refers to the deliberate addition of nutrients, including phosphorus, nitrates, and iron, to the top layer of the ocean. This is done to stimulate biological activity and promote the absorption of CO_2. Phytoplankton, which are tiny creatures, play a significant role in the process of marine carbon sequestration by residing in the uppermost layer of the seas. The CO_2 that is sequestered, in the form of organic marine biomass, is naturally carried to the deep ocean. This process is known as "the biological pump". The literature discusses several side effects of ocean fertilization, including ocean acidification, depletion of oxygen in deep and mid-water regions, increased production of greenhouse gases, unpredictable effects on food cycles, formation of toxic algal blooms, and varied impacts on sea floor and upper ocean ecosystems (Fuss et al, 2018, p. 063002). Moreover, the significant environmental, economic, and social impacts, as well as the energy and material resources involved in fertilizer production, transportation, and distribution, should not be overlooked.

1.6 Problem Statement

India will face significant consequences from climate change at a crucial moment when it is simultaneously dealing with the need for growth. Similar to other emerging nations, certain segments of the Indian population will be unable to shield themselves from the consequences of global warming due to the strong economic interdependence between natural resources and climate-sensitive sectors including agriculture, water, and forestry. India is at risk of a significant danger and has to develop strong adaptive capabilities to effectively address the challenges posed by climate change. Given its status as a developing nation, India has limited capacity to bear the risks and economic repercussions that developed countries can. Given the substantial population that remains below the poverty line, it is crucial to mitigate susceptibility to the effects of climate change. India has a vested interest in promoting a low carbon future globally. Multiple studies have emphasized the susceptibility of the country to the impacts of climate change. Changes in key climatic factors, such as temperature, precipitation, and humidity, are expected to have a significant impact on important sectors including agriculture and rural development. The repercussions of climate change are already evident in the occurrence of extraordinary heat waves, cyclones, floods, coastal erosion, and their impact on agriculture, fisheries, and public health. According to a multitude of data, the consensus among most experts is that the Earth's climate is undergoing change and, specifically, experiencing a rise in temperature. Nevertheless, there are significant disparities in the perspectives about the speed of transformation, the consequences for our ecosystem, and the actions that may or should be taken in response.

Furthermore, climate change has evolved into both a social and economic concern. There are many opinions on global warming. Some claim that it doesn't exist or is too insignificant to be concerned about. Others argue that the repercussions are not severe enough to warrant expensive policy measures. However, there are also some who believe that the implications are so alarming that urgent action is necessary. Several sociologists argue that these repercussions are adversely affecting human existence in terms of life expectancy, health security, and resource availability. Consequently, economics cannot afford to ignore this issue. Global economic growth has been a paramount focus and strategic objective worldwide. The economic and the environment are interconnected, as acknowledged in the concepts of sustainable development. The pursuit of sustainable development has led to significant scientific and intellectual attention being focused on climate change.

Due to the issue of climate change, it is imperative to establish a new framework that guarantees the sustainable expansion of agriculture in India, benefiting both the current and future generations. Therefore, it is essential to create strategies to adapt to the changing environment, since several studies and research have shown a strong association between climatic conditions and agricultural development in India.

This research seeks to investigate the issue of climate change and its effects on agricultural development in India. The research aims to consolidate limited and dispersed literature and data on "Climate Change" and "Agriculture Growth" in order to provide a comprehensive understanding of the significant issue of climate change in India.

1.7 Objective

The major objectives of this study are:

To examine the effectiveness of strategic management choices in mitigating the effects of climate change, specifically targeting carbon, manure, and nitrogen emissions.

To assess stakeholder perceptions, practices, barriers, and opportunities related to climate change mitigation efforts.

To evaluate the implementation of the Strategic Environmental Assessment (SEA) framework in identifying key environmental impacts and developing appropriate mitigation measures.

To analyze the integration of SEA findings into policy-making and strategic management decisions, focusing on adjustments made to emphasize effective emission reduction strategies.

1.8 Research question

This section provides the research questions for the study.

Question 1: How do organizations prioritize strategic management decisions in mitigating climate change effects, considering factors such as cost-effectiveness, long-term sustainability, and stakeholder interests?

Question 2: What roles do government policies, regulations, and incentives play in shaping organizations; strategic management decisions regarding climate change mitigation, and how do these factors interact with internal organizational dynamics?

Question 3: What are the potential unintended consequences or trade-offs associated with certain strategic management choices aimed at mitigating climate change effects, and how can organizations navigate these complexities effectively?

Question 4: What are the emerging trends and best practices in strategic management approaches for addressing climate change impacts, and how can organizations adapt and innovate in response to evolving environmental challenges?

1.9 Significance of study

Industrialization, through the burning of fossil fuels and the consumption of electricity, has been one of the primary factors for increased CO2 emission. The primary consumers of energy are manufacturing and industrial activity, and thus, are accountable for a large part of the world's CO2 emissions, which is a significant contributor to climate change. The climate change impact is global, the problem is long-standing, and the harm is substantially irreversible. However, it is interesting to note that despite being a significant perpetrator of the phenomenon, industries are also bearing the brunt of climate change. Firms face major uncertainties about the extent and timing of climate change risks they are likely to face. An adequate strategy to decrease GHG emissions is difficult to plan out in case of such uncertainties.

Since industrial activity is a significant contributor to climate change, studying the approach of firms towards climate change is vital. The efforts to mitigate climate change is mainly expected from the large-scale firms. Most of these firms have a wide activity scope and thus, emit a considerable amount of GHGs. Moreover, they are subjected to pressure from regulators, stakeholders, customers, country of company's headquarter, etc. Hence, studying their outlook towards climate change through their actions and strategies is of utmost importance.

Apart from large-scale firms, Small and Medium Enterprises (SMEs) play a central role in Indian economy's growth by contributing 45% to the industrial output, 40% of exports, 42 million in employment, producing more than 8000 quality products for the Indian and international markets and creating one million jobs every year. As a result, SMEs are exposed to greater opportunities for diversification and expansion across the sectors. With the growth of the SME sector and the launch of the Make in India initiative, the contribution of SMEs in the overall GHG emissions cannot be neglected. While large enterprises move towards the use of environmentally sound technology with the help of regulations, SMEs lack the required economic or technical capacity to install the necessary control equipment. In addition to governmental regulations, SMEs want their business partners' and government's assistance in handling climate change.

1.10 Thesis organization

This section presents the organization of thesis which is divide into six chapters.

Chapter 1 introduces the central idea of the research, the research context, research problem, need and significance, and objectives of the study.

Chapter 2 details the process adopted for conducting the literature review and presents the outcome of the same, outlining the different aspects on which the firms focus for mitigating climate change. In addition, the chapter presents models on different aspects for climate change mitigation in firms. Considering the different relationships identified from literature review, a theoretical framework has been proposed.

Chapter 3 focuses on the detailed methodology adopted for the study.

Chapter 4 presents analysis of data, outcomes of the analysis and interpretations based on the outcomes.

Chapter 5 provide the discussion of findings of the analysis and interpretations.

Chapter 6 provides summary and recommendations to the Government and policymakers as well as Business organizations based on the outcomes of the study. Further, it presents Theoretical and Managerial implications of the study, followed by Limitations and Future Research Directions, and the Contribution of Research.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Overview

India is among the nations that are very susceptible and prone to risks (Agarwal, Narain and Sharma, 1999). Throughout the years, the population has acquired the ability to manage and deal with many types of threats, whether they are caused by nature or humans. The rapid increase in population, high population densities, poverty, and significant disparities in access to housing, public services, and infrastructure have resulted in a rise in vulnerability in India's metropolitan areas in recent decades. Climate change is projected to amplify the occurrence and severity of existing hazards and the likelihood of severe events. It is also anticipated to trigger the formation of new hazards, such as sea-level rise, and new vulnerabilities that will have varying consequences on various geographical areas and socioeconomic groups. This is anticipated to exacerbate the vulnerability of impoverished groups, comprising around 25% to 50% of the population in major Indian towns, hence diminishing their resistance (Banga, 1991). Climate change is poised to emerge as a progressively significant strategic, economic, and political issue as it gradually erodes India's robust economic growth rates and impacts the lives and livelihoods of millions of individuals.

This chapter begins with an exploration of the theoretical foundations of strategic management, providing a detailed examination of how these principles have evolved in response to environmental challenges. It delves into the role of sustainability as a critical component of modern strategic management, highlighting the increasing importance of integrating environmental considerations into long-term business strategies. The chapter then shifts to a discussion of specific strategic choices that organizations can adopt to address climate change. These include approaches such as adopting sustainable supply chain practices, investing in renewable energy, and promoting eco-innovation. The effectiveness of these strategies is evaluated through case studies and real-world examples, demonstrating how leading companies have successfully implemented them to reduce their environmental footprint while maintaining competitive advantage. Additionally, this chapter addresses the challenges and barriers organizations face when integrating climate change mitigation strategies into their operations.

2.2 Climate Changes Effects in India

India is experiencing significant and multifaceted impacts of climate change, which are increasingly affecting its environment, economy, and society. The country is particularly vulnerable due to its diverse climate zones and large population dependent on climate-sensitive sectors such as agriculture, water resources, and fisheries. Rising temperatures, erratic monsoon patterns, and the increasing frequency of extreme weather events, such as floods, droughts, and cyclones, have exacerbated challenges related to food security, water scarcity, and public health. These climate-induced changes are also intensifying the stress on India's already strained natural resources, leading to declining crop yields, loss of biodiversity, and reduced availability of freshwater.

(Lee, Zeng and Luo, 2024, p. 107324) studied the phenomenon of global warming has generated an increasing apprehension over the consequences of climate change on the stability of food supply. China is a geographically expansive nation characterized by distinct climatic conditions throughout its many regions. This study investigated the influence of climate change on the state of food security in China by analyzing panel data collected from 31 provinces and cities spanning the years 1984 to 2020. Evidence demonstrated that climate change has a substantial impact on food security, introducing heightened levels of uncertainty and associated dangers. Agricultural policy has the potential to alleviate this effect by decreasing production expenses and enhancing farmers' ability to withstand risks and motivation. There is variation in different locations, where climate change has a notable influence on food security in regions that do not produce food, while rainfall has a big impact in the northern and central regions. The study suggested policy implications that are pertinent for enhancing climate change resistance, optimizing system design, and facilitating coordination of regional agricultural output.

(Ahmed, Shuai and Ali, 2024, pp. 14601-14619) examined the escalating levels of greenhouse gas emissions in the atmosphere, along with rising temperatures, worsen the problem, making it a significant concern for food security. The objective of this study is to investigate the impact of climate change on agricultural output in India. This study explicitly examined the effects of temperature, rainfall, CO_2, methane, and N_2O emissions, as well as energy consumption, on food production in India. The study covered the period from 1990 to 2019 and aims to identify the key elements that significantly influence food production in the country. The research used autoregressive distributed (ARDL) estimates to analyze both long-run and short-run cointegration. The empirical findings indicate that energy consumption, precipitation, and methane emissions have a positive impact on food productivity, but temperature and N_2O emissions have a negative effect on both short-term and long-term food production. Nevertheless, the findings indicated that CO_2 emissions had little impact on food production. In addition, they used the dynamic ordinal least squares technique to confirm the reliability of the ARDL findings. The findings also indicate that N_2O emissions and temperature play a crucial role in determining food production. Specifically, an increase in temperature and N_2O emissions has a considerable negative impact on food production in India. However, the results indicated that methane emissions and rainfall have a substantial impact on food production, with coefficients of 0.19 and 0.059, respectively. Key adaptation methods that should be prioritized in response to climate change include reducing greenhouse gas emissions, increasing investment in renewable energy, and embracing innovative technology to address environmental concerns.

(Hussain et al, 2024, p. 1308684) studied that climate change is a worldwide issue that is of great importance in the present century. The quick and continuous increase in intensity of this phenomenon has been seen on a global scale, resulting in significant and far-reaching consequences. Climate change in India has resulted in significant changes to India's natural, socio-economic, and urban environments. In 2019, India was placed seventh among the nations most impacted by severe weather occurrences resulting from climate change. The effect of this event was clearly seen in terms of both the significant loss of human life, with a total of 2,267 people killed, and the substantial economic damage, amounting to 66,182 million US$ Purchasing Power Parities (PPPs). In recent years, India has seen a substantial rise in the occurrence and intensity of severe weather events, leading to adverse impacts on vulnerable people. The nation had acute air pollution issues in many urban centers and was prominently included on the roster of the globe's worst contaminated cities. Moreover, India has emerged as the most populated country worldwide, with a population of 1.4 billion individuals, accounting for around 18% of the global population. Furthermore, India is seeing a growing rate of natural resource use. Given the existing situation in the nation, it is necessary to apply a range of climate mitigation techniques, including nature-based solutions, in order to minimize the effects of climate change and help India achieve its Sustainable Development Goals (SDGs). This analysis aims to comprehensively analyze the impacts of climate change on various sectors in order to identify the problems that India has in reaching Sustainable Development Goal 13 and Sustainable Development Goal 11. Additionally, it emphasized the forthcoming suggestions for climate change-related research from an Indian standpoint.

(Schroder et al, 2024, p. 670-686) stated that the practice of shifting agriculture will experience mounting challenges due to erosion-induced land degradation resulting from escalating cultivation intensities and the impacts of climate change. Nevertheless, there is a scarcity of empirical research about the future patterns of soil erosion and subsequent land degradation in shifting agricultural systems. The Environmental Policy Integrated Climate (EPIC) model is used to examined the synergistic impacts of climate change and agricultural intensification on soil erosion in uphill shifting cultivation systems. This analysis is conducted utilizing six surveyed soil profiles. They evaluated the relationships among climate change, the duration of the fallow period, and the steepness of slopes for two future time periods: near future (2021-2050) and far future (2071-2100). This assessment takes into account three different climate scenarios, five climate models, fallow periods ranging from one to 20 years, and slopes with inclinations ranging from five to 70%. The findings indicated a substantial non-linear correlation between global warming and erosion. By the end of the century, erosion is projected to rise by 1.2 times, 2.2 times, and 3.1 times under the SSP126, SSP370, and SSP585 scenarios, respectively, compared to the historical baseline period of 1985-2014. The interaction of climate change, fallow duration, and slope gradient suggests that steeper slopes necessitate longer periods of fallow, with a doubling of slope from 5% to 10% resulting in a 2.5-fold increase in the required fallow duration. The findings of this study are innovative because they establish a connection between the impact of climate change on shifting cultivation systems and various slopes and fallow regimes.

(Roy, Kumar and Rahaman, 2024, p. 100937) stated that climate change and variability have a widespread impact on both individuals and regions across the globe. However, the most significant effects are observed among rural marginalized communities who heavily depend on agriculture and fishing for their livelihoods. These communities face multiple challenges to their way of life, including the risks associated with climate variability. The current study employs phenomenological research methods to examine the perceptions of climate change and its effects on the livelihoods and well-being of rural marginalized communities in the Dakshin Dinajpur district of West Bengal, India. Key-informant interviews, focus group discussions, household surveys with standardized questionnaires, and case study analysis are utilized. Additionally, participatory social research techniques are employed to investigate the coping mechanisms adopted by these communities. The study largely relies on primary data obtained at the home level using multistage purposive sampling procedures. The overall sample size is 154. Data analysis included descriptive and inferential statistical approaches. The findings were analyzed within the framework of the sustainable livelihoods approach. The results indicate a decline in the availability of water for domestic use, crop failure, and low agricultural production. Additionally, climate change has resulted in reduced human health, poor livestock health, and various other challenges, all of which have had a negative impact on people's livelihoods. The results of this study can assist policymakers and other stakeholders in understanding the current adaptation efforts and the requirements of households. Additionally, it can highlight the disparity between farm households and policymakers, and aid in the development of appropriate policies and effective adaptation strategies to improve the livelihoods of marginalized communities.

(Pathak, 2023, p. 52) introduced the climate change poses serious risks to Indian agriculture as half of the agricultural land of the country is rainfed. Climate change affects crop yield, soil processes, water availability, and pest dynamics. Several adaptation strategies such as heat- and water stress-tolerant crop varieties, stress-tolerant new crops, improved agronomic management practices, improved water use efficiency, conservation agriculture practices and improved pest management, improved weather forecasts, and other climate services are in place to minimize the climatic risks. The agriculture sector contributes 14% of the greenhouse gas (GHG) from the country. Mitigation of GHG emission from agriculture can be achieved by changing land-use management practices and enhancing input-use efficiency. Experiments in India showed that methane emission from lowland rice fields can be reduced by 40–50% with alternate wetting and drying (AWD), growing shorter duration varieties, and using neem-coated urea according to soil health card (SHC) and leaf color chart (LCC). Dry direct-seeding of rice, which does not require continuous soil submergence, can reduce methane emission by 70–75%. Sequestration of carbon (C) in agricultural soil can be promoted with the application of organic manure, crop residues, and balanced nutrients. India has taken several proactive steps for addressing the issues of climate change in agriculture. Recently, it has also committed for reducing GHG emission intensity by 45% by 2030 and achieving net zero emission by 2070. The paper discusses the major impacts of climate change, potential adaptation, and mitigation options and the initiatives of Govt. of India in making Indian agriculture climate-smart.

(Lincoln et al, 2023, p. 166061) analyzed the relationship between climate change and marine trash is closely intertwined, and their interaction varies based on the unique climatic and biological features, as well as other human activities occurring. The detrimental effects arising from these synergistic interactions pose a danger to coastal and marine ecosystems and the multitude of benefits and services they provide. This phenomenon is especially widespread in the coastal region of the Indian subcontinent. India is now facing significant climate change effects, which are expected to exacerbate in the future. Simultaneously, the nation is facing a severe litter issue that is overpowering authorities and communities, impeding the country's progress towards sustainable development objectives. The coastal ecosystem and populations in the southern states of

Kerala and Tamil Nadu are exceptionally susceptible to the consequences of climate change. Although state governments and authorities are increasing their efforts to enhance the management of their coastal zones, the magnitude and seriousness of these concerns are escalating. This analysis examined the synergistic impacts of climate change and marine litter pollution in Southern India, namely in the Gulf of Mannar Reserve in Tamil Nadu and the Malabar Coast in Kerala.

(Liu, Shamdasani and Taraz, 2023, p. 395-423) investigated the effects of rising temperatures on the process of structural change and urbanization in Indian districts from 1951 to 2011. This study revealed a negative correlation between increasing temperatures and the proportion of people employed in nonagricultural sectors. Furthermore, this relationship becomes more pronounced as the time period under consideration lengthens. Empirical research indicates that local demand effects have a significant impact: when temperatures rise, agricultural production decreases, leading to a decrease in the demand for nonagricultural products and services, which in turn affects the demand for nonagricultural labor. The findings demonstrate that increasing temperatures restrict the ability of isolated families to move between different sectors and rural- urban areas.

(Panda et al, 2023, p. 166646) analyzed the Earth's climatic transition between different zones is a significant factor contributing to the loss of biodiversity, migration from rural to urban areas, and the escalation of food crises. The increasing pace of transition from dry to humid zones as a result of climate change has been significantly evident in recent decades. Nevertheless, accurately measuring the extent to which climate change affects the fluctuation of rainfall in the transition between climatic zones continues to be a difficult task. In order to address the problem, the RGL-MARS downscaling method was used with the Koppen climate classification system to forecast future alterations in different climatic zones within the research region. The model's performance was shown to be superior for the humid clusters in comparison to the dry clusters. By the end of the 21st century, it was seen that the dry area in the western province of India will have a little growth, while the humid zone would see a significant rise of 24.28–36.09%. Conversely, the study area would see a decrease in the size of the semi-arid and semi-humid zones. Climate change is causing a significant transformation of the semi-humid zone into a humid zone in the periphery area of the Arabian water. This is due to the increased difference in temperature between the land and water, which is deepening. This study would provide valuable insights for academics and policymakers to implement effective strategies in mitigating climatic zone shifts, therefore enhancing the socioeconomic conditions of both rural and urban communities.

(Baig et al, 2022, p. 1-22) studied in recent years that environmental change has emerged as a pervasive issue and garnered the attention of environmentalists worldwide owing to its enduring detrimental impacts on agricultural productivity, food and water supply, and the lives of rural people. The objective of this research is to investigated the asymmetrical dynamic correlation between climate change and rice production, together with other explanatory factors. The present study used the nonlinear autoregressive distributed lag (NARDL) model and Granger causality technique to analyze the time series data of India from 1991 to 2018. The findings of the NARDL analysis indicate that the average temperature has a detrimental impact on rice output over a prolonged period, but has a beneficial impact on it in the near term. Moreover, increases in rainfall and carbon emission have adverse and substantial effects on rice output in both the short and long term. When comparing, it is evident that negative rainfall shocks have a substantial impact on rice output both in the short term and the long term. The Wald test provides evidence of the non-symmetrical correlation between climatic change and rice production. The Granger causality test demonstrates a reciprocal relationship between mean temperature, declining rainfall, rising carbon emissions, and rice output. Although there is no direct causal link between rising temperatures and declining carbon emissions. Several important policy implications arose from the empirical findings. In order to achieve sustainable rice production in India, it is necessary to enhance irrigation infrastructure by increasing public investment and to cultivate climate-resilient seed types that can withstand the effects of climate change. Additionally, the government should provide comprehensive instruction to farmers at the district level on the appropriate use of pesticides, optimal fertilizer usage, and efficient irrigation techniques.

(Kumar et al, 2022, p. 39) examined the Land use/cover (LULC) and climate are important environmental variables that have a considerable impact on watershed hydrology worldwide. This study aimed to comprehend the impacts of current fluctuations in climate and land use/land cover (LULC) on the hydrological system of the Usri watershed. A semi-distributed Soil and Water Assessment Tool (SWAT) model was used to simulate various water balance components. A total of sixteen scenarios were created by combining four periods of climate data (1974–84; 1985–1995; 1996–2006 and 2007–2016) with four sets of land use maps (1976; 1989; 2000 and 2014). The SWAT model shown strong performance in accurately simulating monthly stream flows throughout both the calibration and validation phases. The research revealed that changes in land use and land cover (LULC) have a significant influence on the increase in streamflow and reduction in evapotranspiration (ET) within the Usri watershed. This is mostly attributed to the rise in urbanization and decline in water bodies, forest cover, and barren land. The synergistic effects of climate fluctuations and changes in land use give rise to intricate interconnections. The research offers valuable understanding of the hydrological response to climatic fluctuations and land use changes in the Usri watershed throughout recent decades. The findings of this research must provide valuable insights for authorities, decision-makers, water resource engineers, and planners in developing effective strategies for managing water resources in the context of climate change and land use and land cover (LULC) changes in comparable ecological zones like Usri.

(Pal et al, 2022, p. 114317) demonstrated the creation of detailed flood susceptibility maps for several future timeframes (up to 2100) by integrating remote sensing data with GIS modeling. In order to measure the future likelihood of flooding, they would utilize Global circulation model (GCM) rainfall data and land use and land cover (LULC) data to analyze numerous elements that contribute to flooding. The current flood susceptibility model has been assessed using the receiver operating characteristic (ROC) curve. The area under the curve (AUC) result indicates an accuracy of 91.57% for this flood susceptibility model, making it suitable for future flood susceptibility modeling. The study's findings suggest that by 2100, there would be an increase of approximately 40-50 mm in maximum monthly rainfall. Additionally, the conversion of natural vegetation to agricultural and built-up land is projected to cover an area of about 0.071 million sq. km.

(Jha and Gupta, 2021, p. 100112) studied the farmer's choice to adapt to climate change has garnered significant attention and praise for its human-environmental approach, both locally and globally. This study aimed to comprehend the anthropogenic aspect of farmers' adaptive decision-making in rural India. They examined the farmer's view of climate change and the socio-economic factors that affect the decisions made by farm households about adaptation and the choices of adaptation solutions. They performed a detailed evaluation at a small scale, specifically targeting 700 farmers and agricultural families in seven districts of the Bihar state in northern India. The data is analyzed using descriptive statistics and logistic regression. According to the report, 80 percent of the farmers polled are aware of and anticipate climatic changes, and they make the decision to adapt to them. This study discovered that many crucial socio-economic factors, including the age, gender, family size, education level, off-farm income, and farm size of farmers, had a significant impact on their choices on adaptation.

(Pal et al, 2021, p. 164-185) focused on the geographical extent and distribution of soil erosion resulting from changes in land cover and climate. They have developed a small-scale soil erosion map that takes into account regional distribution, based on actual data. This study challenged prior studies by providing more accurate estimates of average yearly soil erosion over the whole nation. The map demonstrates that climate and land cover change have significantly influenced the prevention of fertile soil erosion at a detailed level. Additionally, the impact of human activities, driven by densely populated areas, has had a dominant effect across the nation. According to the expected projection of soil loss, studies have shown that about 9.88% of the land surface is experiencing erosion of the top layer of soil at a rate of 80 Mg ha-1 y-1. If human activities and climate change are not controlled, it is predicted that by the year 2100, the affected regions of land surface would increase to 13.14%.

(Ayashia and Garg, 2020, p. 104571) studied that land transitions caused by urban development have an impact on urban hydrology, leading to higher risks of floods. Climate change-induced alterations in precipitation patterns contribute to the increased intricacy of urban flood hazards. This study investigated the impact of changes in land use on the frequency of urban flooding occurrences in 42 Indian cities, including both present and future climate change scenarios. The land use shares for all cities have been determined by processing Landsat photos from 1990, 2000, 2010, and 2017 using a hybrid classification approach. A flooding incident database has been created by doing a standard event-count analysis utilizing newspaper archives. A logistic mixed-effects technique was used in a multilevel model. A study was conducted to predict future flooding episodes using nine models. The study included three climate change- related Representative Concentration

Pathways (RCPs) - 2.6, 4.5, and 8.5 - and three urban growth scenarios. The findings indicated that urban areas should conserve the land uses that function as absorbent surfaces, such as green spaces, open spaces, and bodies of water. As the available places diminish, the frequency of expected flooding incidents rises. According to the RCP 2.6 scenario, the frequency of flooding episodes is much less (with a 95% confidence level) compared to the RCPs 4.5 and 8.5. There is no substantial difference in the projected flooding occurrences between RCP4.5 and RCP8.5 for several scenarios, indicating that Indian cities should strive to limit global temperature rise to below 2 °C to avoid severe repercussions. This study emphasized the need for Indian cities to implement comprehensive spatial planning strategies in order to ensure a resilient and sustainable urban future.

(Sapkota et al, 2019, p. 1342-1354) analyzed the persistent alterations in mean temperatures, precipitation patterns, and fluctuations in climate pose a significant risk to agricultural output, food stability, and the economic well-being of farming communities worldwide. Adapting to climate change is essential for ensuring food security and safeguarding the livelihoods of impoverished farmers. However, by mitigating greenhouse gas (GHG) emissions, they must reduce the severity of climate change and minimize the need for future adaptation measures. Several agricultural strategies have the potential to reduce greenhouse gas (GHG) emissions without negatively impacting food production. They used a bottom-up methodology to examine greenhouse gas (GHG) emissions by using extensive datasets from India's 'cost of cultivation survey' and the '19th livestock census', in conjunction with soil, climate, and management data for each specific area. The Marginal Abatement Cost Curves (MACC) were used to demonstrate the costs and advantages of adopting mitigation measures. These measures and their related costs and benefits were gathered from many sources, such as literature, stakeholder meetings, and expert opinion. The assessed indicate that by 2030, the agricultural sector in India would produce 515 Megatonne CO2 equivalent (MtCO2e) of greenhouse gas (GHG) emissions per year under normal conditions. However, there is a possibility to reduce these emissions by 85.5 MtCO2e per year via the implementation of several mitigation strategies. Approximately 80% of the potential for reducing technical issues might be accomplished by using methods that are both cost- effective and efficient. Three strategies to reduce the negative impact, including optimizing fertilizer use, implementing zero-tillage farming, and managing rice-water, have the potential to achieve almost 50% of the entire possible reduction in emissions.

2.3 Mitigation of Climate Changes

Mitigation of climate change encompasses the measures and tactics used to diminish or avert the release of greenhouse gases, hence constraining the magnitude of global warming and its consequential effects. Adopting this strategy is crucial for tackling the underlying factors contributing to climate change, with a specific emphasis on minimizing the amount of carbon emissions produced in different areas such as energy, transportation, industry, and agriculture. Essential measures to reduce the impact of climate change are shifting to sustainable energy sources like solar and wind, improving energy efficiency, advocating for environmentally friendly land use policies, and advancing carbon capture and storage technology. The efficacy of these measures to reduce the impact is mostly contingent upon global collaboration, legislative frameworks, and technical advancements. It is essential for governments, corporations, and communities to cooperate in order to execute these policies worldwide, taking into account both short-term measures and long-term planning.

Mitigation efforts also include the socioeconomic aspects of climate change, with a focus on ensuring that emission reduction measures are fair and inclusive, especially for marginalized communities who may bear a disproportionate burden from climate policy. Figure 2.1 depict the reframe climate change mitigation strategies as shown below.

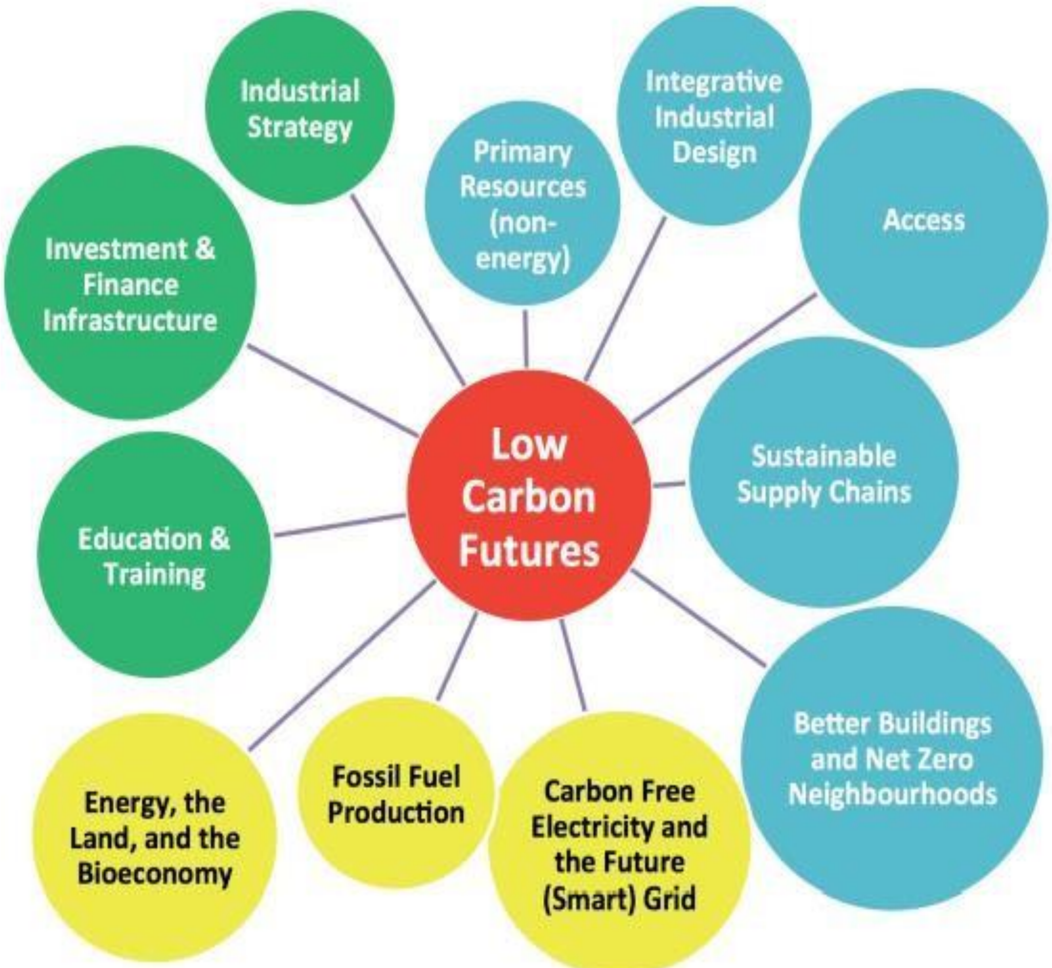

Figure 2.1 Reframe climate change mitigation strategies (Luthfia and Alkhajar, 2021, p. 012100)

(Oh et al, 2024, p. 260-266) stated that the Earth's climate is impacted by the excess heat generated by human-induced warming, which is mostly absorbed by the global seas. However, the specific effects of this heat buildup on the Earth's climate under climate mitigation scenarios are still uncertain. The findings demonstrate that the stored heat would be released at a much slower pace compared to its buildup. This would lead to a consistent and strong pattern of surface ocean warming, which in turn will cause regional precipitation. The warming of the surface ocean is most noticeable in subpolar to polar areas and the equatorial eastern Pacific, where the seas have a low level of stratification, enabling the escape of heat from the deep ocean to the top layer. Additionally, they provide evidence that this pattern of ocean warming is primarily responsible for changes in the distribution of rainfall, such as the movement of the Intertropical Convergence Zone towards the south and increased moisture in regions closer to the poles. This study indicates that deep ocean warming might impede climate recovery in some areas, even if carbon neutrality or net negative emissions are effectively attained.

(Nascimento et al, 2024, p. 233-250) studied under the Paris Agreement, nations are obligated to submit and regularly revise their Nationally Determined Contributions (NDCs) in order to address and reduce the impacts of global climate change. This study used greenhouse gas emissions projections to assess the advancement of 25 nations in meeting their initial and revised Nationally Determined Contributions (NDCs). The study discovered that almost 25% of the nations filed revised NDCs with more ambition, but failed to implement enough measures to achieve their initial objectives. Furthermore, in the majority of nations, revised Nationally Determined Contributions (NDCs) result in emissions that exceed the levels set by existing policy. The results also indicate that these patterns are affected by national limitations, particularly dependence on fossil resources. It is crucial to promptly establish the correct order of increasing ambition and implementing policies in order to effectively put the Paris Agreement into practice.

(Sierra et al, 2024, p. 17153) examined those subsoils, located below a depth of 0.2 m, contain significant amounts of carbon that is often ancient and has been stable for hundreds to millennia. This indicated that carbon sequestration in the subsoil may be used as a method to mitigate climate change. This study examined the primary biophysical mechanisms involved in carbon storage in subsoil and the primary mathematical models used to depict these mechanisms. The primary goal is to evaluate whether a comprehensive knowledge of how soil carbon moves vertically may assist us in determining the storage and long-term presence of carbon across time periods that are important for mitigating climate change. The creation of soil carbon profiles is primarily influenced by bioturbation, liquid phase transport, belowground carbon inputs, mineral association, and microbiological activity. These processes are often included into models utilizing the diffusion–advection–reaction paradigm. Through the analysis of simulated instances and measurements taken from carbon and radiocarbon profiles in various ecosystems, we have shown that advective and diffusive transport likely have a limited impact on the development of soil carbon profiles. The distinction between vertical root inputs and decomposition seems to be a crucial factor in defining the pattern of carbon transformation with depth. By analyzing the time, it takes for carbon to move through a system, we have determined that only a small amount of newly introduced carbon is able to travel through the profile and be stored for more than 50 years. This means that efforts to promote carbon storage in the subsoil must consider the limited amount of carbon that can be effectively stored for long periods of time.

(Bernados and Ocampo, 2024, p. 470-490) examined the influence of social capital on community resilience using the framework of community development. It focused on several aspects such as trust, cooperativism, volunteering, reciprocity, and interpersonal connections in order to understand how they contribute to minimizing the consequences of climate change. A mixed method approach was used, specifically targeting 24 study participants in a suburban community in central Philippines, with a focus on the consequences of floods. The findings indicate that crucial elements in disaster mitigation strategies include the act of asking assistance, collective reactions from communities, interpersonal connections, and the distribution of resources within communities. The findings shown that social capital has been very beneficial in mobilizing resources, fostering resilience, distributing information, facilitating conflict resolution, offering psychological support, and enhancing livelihoods within communities. This study examined the significance of social capital in community development and highlights its relevance in climate change mitigation and catastrophe risk reduction efforts. Policymakers, development practitioners, and community leaders may use these insights to strategically leverage social capital and promote active community engagement.

(Nazir et al, 2024, p. 105959) analyzed that the increase in atmospheric carbon dioxide (CO2) levels, mostly caused by the burning of fossil fuels, combustion of organic matter, and unsustainable land practices, has heightened worldwide worries about climate change. The industrial revolution has caused a significant increase in CO2 emissions, resulting in expected rises in concentrations and changes in the storage of CO2 in agricultural soils. The emissions have been further intensified by land use modifications, including deforestation, biomass burning, variations in agricultural conditions, draining of natural wetlands, and improper soil management methods. Furthermore, the decrease in soil organic carbon (SOC), which is a result of soil degradation and mismanagement, has exacerbated atmospheric CO2 levels. Nevertheless, the adoption of cutting-edge land application and modern management methods in agriculture has the capacity to mitigate the pace of carbon dioxide emissions. Depleted soil organic carbon (SOC) can be restored using different strategies. These include transforming marginal lands into restorative uses, encouraging reduced or zero-tillage practices with cover or residue crops, and implementing nutrient cycling through composting, manure application, and other sustainable soil and water management techniques. Long-term soil carbon sequestration is becoming recognized as a complete approach to address climate change. Soil carbon sequestration may be a comprehensive and efficient method for reducing present climate changes by replenishing exhausted soils, increasing biomass production, purifying surface and groundwater, and compensating for CO_2 emissions from fossil fuels. It is essential to use these creative strategies to effectively address the problems provided by recent environmental changes. This would help position soil carbon sequestration as a potential alternative. This study is to examined the possible approaches for reducing climate change by implementing techniques that include the storage of carbon in soil.

(Silverstein, Segre and Bhatnagar, 2023, p. 2050-2066) Environmental microbiome engineering is becoming recognized as a promising approach for addressing climate change. This approach involves the introduction of microbial inocula into natural microbial communities in order to adjust the activities that control the long-term stability of carbon in ecosystems. This study provided a comprehensive overview of the environmental engineering process. It discussed important factors to consider when targeting ecosystem functions, ways to obtain microorganisms, strategies for designing microbial inocula, methods of delivering inocula, and the factors that facilitate the establishment of inocula within a resident community and their impact on modifying a targeted ecosystem function. Recent research, made possible by advanced technologies and modeling methods, suggests that microbial inocula created using a top-down approach, specifically through directed evolution, are generally more likely to successfully integrate into existing microbial communities compared to other traditional methods of microbiome engineering. They wanted to clarify unresolved inquiries on the factors that influence the development of inocula. Additionally, we provide recommendations for future investigations into the potential and difficulties of using environmental microbiome engineering as a means to mitigate climate change.

(Wang et al, 2023, p. 100015-61) human-induced climate change poses an escalating danger to the sustainability of life on Earth. The hazardous alteration in the Earth's climate is a result of the rise in carbon dioxide and other greenhouse gases in the atmosphere, principally produced by the emissions linked to the combustion of fossil fuels. In the next two to three decades, the impacts of climate change, including heatwaves, wildfires, droughts, storms, and floods, are anticipated to deteriorate, presenting increased hazards to human well-being and world stability. These developments need the deployment of measures to reduce the impact and adjust to the changes. Pollution and environmental degradation worsen preexisting issues and increase the vulnerability of both humans and the natural world to the impacts of climate change. This study provided an analysis of the present condition of global climate change from several viewpoints. They provide a concise overview of the evidence of climate change in Earth's many systems, examine the channels via which emissions occur and the factors that drive climate change, and assess the consequences of climate change on both the environment and human health. In addition, they examined approaches for mitigating and adapting to climate change and emphasize significant obstacles in reversing and adjusting to worldwide climate change.

(Chien, Chau and Sadiq, 2023, p. 103367) Climate degradation is a prominent global concern, and addressing it requires research focus on climate change mitigation technologies and the efficient use of natural resources. This study examined the influence of climate mitigation technologies, namely renewable energy generation and consumption, as well as natural resource management, including natural resource rent and depletion, on climate change, specifically greenhouse gas emissions, in China. A non-linear autoregressive distributed lag (ARDL) approach is used to examine the relationship between the components from 1991 to 2021. The results indicate that in China, there is a negative correlation between greenhouse gas (GHG) emissions and renewable energy (RE) production, RE consumption, natural resource rent, and natural resource depletion. On the other hand, there is a positive correlation between GHG emissions and industrialization and population increase. The study offered recommendations for regulators in developing legislation pertaining to climate change, specifically focusing on the use of climate mitigation technologies and the efficient management of natural resources.

(Sun et al, 2022, p. 33063-33074) studied in considering the use of financial stability to successfully fund the mitigation of climate change and climate hazards, it is crucial to examine the remaining carbon risk in G-5 countries. This study aimed to assess the influence of financial stability on climate risk to enhance the management of climate mitigation endeavors. To accomplish this objective, a method known as Gaussian Mixture Model (GMM) is used. The study's outcomes indicate that climate change mitigation accounted for a significant 18 percent, while financial stability and carbon risks were shown to be even more important at 21 percent. Moreover, it is worth noting that there is a significant link of 19.5% between financial stability and the drift of emissions in the G-5 nations, which gives rise to worries about climate change. For the successful implementation of green economic recovery strategies, which are highly valued for their effectiveness in addressing climate change and securing sustainable economic growth at the national level, a country must have financial stability. The study on green economic growth provides extensive policy implications for the relevant stakeholders.

(Kaack et al, 2022, p. 518-527) focused on the impact of artificial intelligence and machine learning on global greenhouse gas emissions is a subject of significant interest. Nevertheless, the effects of these emissions on the environment are still unclear due to the many ways in which they occur, making it challenging to assess and predict their influence. In this study, they provide a structured framework to analyze the influence of machine learning (ML) on greenhouse gas (GHG) emissions. The framework consists of three main categories: computing-related effects, direct effects of ML application, and overall system-level effects. With the help of this framework, we can determine the most important factors to consider when evaluating the impact and potential outcomes of machine learning on climate change mitigation. Additionally, they suggested specific strategies and tools that can be used to get a deeper knowledge of these impacts and to influence them in a positive way.

(Rohatyn et al, 2022, p. 1436-1439) analyzed that reforesting the extensive arid regions of the world has been seen as a possible approach to mitigate climate change. Nevertheless, the true climatic advantages of the trees remain questionable due to the potential for significant warming impacts caused by their lower albedo. Through the use of advanced spatial analytic techniques on a worldwide scale, we have identified a total of 448 million hectares of drylands that are highly suited for the implementation of afforestation. The carbon sequestration capacity of this region till 2100 is estimated to be 32.3 billion tons of carbon (Gt C). However, 22.6 Gt C of that amount is needed to offset the albedo impacts. The net carbon equivalent would mitigate around 1% of the expected medium-emissions and business-as-usual scenarios within the same time frame. By concentrating forestation efforts only on places that have a net cooling impact, they must use just half of the available land while effectively doubling the offset of emissions. While smart forestation is undoubtedly significant, its climatic advantages are modest, underscoring the need to significantly decrease emissions.

(Arifanti et al, 2022, p. 4523-4528) measured the capacity of mangrove conservation and restoration in Indonesia to reduce the effects of climate change. They derived the emission factors from the most prevalent land uses in mangroves, assessed the rate of deforestation in mangroves, and quantified the overall emissions as well as the potential reductions in emissions that could be attained through the conservation and restoration of mangroves. The analysis of carbon stocks and emissions from land use in mangroves reveals the following findings: (1) Indonesia's mangrove ecosystem has exceptionally high carbon stocks compared to other types of tropical forests; (2) the emissions of greenhouse gases resulting from mangrove deforestation greatly surpass those from deforestation in upland tropical areas; (3) the rates of deforestation in Indonesian mangroves have remained consistently high over the past decade; and (4) the conservation and restoration of mangroves hold great potential for capturing substantial amounts of carbon. Although mangroves make up just around 2.6% of Indonesia's overall forest area, their deterioration and removal contribute to almost 10% of the total greenhouse gas emissions generated by the forestry industry. The significant contribution of greenhouse gas emissions from a relatively small portion of the forest area highlights the importance of including mangroves as a natural climate solution. Mangrove conservation surpasses mangrove restoration in its effectiveness in reducing carbon emissions and serves as an efficient means to satisfy Indonesia's nationally determined contribution (NDC) objectives. If the deforestation of primary and secondary mangroves is stopped and restoration efforts are carried out, it might lead to an emission reduction that is equal to 8% of Indonesia's 2030 NDC emission reduction objectives from the forestry sector.

(Fujimori et al, 2022, p. 110-121) analyzed prior research has acknowledged the possible negative consequences of land-related emissions reduction methods on food security, namely because of the possibility for increased food prices. However, these studies have not differentiated between the specific implications of these techniques under varying circumstances. They demonstrate the impact of three variables - decrease in non-CO2 emissions, generation of bioenergy, and afforestation - on food security and agricultural market conditions in climate- stabilization scenarios with a 2 °C increase. The results indicate that afforestation, which is normally represented in the models by applying carbon pricing to land carbon stocks, might significantly affect food security compared to non-CO_2 emissions policies, often implemented as emissions taxes. These steps, when compared to the present trend scenario baseline, result in an extra 41.9 million and 26.7 million people being at risk of starvation in 2050. This emphasizes the need for improved cooperation in policies aimed at reducing emissions and managing agricultural markets, as well as the inclusion of land use and its accompanying greenhouse gas emissions in modeling.

(Lehmann et al, 2021, p. 883-892) described climate change mitigation not only requires reductions of greenhouse gas emissions, but also withdrawal of carbon dioxide (CO_2) from the atmosphere. Here they reviewed the relationship between emissions reductions and CO_2 removal by biochar systems, which are based on pyrolysing biomass to produce biochar, used for soil application, and renewable bioenergy. Half of the emission reductions and the majority of CO_2 removal result from the one to two orders of magnitude longer persistence of biochar than the biomass it is made from. Globally, biochar systems could deliver emission reductions of 3.4–6.3 $PgCO_2e$, half of which constitutes CO_2 removal. Relevant trade-offs exist between making and sequestering biochar in soil or producing more energy. Importantly, these trade-offs depend on what type of energy is replaced: relative to producing bioenergy, emissions of biochar systems increase by 3% when biochar replaces coal, whereas emissions decrease by 95% when biochar replaces renewable energy. The lack of a clear relationship between crop yield increases in response to fertilizer and to biochar additions suggests opportunities for biochar to increase crop yields where fertilizer alone is not effective, but also questions blanket recommendations based on known fertilizer responses. Locally specific decision support must recognize these relationships and trade-offs to establish carbon-trading mechanisms that facilitate a judicious implementation commensurate with climate change mitigation needs.

(Tao et al, 2021, p. 1-14) studied since 2020, the COVID-19 epidemic has compelled event organizers to transition conferences to online platforms. Virtual and hybrid conferences provide more environmentally friendly options compared to traditional in-person conferences, but a comprehensive evaluation of their environmental sustainability is still lacking. In this study, they presented the results of a comparative life cycle assessment of in-person, virtual, and hybrid conferences. They analyzed various aspects such as food, accommodation, preparation, execution, information and communication technology, and transportation. Additionally, they examined the carbon footprint trade-offs between attending conferences in person and participating in hybrid conferences. Transitioning from in-person to virtual conferencing results in a significant reduction in the carbon footprint by 94% and energy usage by 90%. To ensure that more than 50% of attendees participate in person, strategically chosen hubs for hybrid conferences have the capacity to reduce carbon emissions and energy consumption by 66%. In addition, by transitioning future conferences to plant-based meals and enhancing the energy efficiency of the information and communication technology industry, they may significantly diminish the carbon impact of virtual conferences.

(Hurlimann, Moosavi and Browne, 2021, p. 105188) studied an effective urban planning policies may reduce greenhouse gas emissions and prepare for expected climate change effects. Nevertheless, there has been a scarcity of examination about the degree to which urban planning policy texts specifically tackle the issues of climate change adaptation and/or mitigation. In order to align with the Paris Agreement, it is imperative to expeditiously decrease greenhouse gas emissions to restrict the increase in temperature to 1.5°C over pre-industrial levels by 2100, while also ensuring effective adaptation to this climate change. Attaining this objective will help mitigate harm and reduce the negative impact on both human beings and the natural ecosystem. This study provided a comprehensive analysis of urban planning documents (including policy, regulation, and legislation) in Victoria, Australia. It evaluates the extent to which these documents address and include climate change mitigation and adaptation measures, with a particular emphasis on sea level rise. An analysis was conducted on two levels of government (state and municipal) in relation to three policy areas (urban planning, climate change, and flood control). The assessment framework enhances the limited number of instruments available for examining legislation, regulation, and strategic plans to assess their effectiveness in addressing climate change. The results indicate that there are little measures taken to adapt to and mitigate climate change in urban planning documents. Furthermore, there is a lack of comprehensive synergy between adaptation and mitigation measures. The identification of crucial possibilities for enhanced policy alignment across all disciplines and government tiers, in accordance with the aims of the Paris Agreement, is essential to guarantee the effective execution of decisions pertaining to land use and development. This study concluded that urban planning policy should prioritize the incorporation and seamless integration of climate change adaptation and mitigation measures.

(Gomez-Zavagila, Mejuto and Simal-Gandara, 2020, p. 109256) analyzed that agricultural commodities such as crops, cattle, and fisheries play a significant role in the global economy. The agricultural and fishery sectors are particularly reliant on climatic conditions. Therefore, increased temperatures and carbon dioxide concentrations may significantly affect the optimal nutrient levels, soil moisture, water availability, and other essential performance parameters. Fluctuations in the frequency and intensity of droughts and floods may provide significant difficulties for farmers and jeopardize food security. Furthermore, the rising water temperatures are expected to alter the habitat ranges of several fish and shellfish species, leading to the disruption of ecosystems. Overall, climate change is likely to have adverse effects on agriculture, livestock production, and fisheries. Climate change must be considered as a crucial component, with other developing elements, that might potentially affect agricultural productivity. These variables include changes in agricultural methods and technology, all of which have a significant influence on the availability and price of food. This study aimed to provide a comprehensive and up-to-date analysis of climate change and its impact on the food production and consumption system, with a particular focus on the existing solutions for mitigating its effects.

(Nunes et al, 2020, p. 21) examined that climate change is widely accepted by several experts and academicians as an indisputable fact and is regarded as the most significant obstacle that civilization has ever encountered. Anthropogenic greenhouse gas emissions are widely acknowledged as the primary factor driving the acceleration of the process. Hence, it is essential to discover remedies to alleviate climate change, primarily due to the profound impacts that have already been experienced, often shown by the occurrence of very severe weather phenomena. Forests are unquestionably one of the most efficient and straightforward methods to serve as carbon sinks. Nevertheless, it is crucial and advantageous to examine the duration of carbon retention in forests, since it is directly influenced by the forest management approach used. This study seen to evaluate different forest management models in terms of carbon residence time in temperate forests. The models are categorized into three types: carbon conservation models, carbon storage models, and carbon substitution models. These models are assessed based on their capacity to function as carbon sinks, thus aiding in the mitigation of climate change.

(Markkanen and Anger-Kraavi, 2019, p. 827-844) examined that the Paris Agreement and the Sustainable Development Goals (SDGs) provide ambitious objectives for environmental, economic, and social advancement. Climate change mitigation initiatives are crucial in this process. In order to optimize the advantages and limit the adverse consequences of climate change mitigation measures, policymakers must possess knowledge about the indirect and intricate social and inequality ramifications that these policies may entail, as well as the specific channels via which these ramifications arise. Gaining a more comprehensive understanding of the effects on distribution and inequality is crucial in order to prevent adverse social and distributional consequences as nations increase their climate policy goals in the post-Paris era. This study consolidates findings from the current body of research on the social consequences of climate change mitigation policies and their effects on inequality. The study indicated that the majority of policies are associated with both positive outcomes and negative consequences, and their impact on inequality may be influenced by contextual circumstances, policy design, and policy execution. The probability of unfavorable consequences is higher in situations marked by elevated levels of poverty, corruption, and economic and social disparities, and when insufficient measures are implemented to recognize and alleviate any detrimental repercussions.

2.4 Renewable Energy Integration and Innovation

Renewable energy integration and innovation represent a transmuting approach to combatting climate change. By harnessing sources such as solar, wind, hydro, and geothermal power, businesses can significantly mitigate reliance on fossil fuels and lower carbon emissions. Strategic investment in renewable energy infrastructure, coupled with ongoing innovation in energy storage and efficiency technologies, holds immense potential to reshape energy landscapes. Association with research institutions and startups drive advancements, paving the way for a sustainable energy future while fostering economic growth and environmental stewardship.

Research done by (Kwilinski, Lyulyov and Pimonenko, 2024, p. 100217) examined how renewable energy and environmental technology affected the carbon dioxide (CO2) emissions from the European Union (EU) transportation industry between 2007 and 2020. Key factors impacting decreasing CO2 emissions are identified via the use of workable generalized least square technique and panel-corrected standard error. The findings highlighted the positive relationship between the rising adoption of renewable energy sources and falling emissions, showing a considerable and varied impact of environmental technology and renewable energy on CO2 emissions in the EU transportation sector. In another research (Hassan et al, 2024, p. 100545) considered data from the renewable energy map scheme, and the results suggested that renewable energy sources might provide up to 66% of the worldwide prime energy dispense by 2050. The findings not only clarify the present condition and future direction of renewable energy adoption but also emphasise the crucial significance of customized policies, investments, and partnerships to expedite this worldwide transition. The Integrated Renewable Energy-Driven Hydrogen System was proposed by (Laimon and Yusaf, 2024, p. 119948) as a comprehensive strategy to attain energy autonomy and self-reliance.The research employed a systematic approach to comprehensively analyse the benefits of this integrated system compared to other options. It highlighted the system's 0 greenhouse gas (GHG) emissions, adaptability, energy resilience, and capability for mass hydrogen generation.

Research by (Elfaki and Ahmed, 2024, p. 100221) examined the impacts of globalization and innovation in digital technology adoption on green, sustainable economic progress in several Asian Pacific countries (Australia, Malaysia, Indonesia, Singapore, Philippines, Thailand, Japan, India, Korea, China, New Zealand), by combining environmental quality, globalisation, and the implementation of digital technology (digitalisation and digitization). As a result of the digital adoption index (DAI) data restriction, the Hausman test was used to ascertain the most suitable estimate methodology between the random effect and fixed effect methods. The results showed that the adoption of digital technology fosters economic development in Asian Pacific nations, and the Hausman test validated the random effect technique.

A multivariate empirical macroeconomic method was utilized by (Ciccarelli and Marotta, 2024, p. 107163) for business cycle analysis and an original panel data set for 24 OECD countries for the trial period of 1990-2019. The research examined the combined macroeconomic consequences of green innovation, environmental regulations, and climate change. Researchers discovered proof of major macroeconomic impacts across the business cycle: Transition risks represent downward supply fluctuations, while physical hazards operate as negative demand shocks. Further, (Wei and Khan, 2023, p. 29015-29028) examined the relationship between natural resource extraction strategy in the economies of Brazil, Russia, India, China, and South Africa (BRICS), climate change mitigation, and climate risk. Investigators used the GMM analysis method to come to their results. The results showed that financial strength and carbon hazards were significant at 22.0%, while environmental mitigation was significant at 17%.

Specific policy suggestions were given to decision-makers in the form of the outcome of green economic development. Another research (Sun et al, 2022, p. 33063-33074) found out how financial stability affects climate risk so that attempts to reduce climate change can be managed more effectively. To reach this goal, a method known as GMM was used. The result said that reducing climate change was important (18%) while being financially stable and reducing carbon risks were also important (21%). Research by (Dzwigol et al, 2023, p. 1117) sought to explain how three main factors—knowledge sharing, new ideas, and environmental protection—could increase the use of green energy in all areas and at all levels. To test the theories, the researchers used the following methods: they tested for inactivity in panels, cross- section dependence, co-integration, and estimated models with different parameters. The results supported the idea that new ideas and the sharing of knowledge had a statistically significant effect on green energy.

Another research (Xing et al, 2023, p. 1178-1192) investigated whether China could reach its climate and sustainable development goals (SDGs) through new technologies and policies that encourage the use of green energy. Researchers used various scientific methods, such as the Granger causality test, the bound method of co-integration, the Autoregressive Dynamic Lag (ARDL) dynamics, and structural break, to look at both numeric and theoretical data. Based on the results, they pushed for policy changes to be made in the green energy sector to help China reach its SDGs through investment and new technology. Furthermore, (Dzvimbo et al, 2022, p. 381-402) looked at how farmers in that area feel about steps being taken to react to climate change. The Heckman probit model and the multivariate biprobit model (MVBP) were then used to look more closely at the views and changes. The results showed that using chemicals for herbicides, fertilizers, and dung, as well as combining farming and non-farming activities, had good effects and are the most popular and well-known ways to adapt. Research by (Md et al, 2022, p. 172) was performed to detect the vulnerabilities and consequences of climate change on women in Twelve unions in Shyamnagar upazila, Satkhira district, Southwestern Coastal Region of Bangladesh (SWCRB).

A total of 320 home respondents were chosen at random from SWCRB's nine unions to answer a questionnaire. Findings reveal that climate change and natural catastrophes disproportionately harm women. Another research (Raihan et al, 2022, p. 586-607) checked into how economic growth, the use of green energy, and new technologies could help Malaysia meet its Paris Agreement goals by lowering CO2 pollution. The Dynamic Ordinary Least Squares (DOLS) method was used on time series data from 1990 to 2019. Resulted real-world data show that there was a positive and significant relationship between economic progress and CO_2 emissions. It meant that for every 1% rise in economic growth, there was a 0.9% rise in CO_2 emissions. Finally, (Andriamahery and Qamruzzaman, 2021, p. 778202) conducted a battery of econometric tests, including the following: structural break unit root, Bayer-Hanck united co- integration, autoregressive distributed lag (ARDL), nonlinear ARDL, and the Granger causality test with an error rectification component. The combined co-integration test's results showed a valid long-run connection between Employee Satisfaction (ES), Real Estate (RE), Emotional Intelligence (EI), and Total Revenue (TR) for both nations. Concerning Environmental Kuznets Curve EKC, results using ARDL and nonlinear ARDL confirmed the EKC theory for Morocco and Tunisia.

2.5 Research gaps

Limited understanding of the long-term implications and trade-offs associated with different strategic management decisions for climate change mitigation.

Scarce research on the integration of climate change considerations into broader organizational strategies and decision-making processes.

Need for more empirical evidence on the relationship between strategic management choices for climate change mitigation and organizational performance outcomes.

Inadequate investigation into the role of stakeholders and their influence on the adoption and implementation of strategic management choices for climate change mitigation.

CHAPTER III:

RESEARCH METHODOLOGY

3.1 Overview

This chapter is a systematic approach used to determine the outcome of a particular problem related to a certain subject or issue, also known as the research problem. In the field of methodology, researchers use many criteria to address the study topic at hand. Various sources use different methodologies to address the issue. Methodology refers to the systematic approach used to look for or solve research problems. In the field of research methodology, researchers consistently strive to methodically investigate a given topic using their own unique approach, in order to ascertain all relevant answers till reaching a conclusive outcome. Without using a methodical approach to an issue, the likelihood of arriving at a conclusive outcome is diminished. In the process of identifying or investigating a research issue, a researcher encounters several challenges that may be successfully addressed by using the appropriate research technique. Research technique is a systematic approach used by researchers to tackle selected issues. It may be defined as the study of the systematic and scientific methods used in conducting research. The text explores the systematic approach often used by researchers to address their research problems, including the underlying rationale behind each stage. It is crucial for the researcher to possess expertise not only in research methods and techniques but also in approach. Additionally, they must be aware of the approaches and strategies that are applicable and those that are not. A proficient researcher is someone who has the knowledge of the proper approach to achieve the purpose of the study and selects relevant methods and procedures to produce the study's findings.

Research methodology refers to the set of methods, processes, and norms that individuals in a certain field or involved in research follow. It comprises a diverse array of methodologies and procedures. Epistemology is a field of study within logic that focuses on the broad use of research methodologies to generate knowledge. Occasionally, a distinction is also established between research techniques and research procedures. Research procedures include the methods and tools used in conducting research activities, including collecting observations, capturing data, data processing techniques, and similar practices. Research methods pertain to the actions used in the process of choosing and developing research procedures.

3.2 Techniques used

The techniques which have been used to compile the data statistically and generate the result are listed below. Further, detailed theoretical aspect of each technique is explained followed by brief elucidation of each technique's relevance in the study. Figure 3.1 illustrate the techniques used as shown below.

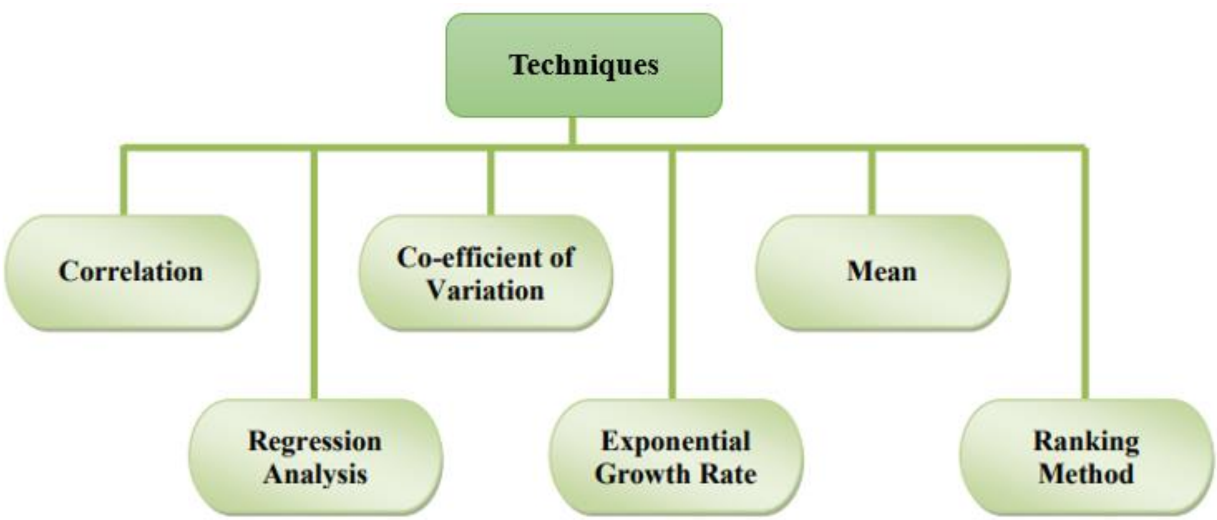

Figure 3.1 Techniques

- **Correlation**

Correlation is a statistical term that quantifies the linear connection between a dependent variable and an independent variable. Correlation analysis is used to quantify the degree of link between the variables being studied. The numerical representation of the relationship between two variables is referred to as the correlation coefficient. The degree of association is quantified by coefficients that fall within the range of correlation ($-1 < r > +1$). The symbol indicates the direction of change. Correlation analysis provides insight into the extent and direction of the link between the two variables being studied. Correlation is a statistical method used to quantify and examine the extent of the link between two variables. Correlation analysis examines the relationship between two or more variables. The correlation coefficient, denoted as r, is a concise metric that quantifies the degree of statistical association between two variables of interval or ratio level. The correlation coefficient is normalized to a range of -1 to +1. When the value of r approaches 0, it indicates a weak correlation between the variable. As r moves farther away from 0, either in the positive or negative direction, the correlation becomes stronger.

- **Regression Analysis**

Regression analysis is a statistical procedure used to estimate the connection between variables in statistical modeling. It encompasses many methodologies for modeling and assessing multiple variables (also known as predictors). Regression analysis provides insight into the normal value of the dependent variable when one independent variable is changed, while keeping the other independent variables constant. Regression analysis typically calculates the predicted value of the dependent variable based on the independent variables. Regression analysis is the practice of accurately fitting straight lines to patterns of data using both artistic and scientific methods. A linear regression model involves predicting the variable of interest by using a linear equation with other factors.

- **Co-efficient variation**

The coefficient of variation quantifies the magnitude of the standard deviation relative to the mean. The coefficient of variation, written as CV, removes the unit of measurement from the standard deviation of a series of values by dividing it by the mean of the series. The coefficient of variation is calculated as the ratio of the standard deviation (S) to the mean (M) for a series of N values:

$$Cv = S/M$$

- **Exponential Growth Rate**

Exponential growth refers to a continuous and rapid increase in quantity or magnitude. It is an outcome that may occur when a reinforcing feedback loop causes a system or dataset to consistently increase by larger and larger quantities. Exponential growth rate refers to the pace at which something develops, rising rapidly in proportion to the expanding total quantity or size. It refers to a consistent and continuous increase in a base value over a certain duration, with a fixed rate of growth. Exponential growth is a phenomenon where the rate of growth of a mathematical function is directly proportional to its present value, leading to a continuous increase over time. An exponential function refers to a situation where the rate of growth increases significantly in proportion to the total number that is rising. Exponential growth has immense power. An essential characteristic of exponential development is its initial sluggishness followed by a rapid increase, frequently leading to astonishingly large amounts.

$$x_t += X_0(1+r)^t$$

Where X0 is the value of X at time O, r is the growth rate in percentage, and Xt is the value of X at time t.

- **Mean**

The mean, also known as the arithmetic average, is calculated by dividing the sum of all values by the total number of values in a given range. A representative value is a single number that describes the complete data collection, namely the 'middle' or 'average' value of the entire set. The central tendency is a statistical measure that represents a single value, and the mean is one of the methods used to define it. The mean, often known as the arithmetic mean, is the numerical average calculated by summing all numbers and dividing the total by the count of numbers. The mean of a set is obtained by summing all the numbers in the set and dividing the sum by the total count of numbers. The formula used to compute the mean:

$$\bar{X} = \frac{\sum X}{N}$$

Where X is the mean value, N is the number of values and $\sum X$ is the sum of entire values.

- **The Ranking method**

A ranking is a hierarchical arrangement of a group of elements, where each item is either considered to be "superior to," "inferior to," or "equal to" another item. It is a method of data assessment in which each value is assigned a rank relative to all other values in the data, without attempting to develop a measure of value. Ranking in statistics refers to the process of arranging values in descending order. It involves replacing numerical or ordinal values with their respective ranks after sorting the data.

3.3 Data source and statistics used in the study

The framework describes the details of indicators of environmental degradation, climate change and Agriculture Growth along with data items, geographical unit of collection of data, periodicity, sources of data and metadata linkage. The framework designed below, describes the data sets used at 3 levels:

Indicators of casual factors behind "Climate Change" and "Environmental Degradation".

Assessed Indicators of Climate Change which may affect agriculture growth.

Indicators & variables representing agriculture growth:

This framework gives a basic conceptual structure of the variables chosen to define environment degradation, climate change and agriculture growth. The respective data sources and we blinks are also well illustrated in the frame structure shown in Figure 3.2 below:

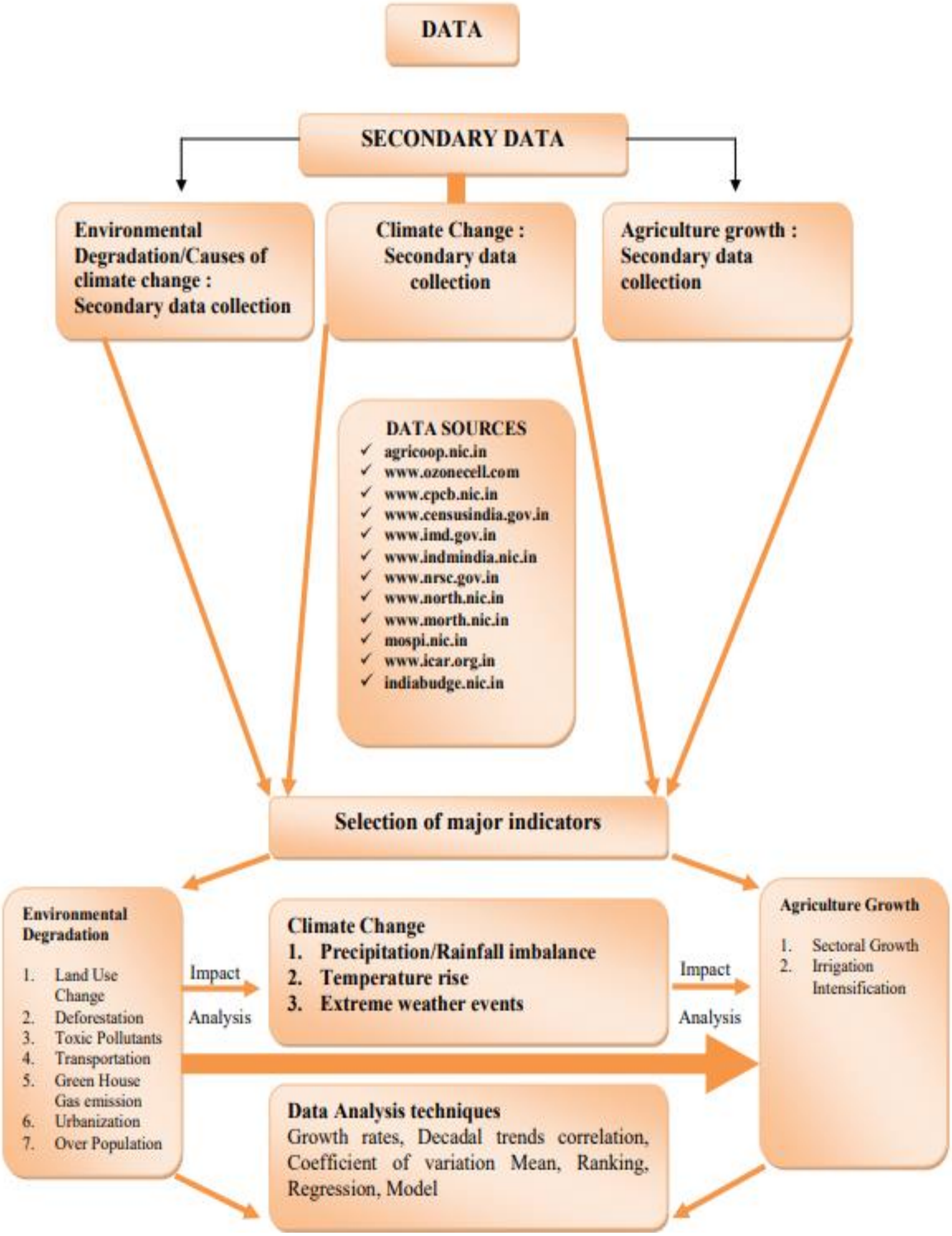

Figure 3.2 Procedure of data collection and methodology

Indicators for causal factors behind climate change and Environmental Degradation:

The key indicators as well as their representative variable are shown below in the following table. Various variables are responsible to degrade environment as well as causing climate to change. From those various variables, eight variables, viz: 1. Cropping Intensity 2. Consumption of Fertilizers 3.Forest area 4. Total consumption of ODS (Ozone Depleting Substances) 5. Total Registered Motor Vehicles 6. Carbon Dioxide Emission 7. Urban Population and 8. Total Population are chosen to display environment degradation which are the causes of climate change at the same time, along with the sources of data, metadata links, geographical unit and periodicity.

Assessed Indicators of Climate change which may affect Agriculture Growth:

Although there are various impacts of climate change responsible to affect Agriculture Growth such as biodiversity loss, melting of glaciers, landslides, extreme weather events, changing sea surface temperature, sea level change, soil/land degradation etc. However three variables chosen for this study are: 1. Overall Annual rainfall 2. Annual Average temperature and 3.Cropped Area Affected.

Indicators & Variables representing Agriculture Growth:

To represent agriculture growth of India two indicators are (1) Sectoral Growth of Agriculture (2) Irrigation Intensification. Five determinant variables are also included in this study which are: 1. Percentage share of agriculture and allied sector to total GDP (at constant prices 2004-05) 2. Gross capital formation in Agriculture and Allied Sector(%). 3. Net Irrigated Area 4.Gross Irrigated Area and 5. Irrigation Intensity.

A. Location and Extent of the Country

Located in South Asia, this country is geographically distinct from the rest of the continent due to the imposing Himalayan mountain range. It is situated mostly on the

Indian Plate, which is the northern half of the larger Indo-Australian Plate. The continental crust of this plate gives rise to the Indian subcontinent. The nation is located in the northern hemisphere, between 80°4' and 370°6' north latitude, and 680°7' and 970°25' east longitude. With a total size of 3,166,414 square kilometers (1,222,559 sq mtr.), it ranks as the seventh biggest country globally and the second largest in Asia. India has a length of 3,214 kilometers from north to south and a width of 2,933 kilometers from east to west. The country has a land border that spans 15,200 kilometers and a coastline that stretches for 7,715 kilometers. India's northern boundaries are mostly delineated by the Himalayan mountain range, which forms the country's borders with China, Bhutan, and Nepal. The western boundary of the country is formed by the Punjab plain and the Thar Desert, which it shares with Pakistan. The Chin Hills and Kachin Hills, located in the extreme northeast, are very elevated hills that serve as a significant barrier between India and Burma. The eastern border of India is mostly delineated by the Khasi hills and Mizo Hills, as well as the watershed area of the Indo Gangetic Plain, which also serves as a boundary with Bangladesh.

The Gangas is India's longest river. The Ganges Brahmaputra System dominates the majority of northern, central, and eastern regions of India, whereas the Deccan Plateau covers the majority of southern India. Kangchenjunga, situated on the boundary between Nepal and the Indian state of Sikkim, stands as the highest point in India, reaching an elevation of 8,598 meters (28,209 ft.). It is often recognized as the third highest mountain in the world. The climate of India varies from tropical in the southern regions to alpine in the higher parts of the Himalayas. India extends southward and is surrounded by the Indian Ocean, namely the Arabian Sea to the southwest, the Laccadive Sea to the south, and the Bay of Bengal to the southeast. The Palk Strait and Gulf of Mannar serve as a boundary between India and Sri Lanka in the southeast, while the Maldives are located around 400 kilometers to the southwest. The Andaman and Nicobar Islands of India are located approximately 1200 kilometers southeast of the mainland. These islands have maritime boundaries with Burma, Thailand, and Indonesia. The southernmost tip of the Indian mainland is Kanyakumari, situated at coordinates 80 4'41" N and 770 32'28" E. However, the southernmost point in all of India is Indira Point, which is located on Great Nicobar Island. India's territorial waters extend 12 nautical miles from the coast baseline into the sea.

B. Geological Development

India is located entirely on the Indian plate, which is a prominent tectonic plate that formed from the separation of the ancient continent Gondwana land, which was a component of the southern portion of the supercontinent Pangea. India is located on the Indian plate. There is a separation between the Indian Plate and the Australian Plate, which is known as the Indo-Australian Plate. In the late Cretaceous period, roughly 90 million years ago, the Indian plate began to move toward the north at a rate of approximately 15 centimeters per year. This movement occurred during the Cretaceous period. A collision between the plate and Asia occurred approximately fifty to fifty-five million years ago, during the Eocene Epoch of the Cenozoic Era. The plate had traveled a distance of two thousand to three thousand kilometers previously. This movement of the Indian plate was, in comparison to the movement of other plates that are known, extraordinarily rapid. In 2007, German geologists made the discovery that the Indian plate's capacity to move at a quick pace is related to the fact that its thickness is just half that of the other plates that were originally a part of Gondwanaland. The construction of the geologic structure that resulted in the formation of the Tibetan Plateau and the Himalayas was caused by the convergence of the Eurasian plate and the Indian plate close to the boundary that currently separates India and Nepal. In 2009, the Indian plate was moving in a direction that was toward the northeast at a rate of 5 centimeters per year, while the Eurasian plate was moving in a direction that was toward the north at a rate that was 2 centimeters per year. The term "Fastest Continent" is frequently used to refer to India. The compression of the Indian plate is occurring at a pace of four millimeters per year as a consequence of the deformation of the Eurasian plate.

C. Agro climate zones of India

Within the context of agriculture, the term "agroclimatic zone" refers to a particular region of land that is distinguished by its prevailing climate and growing season, which makes it suitable for particular kinds of crops and farmers. An ecological region is characterized by different biological responses to large-scale climate patterns. These responses are observable in the flora as well as the fauna and aquatic systems that are associated with it. In response to the midterm evaluation of the planning goals of the VII plan, the planning commission divided the country into 15 broad agro climatic zones. This classification was made by taking into consideration a variety of criteria, including climate and physiography. The creation of resources and the effective utilization of those resources within the constraints and opportunities of each area were placed at the center of the attention.

Table 3.1 Agro climate zones of India

1.	Western Himalayan Region	:	Ladakh, Kashmir, Punjab, Jammu etc.brown soils & silty loam, steep slopes
2.	Extern Himalayan Region	:	Arunachal Pradesh, Sikkim and Darjeeling,Manipur etc, High rainfall and high forests covers heavy soil erosion, floods
3.	Lower Gangastic Plants Regions	:	West Bengal soils mostly alluvial & areprone to floods

4.	Middle Gangatic Plains Region	:	Bihar, Uttar Pradesh High rainfall 39%irrigation, cropping intensity 142%
5.	Upper Gangatic Plains Region	:	North region of U.P. (32 dists) irrigated bycanal & tube wells good ground water
6.	Trans Gangatic Plains Region	:	Punjab Haryana Union territory of Delhi,Highest sowa area irrigated high
7.	Extern Plateaus & Hills Region	:	Chota Nagpur, Garihjat hills, M.P., West Banghelkhand Plateau, Orissa, Soils Shallow to medium sloppy, undulating irrigation tank & tube wells.
8.	Central Plateaus & Hills Region	:	Madhya Pradesh
9.	Western Plateaus & Hills Region	:	Sahyadry, M.S. M.P. rainfall 904 mm sownarea 65% forest 11% irrigation 12.4%
10.	Southern Plateaus & Hills Region	:	T Nadu, Andhra Pradesh, Karnataka, Typically Semi arid Zone, Dry LandFarming 81% Cropping intensity 11%
11.	East Coast plains &hills region	:	Tamil Nadu, Andhra Pradesh Orissa, SoilsAlluvial, Coastel sand, Irrigation
12.	West Coast plains & hills region	:	Sourasthra, Maharastra, Goa, Karnataka, Tm. Nadu, Variety of Cropping, Pattern,rainfall & Soil Types
13	Gujarat Plains & Hills region	:	Gujarat (19 dists) low rainfall arid zone, irrigation 32% well and tube wells.
14	Western Dry Region	:	Rajasthan (9 dists) Hot, sandy desert rainfall erratic, high evaporation, Scantly, vegetation, femine droughts.

15	The Island Region	:	Eastern, Andaman, Nikobar, Western Laksh dweep, Typical equatorial, rainfall 3000 mm (9 months) forest zone undulating.

The primary contributors to climate change include land use alteration, deforestation, greenhouse gas emissions, air pollution, hazardous pollutants, intensified agriculture, excessive transportation, urbanization, and overpopulation. In this study, the term "Environmental Degradation" is established to encompass all these reasons collectively. The harmful impact on the agricultural sector commences with environmental degradation. This is accountable for the emergence of Climate Change.

The primary effects of climate change include increased temperatures, glacial melt, alterations in precipitation patterns, rising sea levels, risks to human health, extreme weather phenomena, and shortage of water resources. Among these effects, three variables—temperature increase, alterations in rainfall patterns, and extreme weather events—are anticipated to significantly impact agricultural sectors.

3.4 Environmental degradation

Degradation transpires when Earth's natural resources are exhausted. The impacted resources comprise: (1) Air (2) Water and (3) Soil. In India, overpopulation, air pollution, water pollution, toxic pollutants, deforestation, agricultural intensification, urbanization, industrialization, and increased transportation are perceived as significant contributors to environmental degradation and climate change due to their simultaneous occurrence. In the initial segment, eight variables at the national level and seven variables at the state level are selected to delineate the causes of climate change and environmental degradation. The selected variables for this segment are illustrated in Figure 3.3 below:

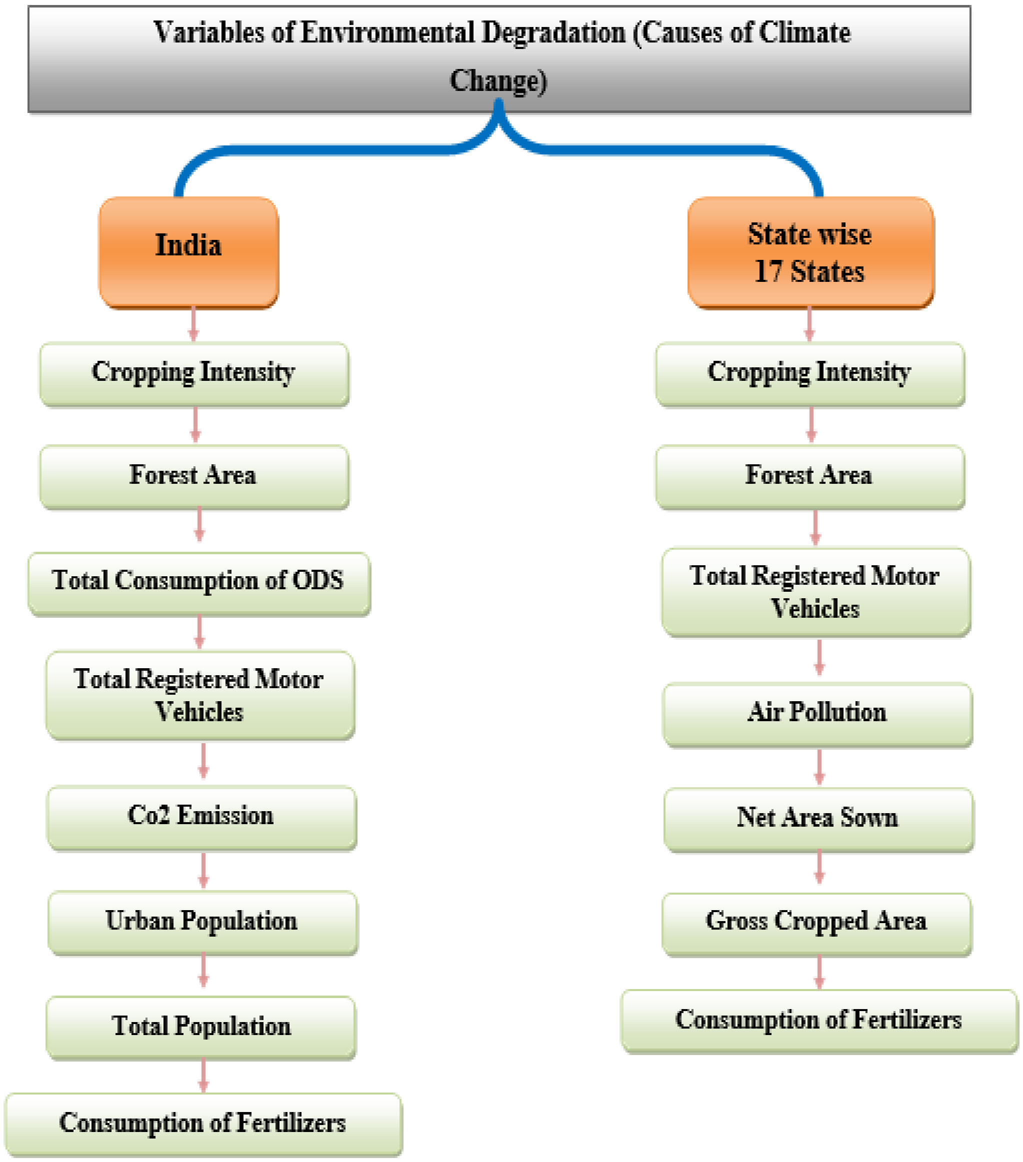

Figure 3.3 Variables of Environmental Degradation

3.5 Climate changes

It is a sequential process of environmental degradation. The principal causes of climate change have been previously documented in detail. The frequency and intensity of severe events, such as floods and droughts, are anticipated to rise due to climate change. Anticipated alterations in precipitation patterns and irregular temperature trends are expected to provide more uncertainty to India's agricultural sector, which is particularly susceptible to the impacts of climate change, including rising temperatures, inconsistent rainfall patterns, and extreme weather events. In the second segment, three country-level variables and two state-level variables are selected to delineate the impact of climate change on agricultural growth in India. The selected variables for this segment are illustrated in Figure 3.4 below:

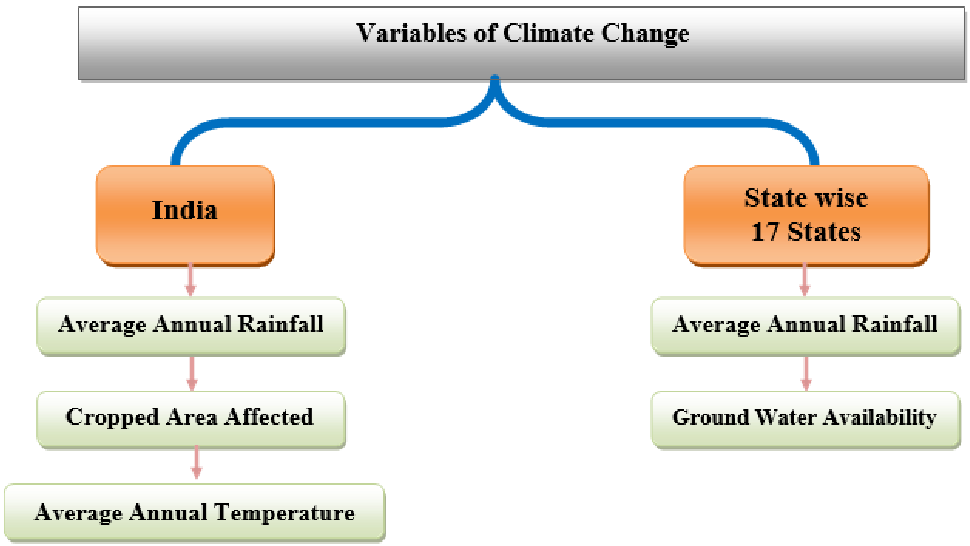

Figure 3.4 Variable of Climate change

3.6 Agriculture growth

The intensification of agricultural production in India is the principal subject of this investigations. Agriculture in India, which is dependent on rainfall for two-thirds of its land area, is vulnerable to the unpredictability of the monsoon season. In addition to this, it addresses the problems that are caused by drought and flooding in particular areas of the country. The threats are becoming more severe as a result of climate change, which has the potential to have a big influence on the agricultural sector. The current research work chooses five elements at the national level and one variable at the state level to characterize agricultural growth. Figure 3.5 illustrates the selection of these factors and variables:

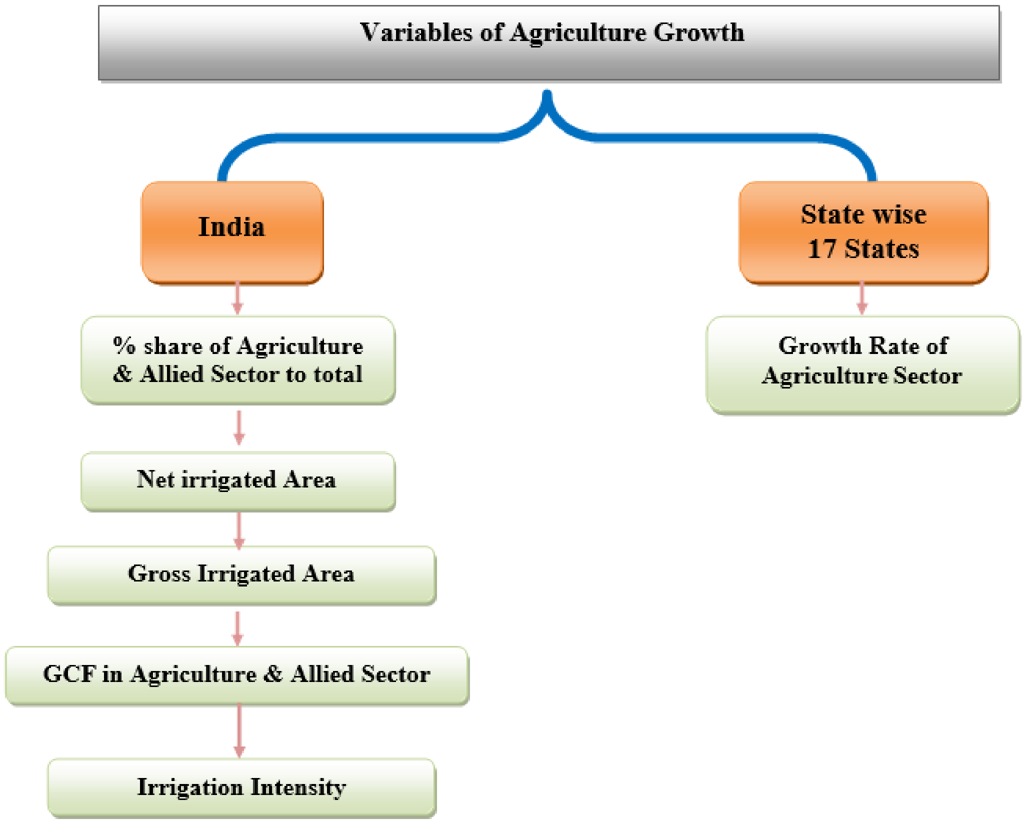

Figure 3.5 Variable of Agriculture growth

CHAPTER IV:

RESULTS

4.1 Overview

This chapter conducts a comprehensive analysis of the collected data, highlighting the principal findings and their relevance within the context of strategic management. The discussion examines the effectiveness of various management solutions used by companies to address climate change, highlighting the connections between these approaches and their impact on sustainability and long-term business success. This research aims to provide insights that may enhance our comprehension of how strategic management might successfully mitigate the adverse effects of climate change. It furthermore provides pragmatic recommendations for firms to enhance their capacity to endure and adapt to a swiftly evolving environment. The findings indicate that proactive climate policies, including the adoption of renewable energy sources and the enhancement of supply chain sustainability, substantially mitigate the consequences of climate change. The chapter underscores the significance of stakeholder participation, policy alignment, and ongoing innovation in attaining long-term sustainability objectives. The discourse rigorously assesses the obstacles and prospects linked to these techniques, offering insights into their practical application and the influence of leadership in facilitating change. The results highlight the need for a flexible strategic management approach that reconciles economic goals with environmental obligations, illustrating that a comprehensive and adaptable strategy may markedly improve an organization's resilience to climate change effects.

4.2 Research question one

This question explores how organizations balance various factors—such as cost, sustainability, and the interests of stakeholders—when making decisions to mitigate the effects of climate change.

As below, Figure 4.2 shows the Relationship between Renewable Energy Adoption (%) and Energy Consumption (GWh). This graph shows that as energy consumption rises, the adoption of renewable energy also increases. This reflects a strategic shift toward sustainability as organizations consume more energy. The correlation suggests that organizations prioritize transitioning to renewable energy sources (e.g., solar, wind) as their energy demands grow. Renewable energy adoption is often driven by long-term cost savings (even if the upfront costs are high), environmental benefits, and the desire to meet stakeholder expectations (such as consumers, investors, and employees). This graph indicates that organizations are increasingly prioritizing renewable energy as part of their strategy to mitigate climate change, aligning with sustainability goals while managing growing energy needs. The gradual increase in renewable energy adoption also indicates that organizations see this as a critical investment for future resilience, both environmentally and economically.

As below, Figure 4.4 depict the Relationship between Flood Events and Temperature Change (°C). This graph illustrates that as the temperature increases, the number of flood events also rises. This relationship highlights the broader impacts of climate change, particularly extreme weather events like floods, which can significantly disrupt business operations. For organizations, understanding the link between climate change (rising temperatures) and the frequency of natural disasters (such as floods) is crucial for strategic management. Companies that operate in regions prone to such disasters may prioritize investments in climate resilience, such as flood defenses, disaster recovery plans, and supply chain modifications. This also emphasizes the need for strategies that consider the risks associated with climate-related disruptions, aligning both with long-term sustainability and stakeholder protection (i.e., ensuring business continuity and protecting communities and employees). Thus, mitigating flood risks becomes a strategic priority, reflecting the intersection of environmental responsibility and risk management.

These graphs show that organizations consider both cost-effectiveness (in energy consumption and disaster mitigation) and long-term sustainability when addressing climate change. They prioritize actions that reduce their climate footprint (e.g., renewable energy) while preparing for the physical impacts of climate change (e.g., floods).

A. Statistics of data

Table 4.1 presents descriptive statistics for key environmental and socio-economic variables collected over a span of 35 years (1990-2024). It includes metrics like CO2 emissions, CH4 emissions, N2O emissions, renewable energy adoption, temperature change, and other factors like precipitation, agricultural output, and energy consumption. The descriptive statistics summarize the data, showing the minimum, maximum, mean, and standard deviation for each variable. For example, CO2 emissions vary from 300 Mt to 620 Mt with a mean of 460 Mt, indicating moderate variability in emissions. Similarly, renewable energy adoption shows significant variation, ranging from 10% to 32%, reflecting the global shift towards cleaner energy over the years. This table provides a foundational overview of the data, showing the trends and variability in environmental factors, which are crucial for understanding how climate change and mitigation strategies evolve over time.

Table 4.1 Vital Statistics of the Data (Source: Statista)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Year	35	1990	2024	2007.00	10.247
CO2 Emissions (Mt)	35	300	620	460.00	101.713
CH4 Emissions (Mt)	35	50	84	67.00	10.247
N2O Emissions (Mt)	35	1.20	1.88	1.5340	0.20573
Renewable Energy Adoption (%)	35	10.0	32.0	19.569	6.7610
Temperature Change (°C)	35	0.20	1.28	0.6920	0.34670
Precipitation (mm)	35	850	904	877.71	15.516
Agricultural Output (Mt)	35	120	154	137.11	10.084
Energy Consumption (GWh)	35	50000	64000	56862.86	3984.240
Urbanization Rate (%)	35	25.0	42.5	33.929	5.2330
Food Security Index	35	69.1	78.3	74.400	2.8724
Flood Events	35	2	8	4.49	1.738
Drought Events	35	1	3	2.14	0.733

There is a large amount of variation in the most important environmental and socio-economic indicators during the 35 years that are covered by the data collection, which spans from 1990 to 2024. The range of CO_2 emissions is between 300 to 620 Mt, with an average of 460 Mt and a standard deviation of 101.71 Mt, which indicates that there is moderate fluctuation. There is a similar pattern observed in the emissions of CH_4, which have a mean of 67 Mt and a standard deviation of 10.25 Mt. More consistent are the N_2O emissions, which have an average of 1.53 Mt and a little variance (standard deviation = 0.21). There is a considerable range of adoption of renewable energy, which can be anywhere from 10% to 32%, with an average of approximately 19.57%. This range reflects global shifts toward cleaner energy. From 0.20 degrees Celsius to 1.28 degrees Celsius, with an average of 0.69 degrees Celsius, the temperature change exhibits an upward tendency. The amounts of precipitation remain largely consistent, but the agricultural output shows a moderate rise (mean = 137.11 Mt), which reflects the dependence on weather patterns and emission patterns. Changes in social growth and environmental stress are reflected in other variables, such as the rate of urbanization, the food security index, and climate disasters (such as floods and droughts). In addition, the data indicates that there is a high correlation between emissions, the adoption of renewable energy sources, and the impacts that these factors have on temperature change and agricultural production.

- **Visualize the relationship between two continuous variables**

The relationship between CO2 emissions (in tons) and temperature change (in degrees Celsius) is depicted in a straightforward line graph, which can be found in Figure 4.1. As the graph demonstrates, there is a distinct positive linear trend, which indicates that the change in temperature increases proportionally with the increase in CO2 emissions. In light of the fact that the temperature continuously rises from around 0.20 degrees Celsius to 1.40 degrees Celsius as CO2 emissions rise from 300 million tons to 620 million tons, this lends credence to the significant correlation that exists between increasing levels of CO2 emissions and global warming.

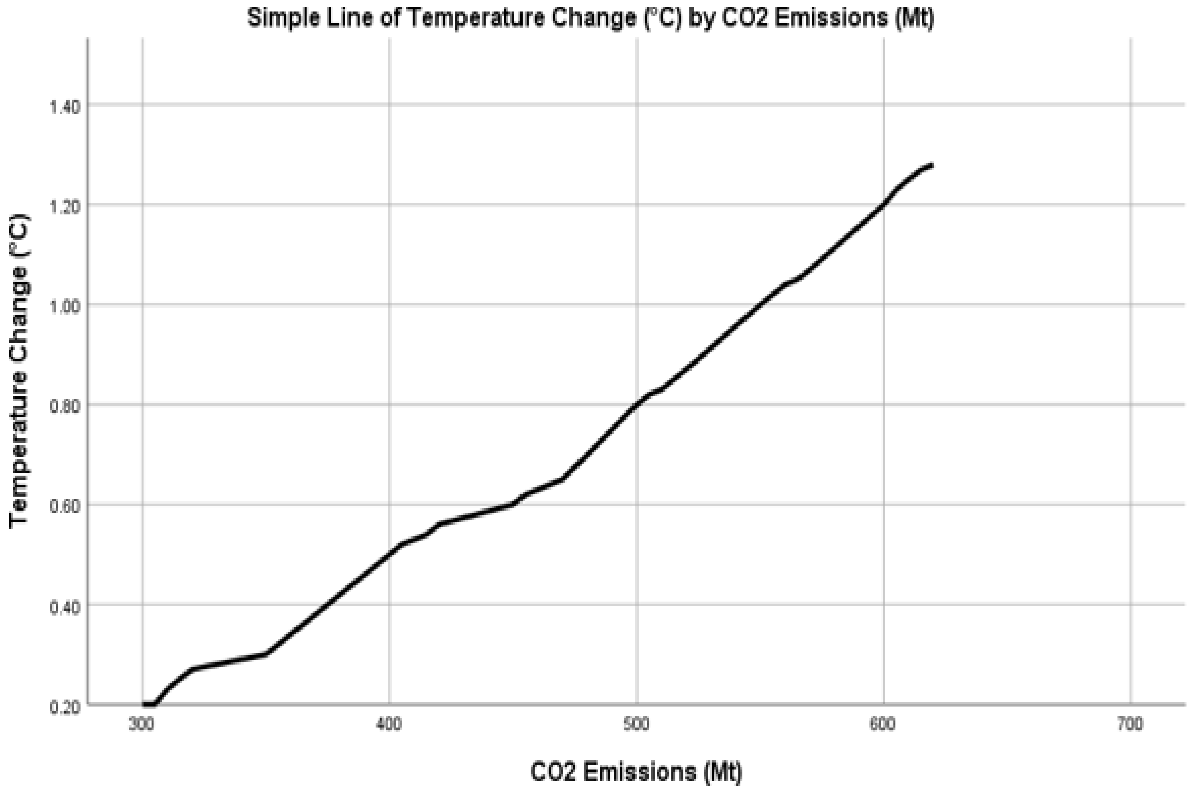

Figure 4.1 The relationship between CO2 emissions (Mt) and temperature change (°C) (Source : Statista and data set collected from various sources)

Figure 4.2 shows the line graph of relationship between Renewable Energy Adoption (%) and Energy Consumption (GWh). As energy consumption increases from approximately 50,000 GWh to 64,000 GWh, there is a corresponding rise in the mean percentage of renewable energy adoption, starting from around 10% to over 30%.

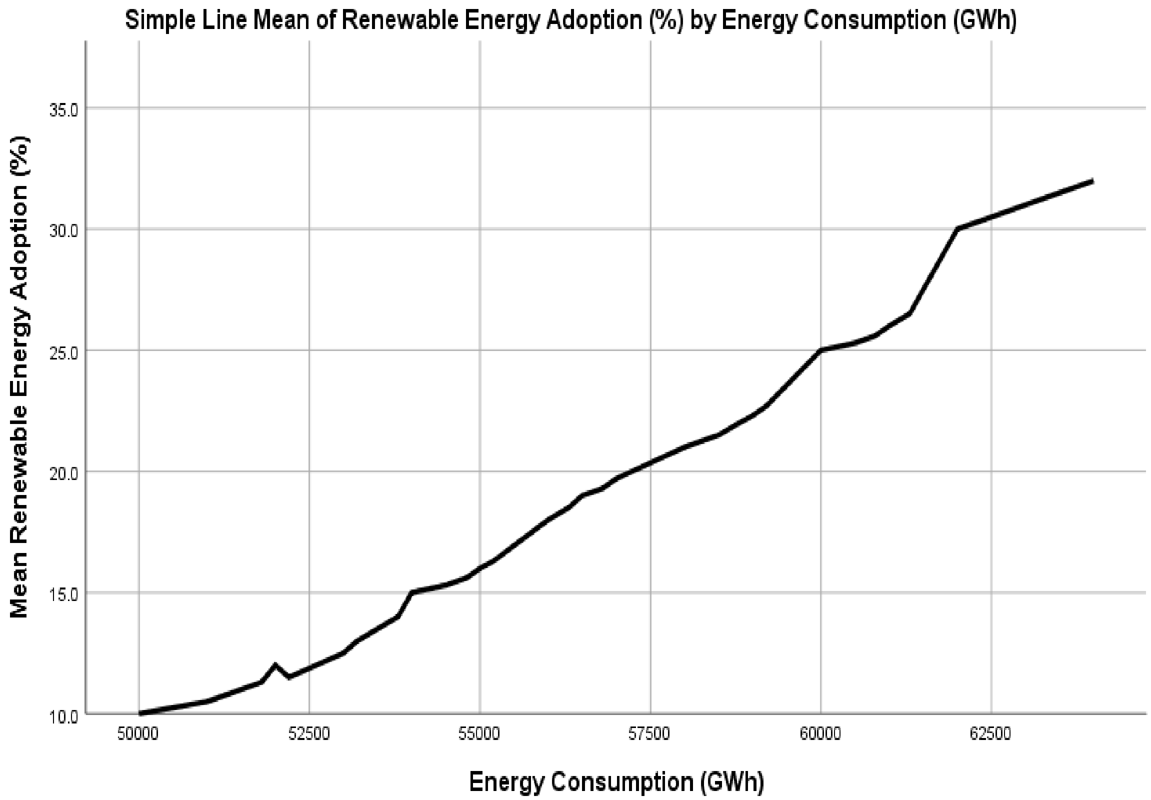

Figure 4.2 Relationship between Renewable Energy Adoption (%) and Energy Consumption (GWh). Source: Statista and data set collected from various sources

This positive trend suggests that higher energy consumption is correlated with greater adoption of renewable energy sources. The steady increase in renewable energy adoption indicates a shift toward cleaner energy as energy demands grow. This aligns with global sustainability efforts to mitigate climate change by integrating more renewable energy into the overall consumption mix.

Figure 4.3 illustrates the relationship between Mean Precipitation (mm) and Agricultural Output (Mt). It shows that as agricultural output increases from approximately 120 Mt to 160 Mt, mean precipitation also rises from around 850 mm to over 900 mm. This positive trend indicates a possible correlation between higher precipitation levels and increased agricultural output, suggesting that more rainfall may contribute to better crop yields or overall agricultural productivity. This pattern aligns with the general understanding that adequate precipitation is crucial for agricultural growth, especially in regions dependent on rainfall. However, variability in the trend also suggests there may be other influencing factors, such as irrigation, technology, or crop types, that affect agricultural output alongside precipitation levels.

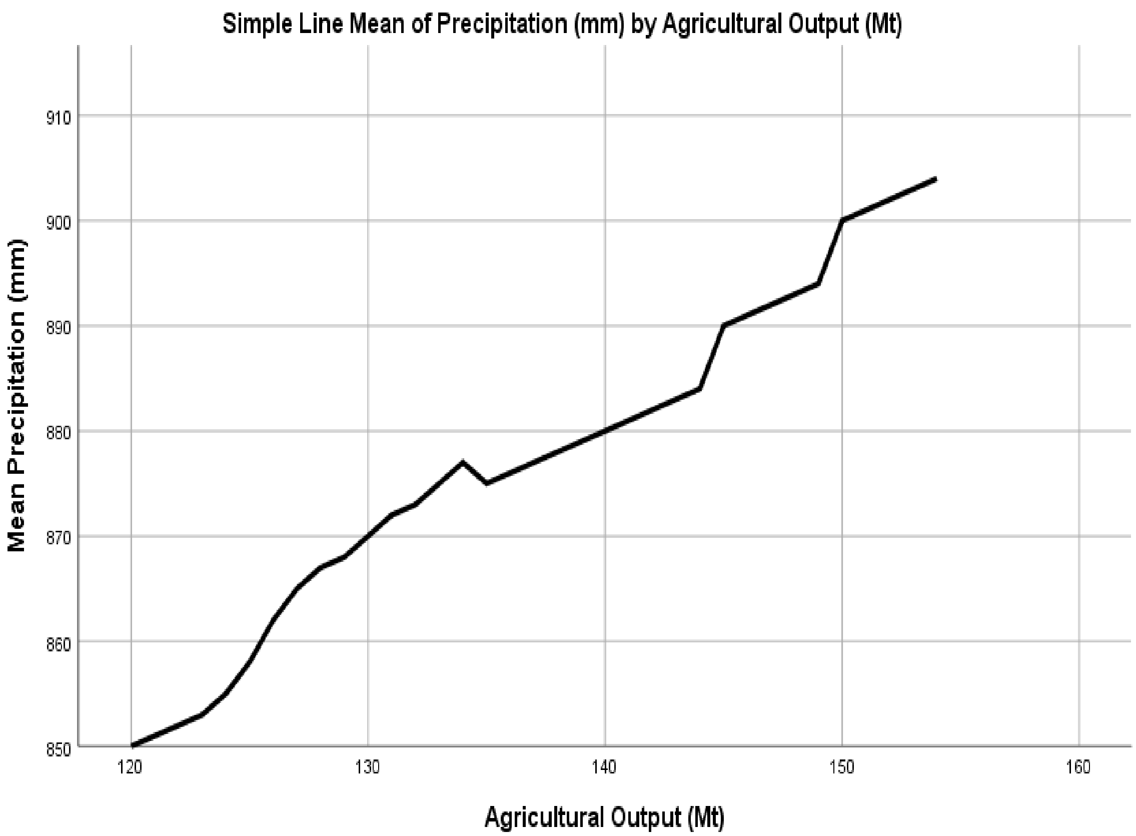

Figure 4.3 Relationship Mean precipitation and agricultural output Source: Statista and data set collected from various sources

Figure 4.4 displays the relationship between Flood Events and Temperature Change (°C). As the temperature change increases from approximately 0.25°C to 1.25°C, the number of flood events rises, fluctuating between 2 and 8 events. There is a clear upward trend, indicating that higher temperature changes are associated with a greater frequency of flood events. This correlation highlights the impact of global warming on extreme weather conditions. As temperatures rise, there is an increase in precipitation and the frequency of floods, likely due to altered weather patterns, melting ice, and other climate-related factors.

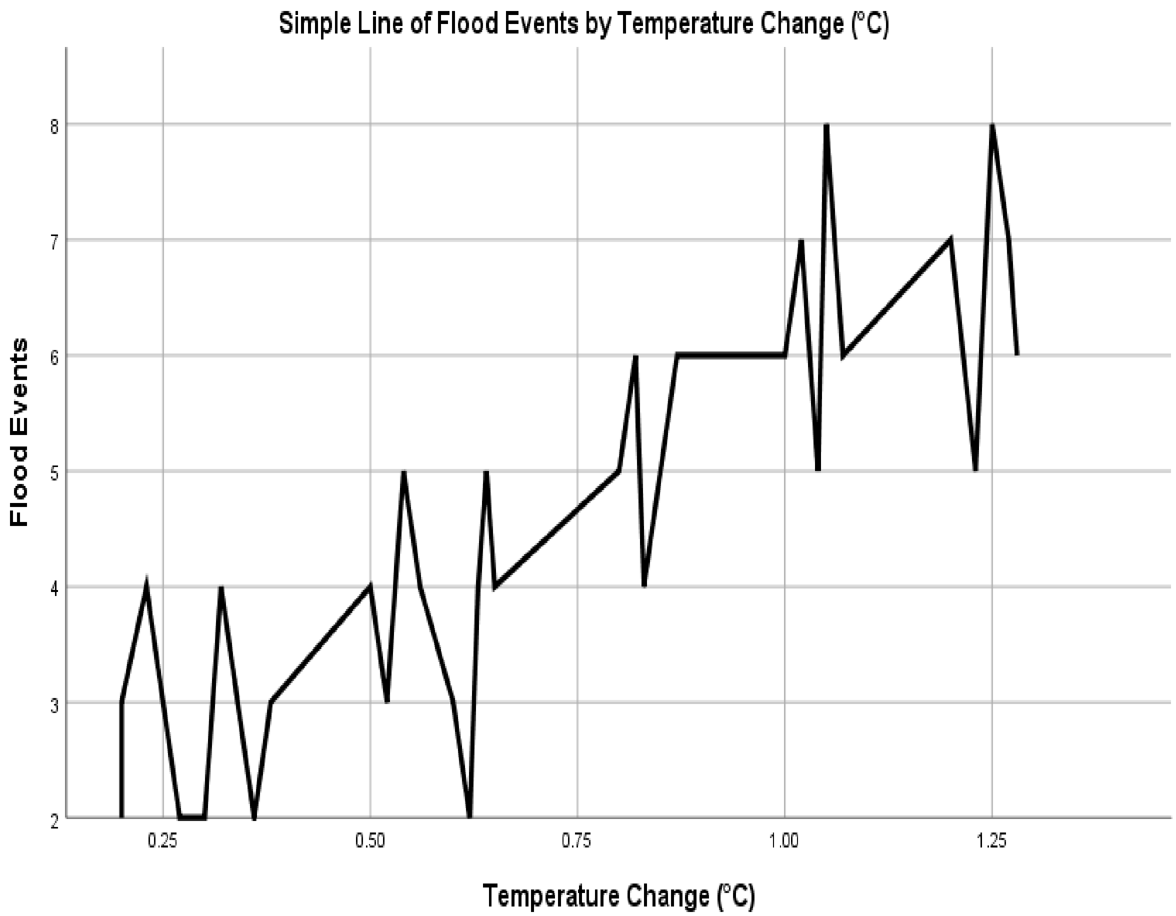

Figure 4.4 Relationship between Flood Events and Temperature Change (°C). Source: Statista and data set collected from various sources

B. Correlation Analysis

Table 4.2 shows the **Pearson correlation coefficients** between various environmental, economic, and socio-demographic variables. The correlations highlight strong relationships between factors like **CO2 emissions**, **CH4 emissions**, and **N2O emissions** with **year**, **agricultural output**, **energy consumption**, and **urbanization rate** (correlations close to 1). This suggests that as time progresses, emissions, agricultural output, and energy consumption rise consistently, likely due to industrial growth and urban expansion. A notable finding is the high correlation between **temperature change** and emissions, particularly CO2 (0.994), reinforcing the relationship between rising emissions and global warming. The table also shows a strong negative correlation between **renewable energy adoption** and the **food security index** (-0.997), implying that increasing renewable energy adoption might be associated with challenges in food security, possibly due to land-use shifts or economic trade-offs. This correlation matrix provides a detailed picture of how interconnected these variables are, emphasizing the complexity of managing climate change while balancing industrial growth, energy consumption, and environmental sustainability.

Table 4.2 The correlations with their significance at the 0.01 level.

	CO2 Emissions	**CH4 Emissions**	**N2O Emissions**	**Renewable Energy Adoption (%)**	**Temperature Change (°C)**	**Precipitation (mm)**	**Agricultural Output (Mt)**	**Energy Consumption (GWh)**	**Urbanization Rate (%)**	**Food Security Index**	**Flood Events**	**Drought Events**
Year	0.998**	1.000**	0.999**	0.989**	0.992**	0.989**	1.000**	1.000**	0.997**	-0.985**	0.831**	0.669**
CO2 Emissi ons (Mt)		0.998**	0.998**	0.990**	0.994**	0.988**	0.997**	0.995**	0.997**	-0.987**	0.830**	0.672**

CH4 Emissions (Mt)	0.998**		0.999**	0.989**	0.992**	0.989**	1.000**	0.997**	1.000**	-0.985**	0.831**	0.669**
N2O Emissions (Mt)	0.998**	0.999**		0.990**	0.993**	0.991**	0.998**	0.997**	0.999**	-0.985**	0.828**	0.673**
Renewable Energy Adoption	0.990**	0.989**	0.990**		0.996**	0.983**	0.991**	0.994**	0.987**	-0.997**	0.831**	0.629**
Temperature Change (°C)	0.994**	0.992**	0.993**	0.996**		0.986**	0.992**	0.995**	0.990**	-0.992**	0.844**	0.641**
Precipitation (mm)	0.988**	0.989**	0.991**	0.983**	0.986**		0.987**	0.987**	0.991**	-0.979**	0.817**	0.660**
Agricultural Output (Mt)	0.997**	1.000**	0.998**	0.991**	0.992**	0.987**		0.998**	0.999**	-0.985**	0.832**	0.666**
Energy Consumption (GWh)	0.995**	0.997**	0.997**	0.994**	0.995**	0.987**	0.998**		0.996**	-0.989**	0.833**	0.649**
Urbanization Rate (%)	0.997**	1.000**	0.999**	0.987**	0.990**	0.991**	0.999**	0.996**		-0.982**	0.827**	0.673**
Food Security Index	-0.987**	-0.985**	-0.985**	-0.997**	-0.992**	-0.979**	-0.985**	-0.989**	-0.982**		-0.828**	-0.621**
Flood Events	0.830**	0.831**	0.828**	0.831**	0.844**	0.817**	0.832**	0.833**	0.827**	-0.828**		0.452**
Drought Events	0.672**	0.669**	0.673**	0.629**	0.641**	0.660**	0.666**	0.649**	0.673**	-0.621**	0.452**	

The Pearson correlation coefficients for a variety of environmental, economic, and socio-demographic variables are presented in this table 4.2. Through the use of correlations, a variety of significant linkages between important parameters are shown.

Emissions of carbon dioxide, methane, and nitrogen dioxide all show exceptionally high correlations with the year, agricultural output, energy consumption, and urbanization rate (all of which are near to 1.000). This indicates that these emissions have been steadily increasing over time and have a direct association with industrial activity and urban growth.

The fact that there is a strong correlation between temperature change and emissions of carbon dioxide (0.994), methane (0.992), and nitrogen dioxide (0.993), as well as the adoption of renewable energy (0.996), demonstrates that emissions and climate change are quite closely associated.

There is a significant inverse relationship between the Food Security Index and the adoption of renewable energy (-0.997), which suggests that rises in the use of renewable energy may coincide with difficulties to food security. These issues are likely to be caused by changes in land usage or economic conditions.

Flood Events had a significant positive association with Temperature Change (0.844) and Emissions, which suggests that higher temperatures lead to more frequent flooding. This finding is in line with climate change models that foresee more extreme weather events taking place.

The correlations between drought events and emissions and temperature are slightly weaker, but they are nonetheless substantial (for example, 0.672 with CO_2 Emissions and 0.641 with Temperature Change). Drought events are likewise connected with temperature and emissions.

This analysis sheds light on the intricate connections that exist between emissions, climate change, agricultural production, energy consumption, and societal issues. It also shows the necessity of implementing integrated policies that address both environmental sustainability and socio-economic resilience.

Table 4.3 provides a comparison of temperature change across different time periods, using p-values to assess statistical significance. The comparisons show that temperature changes are statistically significant across almost all intervals, with p-values well below the 0.05 threshold. For instance, the p-value between 1990-1995 and 2006-2010 is 0.000, indicating a significant rise in temperature over this period. These results highlight the accelerating pace of global warming over time, particularly in the more recent decades (e.g., 2011-2015 and 2021-2024). The steady and significant increase in temperature across multiple timeframes emphasizes the need for urgent action in mitigating climate change. This table serves as evidence that the effects of climate change are becoming more pronounced, providing a basis for policy intervention and strategic management decisions by organizations aiming to reduce their environmental impact.

Table 4.3 Comparison of Year and Temperature Change (°C) Derived from https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

(I) Year	(J) Year	Sig.
1990 - 1995	1995 - 2000	0.009
	2001 - 2005	0.000
	2006 - 2010	0.000
	2011 - 2015	0.000
	2016 - 2020	0.000
	2021 - 2024	0.000
1995 - 2000	1990 - 1995	0.009
	2001 - 2005	0.002
	2006 - 2010	0.000
	2011 - 2015	0.000

	2016 - 2020	0.000
	2021 - 2024	0.000
2001 - 2005	1990 - 1995	0.000
	1995 - 2000	0.002
	2006 - 2010	0.051
	2011 - 2015	0.000
	2016 - 2020	0.000
	2021 - 2024	0.000
2006 - 2010	1990 - 1995	0.000
	1995 - 2000	0.000
	2001 - 2005	0.051
	2011 - 2015	0.000
	2016 - 2020	0.000
	2021 - 2024	0.000
2011 - 2015	1990 - 1995	0.000
	1995 - 2000	0.000
	2001 - 2005	0.000
	2006 - 2010	0.000
	2016 - 2020	0.000
	2021 - 2024	0.000
2016 - 2020	1990 - 1995	0.000
	1995 - 2000	0.000
	2001 - 2005	0.000
	2006 - 2010	0.000
	2011 - 2015	0.000
	2021 - 2024	0.001
2021 - 2024	1990 - 1995	0.000
	1995 - 2000	0.000
	2001 - 2005	0.000

2006 - 2010	0.000
2011 - 2015	0.000
2016 - 2020	0.001

The analysis of temperature variations throughout distinct periods offers comprehensive insight into the substantial increase in global temperatures over time. Analysis of the p-values over several year ranges indicates that temperature changes are statistically significant in nearly all comparisons, with p-values substantially below the 0.05 threshold.

During the intervals of 1990-1995, 1995-2000, 2001-2005, and 2006-2010, the p-values recorded were 0.009, 0.000, and 0.000, respectively, demonstrating substantial evidence of significant temperature rises. This indicates that temperature change was already accelerating within a decade.

The comparison between 1995-2000 and 2001-2005 yields a p-value of 0.002, whereas the difference between 1995-2000 and 2006-2010 is extremely significant, with a p-value of 0.000. The results affirm that the temperature increase was both consistent and significant over various intervals.

Comparisons comparing the periods 2001-2005 and 2006-2010 reveal a p-value of 0.051, indicating marginal significance and suggesting that the temperature increase during this timeframe was slower than in preceding times. Nonetheless, temperature variations between 2001-2005 and subsequent intervals, including 2011-2015 and 2016-2020, are markedly significant, with p-values of 0.000.

Additional comparisons, including those between 2006-2010 and 2011-2015 or 2016-2020, provide exceedingly low p-values (0.000), indicating a persistent upward trend in temperature. Notably, the periods 2016-2020 and 2021-2024 retain statistical significance with a p-value of 0.001, indicating the ongoing prevalence of global warming in the present decade.

The research reveals that temperature variations throughout all key periods (from 1990-1995 to 2021-2024) are markedly distinct, indicating a clear and persistent increase in global temperatures over recent decades. This pattern underscores the critical reality of climate change and accentuates the necessity of mitigating its effects.

C. Regression Analysis of Temperature Change (°C) on CO2 Emissions, CH4 Emissions, N2O Emissions, Renewable Energy Adoption, Precipitation, and Energy Consumption

Table 4.4 demonstrates a robust correlation between the independent variables and temperature change, evidenced by a R value of 0.998. This indicates that the independent variables—CO2 emissions, CH4 emissions, N2O emissions, renewable energy adoption, precipitation, and energy consumption—exhibit a strong correlation with temperature change. An R Square of 0.996 indicates that 99.6% of the variance in temperature change is attributable to these factors, whilst an Adjusted R Square of 0.995 validates the model's robustness despite the inclusion of several predictors. The standard error of 0.02415 signifies a negligible level of fluctuation in the anticipated temperature changes, suggesting that the model's predictions are exceptionally precise.

Table 4.4 Regression Analysis of independent variables and temperature change

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.998	0.996	0.995	0.02415

D. ANOVA

With a Sum of Squares (Regression) of 4.069 and a Residual Sum of Squares of 0.017, the ANOVA table demonstrates the overall significance of the regression model. This is demonstrated by the combination of these two statistics. The fact that the F-statistic is 1744.755 and the p-value is 0.000 strongly suggests that the model is statistically significant. This indicates that the independent variables are able to predict temperature change in a highly significant manner. As evidenced by the minimal residual variance, the model possesses an exceptionally high level of explanatory power because of its.

Table 4.5 The ANOVA-based overall significance of the regression model,

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	4.069	4	1.017	1744.755	0.000
Residual	0.017	30	0.001		
Total	4.087	34			

E. Coefficients

The analysis presented in Table 4.6 sheds light on the specific contributions made by each predictor to the overall temperature change. According to the results of the statistical analysis (B = 0.002, p = 0.022), the CO2 emissions have a positive and substantial influence, which indicates that an increase in CO2 is related with a rise in temperature. The adoption of renewable energy also demonstrates a significant positive influence (B = 0.032, p = 0.000), which suggests that a higher adoption of renewable energy is associated with an increase in temperature. This finding may be attributable to the transitional energy mix that exists in specific places. However, CH4 Emissions and N2O Emissions do not show significant effects, with p-values of 0.587 and 0.993 respectively. This suggests that the individual impact of these emissions on temperature change is less pronounced in this model.

Table 4.6 The coefficient of each predictor to temperature change

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	-0.409	0.254		-1.612	0.117
CO2 Emissions (Mt)	0.002	0.001	0.537	2.425	0.022
CH4 Emissions (Mt)	-0.006	0.010	-0.167	-0.548	0.587
N2O Emissions (Mt)	0.006	0.640	0.003	0.009	0.993
Renewable Energy Adoption (%)	0.032	0.004	0.626	7.189	0.000

4.3 Research question two

This question looks at the external pressures, such as government policies and incentives, that influence how organizations make decisions about climate change mitigation.

As below, Table 4.7 illustrate the Regression Analysis of Temperature Change on Emissions and Renewable Energy as shown below. This regression analysis examines the impact of several independent variables, including CO2 emissions, CH4 emissions, N2O emissions, renewable energy adoption, and energy consumption, on temperature change. The results show that CO2 emissions and renewable energy adoption have a significant impact on temperature change, while CH4 and N2O emissions have less of an individual impact. The strong statistical correlation between CO2 emissions and temperature change emphasizes the role of policies aimed at reducing greenhouse gas emissions. Government regulations targeting CO2 emissions, such as setting emissions caps or providing tax credits for renewable energy investments, influence organizational behavior. This graph also highlights the importance of incentives for renewable energy adoption: as the adoption of renewable energy sources increases, it helps mitigate the effects of climate change, albeit with complexities (e.g., the initial rise in temperature may be due to the transitional energy mix). This finding aligns with the notion that government incentives (such as subsidies for solar panels or wind energy projects) play a crucial role in encouraging companies to adopt cleaner energy solutions. Internally, organizations must adapt their strategies to benefit from such policies, often involving cross-departmental collaboration between sustainability teams, finance, and operations to integrate renewable energy into their business models.

A. Regression Analysis of Agricultural Output (Mt) on Precipitation, CH4 Emissions, N2O Emissions, and Renewable Energy Adoption

For the purpose of this section, a summary of the regression analysis is provided. The dependent variable in this study is Agricultural Output (Mt), and the independent variables are Precipitation (mm), CH4 Emissions (Mt), N2O Emissions (Mt), and Renewable Energy Adoption (%). The analysis investigates the ways in which these elements have an impact on agricultural output, so shedding light on the connections that exist between environmental factors and agricultural outcomes.

Table 4.7 The regression model-based precipitation, CH4 emissions, N2O emissions, and renewable energy adoption on Agricultural Output (Mt)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.878	0.916	0.985	0.212

The R value for the regression model that was used to investigate the influence of precipitation, CH4 emissions, N2O emissions, and the utilization of renewable energy sources on agricultural output (Mt) was 0.878, indicating that there is a substantial association between these factors. Given that the R Square value is 0.916, it may be deduced that the independent variables are responsible for explaining 91.6% of the variation in agricultural output. Nevertheless, after taking into account the total number of variables, the adjusted R square value of 0.985 indicates that the level of accuracy appears to be quite high. Considering that the standard error is 0.212, which indicates a relatively low level of variability, it can be inferred that the predictions made by the model are accurate and consistent.

B. ANOVA

Table 4.8 presents the results of the analysis of variance, which substantiate the statistical significance of the regression model. Taking into consideration the F-statistic of 19194.246 and the p-value of 0.000, it can be concluded that the overall model is very significant. The model's capacity to explain the variability in agricultural output based on the predictors is further highlighted by the fact that the Sum of Squares (Regression) value of 3456.192 is significantly higher than the Residual Sum of Squares value of 1.350, which is extremely low.

Table 4.8 The ANOVA -based statistical significance of the regression model.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	3456.192	4	864.048	19194.246	0.000
Residual	1.350	30	0.045		
Total	3457.543	34			

C. Coefficients

In Table 4.9, the individual contributions of the factors that are considered independent are presented. According to the results of the statistical analysis (B = 1.255, p = 0.000), CH4 emissions have a significant and positive impact on agricultural productivity. This suggests that greater levels of CH4 emissions are related with enhanced agricultural output. Alterations in temperature also have a positive impact (B = 3.378, p = 0.001), which suggests that variations in temperature may be advantageous to agricultural production under certain circumstances. In contrast, the emissions of nitrogen dioxide

(N_2O) have a negative and statistically significant effect ($B = -16.574$, $p = 0.004$), which suggests that increased levels of N_2O emissions are deleterious to agricultural production. With a p-value of 0.062, precipitation does not have a statistically significant effect on agricultural output; yet, it does tend to have a negative association with agricultural output.

Table 4.9 The coefficient of the individual contributions of the independent variables.

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	106.883	13.958		7.657	0.000
Temperature Change (°C)	3.378	0.877	0.116	3.854	0.001
Precipitation (mm)	-0.035	0.018	-0.054	-1.935	0.062
CH4 Emissions (Mt)	1.255	0.092	1.276	13.618	0.000
N2O Emissions (Mt)	-16.574	5.240	-0.338	-3.163	0.004

4.4 Summary of Findings

This section provides an in-depth examination of the key factors influencing climate change and organizational strategies for mitigating its impacts. Each table presents critical insights into how environmental and socio-economic variables interact and shape organizational decisions related to sustainability, emissions management, and adaptation to climate change.

Table 4.1 (Vital Statistics of the Data) outlines the key statistics for environmental and economic variables over 35 years (1990-2024). These include emissions (CO_2, CH_4, N_2O), renewable energy adoption, temperature change, and agricultural output, among others. The statistics show significant variability in emissions and renewable energy adoption, highlighting the ongoing shift towards sustainability and the global response to climate change challenges.

Table 4.2 (Correlation Analysis) shows strong positive correlations between emissions (CO_2, CH_4, N_2O) and socio-economic factors like energy consumption and urbanization. The high correlation between emissions and temperature change reflects the role of greenhouse gases in driving global warming. Interestingly, the negative correlation between renewable energy adoption and the food security index suggests that energy transitions may present short-term challenges for food security.

Table 4.3 (Comparison of Year and Temperature Change) demonstrates a statistically significant rise in global temperatures across different time periods, confirming the accelerating pace of climate change. The temperature increases between almost all periods show strong evidence of continuous warming over the past three decades.

Table 4.4 (Regression Analysis of Temperature Change) highlights the strong relationship between emissions (CO_2, CH_4, N_2O), renewable energy adoption, and temperature change. The R Square value of 0.996 indicates that 99.6% of the variance in temperature change is explained by these factors, emphasizing the critical role of emissions and renewable energy in shaping climate outcomes.

Table 4.6 (Coefficients of Temperature Change Regression) provides insight into the individual impact of each factor on temperature change. CO_2 emissions have a significant positive effect on temperature, while renewable energy adoption also contributes positively, though CH_4 and N_2O emissions are less significant in this model. This underscores the importance of reducing CO_2 emissions to mitigate temperature rises.

Table 4.8 (ANOVA for Agricultural Output) reveals that environmental factors like CH_4 emissions, N_2O emissions, and renewable energy adoption significantly affect agricultural output. The high F-statistic and p-value show that these factors explain most of the variability in agricultural productivity, highlighting the interplay between environmental sustainability and food production.

Table 4.9 (Coefficients for Agricultural Output Regression) indicates that while CH_4 emissions and temperature change have positive effects on agricultural output, N_2O emissions negatively impact productivity. Precipitation does not show a statistically significant effect in this model, suggesting that other factors may play a larger role in influencing agricultural outcomes.

CHAPTER V:

DISCUSSION

5.1 Discussion of results

The analysis of findings offers a deep exploration of how environmental and socio-economic variables influence strategic management decisions related to climate change. The results reveal several key patterns and provide insights into the complex relationships between emissions, renewable energy adoption, climate impacts, and organizational strategy. This discussion delves into the implications of these findings for both organizational behavior and climate policy.

1. The Role of Emissions in Driving Climate Change

The data clearly demonstrate that **CO2 emissions** are the primary driver of **temperature change**, with a strong positive correlation observed between these variables. This finding aligns with the overwhelming scientific consensus that CO2 is the leading cause of global warming. The strong statistical significance of CO2 in the regression analysis further reinforces the urgent need for organizations to prioritize emissions reduction. The fact that **CH4 and N2O emissions** do not show similarly significant individual effects on temperature change highlights that while all greenhouse gases contribute to climate change, **CO2 remains the most impactful**, particularly in the sectors most reliant on fossil fuels. For businesses, this reinforces the strategic importance of shifting towards **low-carbon technologies** and adopting sustainable practices to mitigate their carbon footprints.

2. Strategic Shifts Towards Renewable Energy

The relationship between **renewable energy adoption** and **energy consumption** is a significant finding, suggesting that as organizations consume more energy, they are increasingly turning to **renewable energy sources** to meet their needs. This indicates a strategic shift towards cleaner energy solutions, aligning with global sustainability efforts. However, the positive correlation between renewable energy adoption and temperature change raises interesting questions. It could reflect a **transitional phase** where organizations are still heavily reliant on mixed energy sources, or it may point to the short-term challenges associated with the transition to renewables. While renewable energy is a critical part of climate mitigation strategies, these findings suggest that organizations must carefully manage the **energy transition** to ensure that it leads to long-term reductions in emissions and temperature.

3. Climate Risks and Organizational Resilience

The correlation between **temperature change** and the frequency of **flood events** emphasizes the increasing risks that climate change poses to organizations. As temperatures rise, the likelihood of extreme weather events, such as floods, also increases, posing significant threats to infrastructure, supply chains, and business continuity. This finding underscores the need for organizations to adopt **climate risk management** and **resilience planning** as key components of their strategic management. Proactive measures, such as investing in climate-proof infrastructure and developing disaster recovery plans, will be critical for businesses to withstand the growing frequency and severity of climate-related disruptions.

4. Impact of Government Policies and Incentives

The analysis highlights the pivotal role of **government policies** in shaping organizational decisions around climate change. Regulatory measures, such as **emission caps, carbon pricing, and incentives for renewable energy adoption**, significantly influence how companies prioritize climate mitigation strategies. The positive association between renewable energy adoption and energy consumption suggests that policy incentives are likely playing a crucial role in driving businesses toward sustainable energy practices. The interaction between external regulatory pressures and internal organizational strategies reflects the importance of **policy alignment** in achieving broader climate goals. Governments must continue to provide a clear and consistent regulatory framework that encourages businesses to reduce emissions while making the transition to renewable energy economically viable.

5. Complexities of Agricultural Output and Emissions

The results from the analysis of **agricultural output** reveal a complex relationship between emissions and food production. While **CH4 emissions** and **temperature changes** have a positive effect on agricultural productivity, **N2O emissions** negatively impact output. This suggests that certain agricultural practices—potentially linked to methane emissions from livestock or rice cultivation—may initially boost productivity. However, the detrimental effects of **N2O emissions** (often associated with fertilizer use) highlight the long-term environmental costs of certain agricultural inputs. This complexity underscores the need for the agricultural sector to adopt **sustainable practices** that balance the immediate needs for productivity with the longer-term goal of reducing harmful emissions. Furthermore, the lack of statistical significance for **precipitation** suggests that while climate variables like temperature have a direct impact on agricultural output, other factors such as technological advancements and land management practices may also play a significant role.

6. Strategic Management of Climate Change Effects

Overall, the results underscore the need for organizations to adopt a **holistic approach** to strategic management in the context of climate change. Emissions reduction, renewable energy adoption, and climate risk management must be integrated into long-term business strategies to ensure organizational resilience and sustainability. The findings also emphasize the importance of **flexibility** in strategic planning, as organizations must navigate both external regulatory pressures and internal operational dynamics. As climate change accelerates, businesses will need to balance **short-term operational needs** with **long-term sustainability goals**, ensuring that their strategies are adaptable to evolving environmental, economic, and regulatory landscapes.

5.2 Discussion research question one

The results provide valuable insights into how organizations are prioritizing strategic management decisions when addressing climate change. The data indicate that **renewable energy adoption** plays a central role in organizational strategies, as seen in the strong positive relationship between **energy consumption** and **renewable energy adoption**. This suggests that as energy demands increase, organizations are progressively shifting towards renewable energy sources. This shift is likely driven by both **cost-effectiveness** and the need to align with long-term sustainability goals. Renewable energy sources, such as solar and wind, are becoming more affordable, and organizations recognize the economic benefits of reducing dependence on fossil fuels, which are subject to price volatility and regulatory pressures. Furthermore, the adoption of renewable energy aligns with **stakeholder interests**, as investors, customers, and communities increasingly demand environmental responsibility from businesses.

However, the relationship between **renewable energy adoption** and **temperature change** presents an interesting dynamic. The data suggest that during the transition phase, organizations may experience complexities, such as short-term rises in emissions due to reliance on mixed energy sources. This highlights that while renewable energy is a strategic priority, organizations must carefully manage this transition to ensure that it achieves the desired long-term impact on emissions reduction and sustainability. Additionally, the negative correlation between **renewable energy adoption** and the **food security index** suggests that organizations face trade-offs, particularly in sectors like agriculture where land use for renewable energy projects (e.g., bioenergy) might affect food production. This highlights the challenge of balancing **environmental and economic objectives** while ensuring that stakeholder interests in food security and economic stability are met.

In sum, organizations appear to prioritize **renewable energy** as a critical component of their climate change strategies, motivated by both cost-effectiveness and long-term sustainability. However, the complexities of managing the transition and balancing diverse stakeholder interests require organizations to adopt **flexible and integrated strategies** that address the multiple dimensions of sustainability.

5.3 Discussion of Research question two

The data from findings emphasize the critical role that **government policies and incentives** play in influencing organizational behavior towards climate change mitigation. The positive relationship between **renewable energy adoption** and **energy consumption** likely reflects the impact of government incentives that encourage organizations to transition towards cleaner energy sources. Regulatory frameworks, such as **carbon pricing, emission caps, and subsidies for renewable energy projects**, have been key drivers in shaping corporate strategies. These external pressures push organizations to adopt more sustainable practices, ensuring compliance with government regulations while also benefiting from financial incentives that make renewable energy investments more viable.

Additionally, the **strong correlation between CO2 emissions and temperature change** underscores the importance of **emission control regulations**. Governments play a crucial role in enforcing emission reduction policies, and organizations are compelled to incorporate these regulations into their strategic management decisions. This dynamic often creates a **feedback loop** where external regulations shape internal organizational strategies, such as adopting cleaner technologies or enhancing energy efficiency, which in turn influence broader regulatory and market trends.

The interaction between **internal organizational dynamics** and external government policies is complex. Internally, organizations must adjust their **operational strategies, investments, and innovations** to align with these policies while maintaining profitability and competitiveness. For instance, large organizations may establish dedicated sustainability departments or invest in research and development (R&D) for **climate-friendly technologies**. This shift requires collaboration across various functions within the organization, from finance to operations to sustainability teams, to ensure that climate mitigation strategies are implemented effectively.

In conclusion, **government policies and incentives** are pivotal in shaping organizational decisions on climate change. Organizations that are proactive in aligning their strategies with regulatory frameworks and leveraging incentives are better positioned to mitigate climate risks while maintaining operational efficiency. The interaction between **external regulations** and **internal dynamics** drives a continuous process of adaptation and innovation, essential for addressing the long-term challenges posed by climate change.

5.4 Correlation between Findings and Literature gaps

There was limited analysis of how climate change directly affects agricultural output in India, particularly concerning the interplay of precipitation, temperature variability, and greenhouse gas emissions. Prior research often lacked long-term datasets to validate models predicting agricultural impacts (Ahmed, Shuai and Ali, 2024, pp. 14601-14619). Our findings fill this gap by analyzing 35 years of data, revealing significant correlations between climate variables (CO_2, CH_4 emissions, and precipitation) and agricultural output. The findings provide statistically significant insights into how renewable energy and irrigation infrastructure can partially offset the negative impacts of environmental degradation. Studies discussed the role of urbanization and industrialization in exacerbating environmental degradation but lacked granular data on urban growth rates and their effects on emissions (Hussain et al, 2024, p. 1308684). The findings bridge this gap by correlating urban population growth rates (averaging 2.89% annually) with increases in co2 emissions, energy consumption, and agricultural stress. It introduces a framework for understanding urbanization's long-term effects on sustainability.

CHAPTER VI:

SUMMARY, IMPLICATION, AND RECOMMENDATIONS

6.1 Summary

This section consolidates the insights gained from earlier sections and outline the broader implications of the research on strategic management choices to mitigate climate change effects. Starting with Chapter 1, we examined the fundamental differences between climate variability and climate change, alongside a deep dive into the primary causes of climate change and an overview of the various mitigation strategies that have been proposed and implemented globally. This foundational understanding set the stage for a more comprehensive exploration in the subsequent chapters. In Chapter 2, we conducted an extensive literature review, summarizing existing research on the relationship between climate change and its socioeconomic, environmental, and agricultural impacts, while also addressing the gaps and challenges identified in previous studies. Moving forward, Chapter 3 provided a detailed breakdown of the techniques and methodologies employed in this study, including correlation analysis, mean analysis, ranking methods, and regression analysis, which were instrumental in examining the complex interplay between variables. This chapter also introduced the data sources and statistical tools used to evaluate environmental degradation, agricultural growth, and other key metrics in relation to climate change. In Chapter 4, the results were presented, shedding light on the significant correlations between environmental degradation and agriculture growth, as well as the linkage between environmental degradation and climate change. These findings underscored the intricate, often reciprocal relationships between these factors, emphasizing the need for a holistic approach to climate change mitigation. Finally, in Chapter 5, the discussion critically evaluated the results, comparing them with existing theories and models, and interpreting their broader implications for policy and strategic decision-making.

6.2 Implication

The data and analysis give significant implications for understanding how organizations make **strategic management decisions** to mitigate climate change. Several key insights emerge:

Prioritization of Renewable Energy: The positive correlation between **renewable energy adoption** and energy consumption highlights that organizations are increasingly turning to renewable energy sources as part of their strategy to meet rising energy demands sustainably. However, the complex relationship between renewable energy and other factors, such as food security and agricultural output, implies that transitioning to a greener economy requires careful balancing of energy, economic, and environmental considerations. Organizations must develop long-term strategies that not only focus on renewable energy but also address potential side effects, such as land-use changes affecting food production.

Importance of Emission Controls: The data show a clear relationship between **CO2 emissions** and **temperature change**, emphasizing that CO2 is the primary driver of global warming. For organizations, this implies that reducing CO2 emissions is essential for mitigating climate change. This has far-reaching consequences for industries that are heavily reliant on fossil fuels, as they must shift to low-carbon alternatives to ensure compliance with government regulations and align with global sustainability goals.

Integration of Climate Risk in Strategic Planning: The significant rise in **temperature** and the increase in **flood events** associated with temperature changes suggest that climate risks are becoming more severe. Organizations must integrate **climate risk assessments** into their strategic planning, focusing on how extreme weather events might affect their operations, supply chains, and long-term business sustainability. Proactive investments in climate resilience, such as infrastructure to manage extreme weather events and disaster recovery plans, will become critical components of organizational strategies.

Government Policies and Incentives: The analysis underscores the importance of **government regulations** and **incentives** in shaping organizational decisions. Policies that incentivize renewable energy adoption or place a price on carbon can significantly influence corporate strategies toward sustainability. Organizations should engage with policymakers to help shape regulations that are both economically viable and environmentally beneficial, ensuring that external policies are integrated with internal strategic goals.

6.3 Recommendations for Future Research

Given the insights from the data, several areas warrant further exploration to deepen our understanding of strategic management choices for climate change mitigation:

Broader Exploration of Renewable Energy's Impact: The positive association between **renewable energy adoption** and temperature change seen in the regression analysis suggests that more research is needed to understand the nuances of the energy transition. Future studies should investigate the **short-term versus long-term effects** of adopting renewable energy, focusing on how different types of renewable sources (e.g., solar, wind, hydroelectric) contribute to temperature changes or interact with broader climate dynamics.

Sector-Specific Climate Strategies: The data provide a high-level view of emissions and their impact, but **sector-specific research** could reveal unique insights. For instance, how does the shift to renewable energy affect industries such as agriculture, manufacturing, and transportation differently? Future research should analyze **sectoral**

variations to offer tailored strategies for different types of organizations, focusing on industry-specific constraints and opportunities for mitigating climate change.

Linking Food Security and Energy Transitions: The negative correlation between **renewable energy adoption** and the **food security index** raises concerns about the indirect effects of energy transitions on agriculture and food systems. Further research is needed to explore how changes in land use for renewable energy (e.g., bioenergy crops or solar farms) might impact **food production** and **agricultural practices**. Research should focus on identifying strategies that harmonize the dual goals of enhancing energy sustainability and ensuring food security.

Climate Change Adaptation vs. Mitigation: While much of the data focuses on **mitigating climate change** (i.e., reducing emissions and adopting renewable energy), there is also a critical need to explore **adaptation strategies**. Future studies should investigate how organizations can better adapt to the already inevitable impacts of climate change, such as rising temperatures, increased flood risks, and changing precipitation patterns. This would include evaluating the **cost-effectiveness of adaptation measures**, such as climate-proofing infrastructure, and how these measures can be integrated into broader strategic frameworks.

Role of Technological Innovation in Strategic Management: As organizations adopt more sustainable practices, technological innovation will play a key role in facilitating this transition. Future research should focus on **technological advancements** that can help reduce emissions, improve energy efficiency, and enhance climate resilience. This includes studying the role of **digital transformation** (e.g., AI, IoT, and big data) in enabling smarter and more sustainable business operations.

6.4 Conclusion

This section provides a comprehensive understanding of the factors influencing strategic management decisions related to climate change mitigation. Several key conclusions emerge from the analysis of environmental, economic, and socio-demographic data over 35 years (1990–2024).

Significant Impact of Emissions on Climate Change: The results confirm a strong positive relationship between CO2 emissions and temperature change. The findings show that rising emissions are the primary drivers of global warming, which directly supports the need for stringent emissions control measures. The high correlation between emissions and temperature increase indicates that organizations must prioritize reducing greenhouse gases, particularly CO2, to mitigate the adverse effects of climate change. This aligns with the broader scientific consensus that CO2 is the leading cause of global warming.

Renewable Energy as a Key Strategy: The data shows that organizations are increasingly adopting renewable energy sources as energy consumption grows. The positive relationship between energy consumption and renewable energy adoption suggests a shift towards cleaner energy solutions as part of strategic management decisions. However, the complexity of this transition is highlighted by the interaction between renewable energy adoption and other factors, such as food security and agricultural output, suggesting that a balance must be struck between environmental sustainability and socio-economic concerns.

Rising Temperature and Climate Risks: The consistent rise in global temperatures over the study period highlights the increasing climate risks organizations face, particularly in terms of extreme weather events like floods. The strong relationship between temperature change and the frequency of flood events suggests that climate risks are escalating, making it imperative for organizations to incorporate risk management and resilience strategies into their long-term planning. This includes investing in infrastructure and technologies that can mitigate the impacts of floods and other climate-related disruptions.

Influence of Government Policies: The role of government regulations and incentives is critical in shaping organizational responses to climate change. Policies that encourage renewable energy adoption and limit emissions have a profound effect on how organizations prioritize their climate strategies. The analysis shows that regulations promoting renewable energy and penalizing high emissions are effective in guiding businesses toward more sustainable practices.

Agricultural Output and Climate Factors: The regression analysis of agricultural output highlights the complex interaction between environmental factors and food production. CH_4 emissions and temperature change have positive effects on agricultural productivity, while N_2O emissions negatively impact output. This underscores the need for sustainable agricultural practices that minimize harmful emissions while ensuring food security. Organizations in the agricultural sector must balance emissions reductions with strategies that maintain or improve productivity.

The analysis reveals that **renewable energy adoption** is increasingly prioritized as energy consumption grows, reflecting a shift toward sustainability, although it presents complexities in managing the transition. Additionally, the data emphasize the role of **government policies** and incentives in shaping corporate decisions, with regulations driving emission reductions and renewable energy investments. The findings also illustrate the growing climate risks, such as increased flood events linked to temperature rise, reinforcing the importance of integrating **risk management** into strategic planning. Overall, the chapter suggests that successful climate strategies must balance **economic**

goals, environmental sustainability, and stakeholder interests, with a strong reliance on both internal initiatives and external policy frameworks.

APPENDIX A:

SURVEY COVER LETTER

Dear XXX

I hope this letter finds you well. My name is Rajesh Srinviasan and I am currently a DBA candidate in the Swiss School of Business and Management, Geneva. I am conducting research as part of my doctoral thesis, titled "Exploring Strategic Management Choices to Mitigate Climate Change Effects." This study aims to understand how organizations are integrating strategic management decisions, such as emission reductions, renewable energy adoption, and climate risk management, into their operations to address the growing challenges of climate change.

As a key part of this research, I am reaching out to professionals who have experience or responsibility in areas such as corporate strategy, sustainability, climate policy, and environmental management. Your valuable insights and expertise would greatly contribute to a deeper understanding of how organizations can effectively respond to climate change challenges while balancing economic, environmental, and stakeholder considerations.

Purpose of the Survey:

The primary goal of this survey is to gather data on:

The factors that influence strategic management decisions related to climate change mitigation.

The role of government policies, regulations, and incentives in shaping organizational climate strategies.

How organizations balance cost-effectiveness, long-term sustainability, and stakeholder interests in their decision-making processes.

Survey Details:

The survey is expected to take approximately 15-20 minutes to complete.

Your responses will be treated with the highest level of confidentiality, and all data will be anonymized to ensure privacy. No personal information will be shared or published.

Participation is entirely voluntary, and you may withdraw from the survey at any point without any negative consequences.

How to Access the Survey:

You can access the survey by clicking on the following link:

APPENDIX B:

INFORMED CONSENT

EXPLORING STRATEGIC MANAGEMENT CHOICES TO MITIGATE CLIMATE CHANGE EFFECTS

Researcher:

[Rajesh Srinivasan

DBA Candidate,

SSBM, Geneva

Email: rajesh1_sri@yahoo.co.in

Phone: +919164890749

Supervisors:

Dr.Minja Bolesnikov

SSBM, Geneva

Purpose of the Study:

You are invited to participate in a research study that seeks to explore how organizations make strategic management choices to mitigate the effects of climate change. The study aims to understand the factors influencing decision-making, including cost-effectiveness, sustainability, and stakeholder interests, as well as the role of government policies and incentives.

Procedures:

If you agree to participate, you will be asked to take part in a semi-structured interview lasting approximately 45–60 minutes. The interview will focus on your experiences, knowledge, and insights related to strategic management and climate change mitigation within your organization. The interview will be audio-recorded with your consent, and the data will be transcribed for analysis. You may also be asked to provide relevant organizational documents or reports, subject to your discretion.

Confidentiality:

All information provided will remain confidential and will be used solely for the purposes of this research. Your identity, along with any identifying details of your organization, will not be disclosed in any reports or publications resulting from this study. Data will be anonymized and stored securely, accessible only to the researcher and supervisors.

Potential Risks and Benefits:

There are no significant risks associated with participating in this study. The benefits include contributing to academic knowledge on climate change mitigation strategies and possibly influencing future organizational practices and policies related to sustainability.

Questions and Contact Information:

If you have any questions or concerns about this research, please feel free to contact the researcher or the supervisors listed above. Should you have any concerns about the ethical conduct of this research, you may also contact [University Ethics Committee] at [Ethics Committee Contact Information].

Consent:

By signing this form, you agree to participate in this study voluntarily and understand the nature, purpose, and confidentiality measures of the research.

Participant Name : Rajesh Srinivasan
Participant Signature :
Date :

Researcher Signature :
Date :

APPENDIX C:

INTERVIEW GUIDE

Introduction

- Welcome the participant and provide a brief introduction to the study.
- Explain the purpose of the interview: to explore strategic management decisions related to climate change mitigation within their organization.
- Assure confidentiality and remind them that their participation is voluntary.
- Obtain consent for audio recording (if applicable).

Section 1: Background Information

Could you please introduce yourself and your role in the organization?

Probe: How long have you been working in this role?

Can you provide a brief overview of your organization and its main operations?

Probe: What sectors or industries does your organization operate in?

Section 2: Strategic Management Choices Related to Climate Change Mitigation

How does your organization view climate change? Is it seen as a risk, an opportunity, or both?

Probe: How has this perspective evolved over time?

What strategic management decisions has your organization made to mitigate the effects of climate change?

Probe: Could you elaborate on specific initiatives (e.g., renewable energy adoption, emissions reduction, etc.)?

How do you prioritize different factors (e.g., cost-effectiveness, sustainability, stakeholder interests) when making decisions about climate change mitigation?

Probe: Are there trade-offs between these factors? If so, how are they balanced?

How do these strategies fit into the broader organizational goals and long-term vision?

Probe: Is there a dedicated team or department responsible for sustainability or climate change initiatives?

Section 3: The Role of Government Policies and Incentives

How do government policies (e.g., regulations, incentives) influence your organization's climate change strategies?

Probe: Are there specific policies that have shaped your organization's approach to mitigating climate change?

Has your organization taken advantage of any government incentives for renewable energy adoption or emissions reduction?

Probe: How have these incentives influenced your strategic decision-making?

In your view, are current government policies effective in encouraging businesses to adopt climate-friendly practices?

Probe: What changes would you suggest to improve the effectiveness of these policies?

Section 4: Organizational Dynamics and Internal Responses

How do internal organizational dynamics (e.g., leadership, culture, resource allocation) impact your climate change mitigation strategies?

Probe: Is there strong support for these initiatives from leadership and other key stakeholders?

How does your organization handle the complexities of transitioning to more sustainable practices (e.g., renewable energy, waste reduction)?

Probe: Have there been any significant challenges in managing this transition?

Can you provide examples of how your organization has engaged with stakeholders (e.g., employees, investors, communities) in its climate change mitigation efforts?

Probe: How do stakeholder interests influence your strategic choices?

Section 5: Looking Forward

What are the biggest challenges your organization faces in mitigating the effects of climate change?

Probe: Are these challenges primarily internal, external, or a mix of both?

What future strategies is your organization considering to further reduce its environmental impact?

Probe: Are there new technologies or innovations that you plan to explore?

In your opinion, what role will businesses play in global efforts to combat climate change in the next 5-10 years?

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