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Gauging the Assessment of Some Anthropogenic Factors Driving Climate- Change

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Abstract
Climate-change (CC) is associated with any shifts in weather patterns, whether in space or time, and is largely attributed to enduring human activities. Climate-change is also caused by natural phenomena including dust storms, earthquakes and volcanic eruptions besides meteorites crashing onto the surface of the earth. Rising global temperatures are a significant consequence of climate-change, causing an increase in freak weather phenomena as well as causing damage to biodiversity, ecosystems, plant-pollinator connections, seed distribution and recruitment, food security, public-health and water. Presence and detection of oxides of nitrogen & sulphur, methane, water-vapour and carbon-di-oxide (mainly greenhouse gases) constitute the key determinants of the ill-effects on climate caused by human interference and exploitation. Aerosols, too, contribute significantly to global warming, as do chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). By the conclusion of the century, a distressing increase of 1.5°C in average surface temperature is projected. This review examines the current condition of climate-change while investigating its causes, compiling results of its negative effects on plant pollination, seed dispersal, ecosystems and biodiversity, in addition to public health. Furthermore, this study also includes a comprehensive overview of sustainable mitigating measures to overcome the disaster of climate-change.

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Introduction

Climate-change primarily encompasses alterations in the climate caused by human activities and/or natural factors, leading to a global-level modification in the composition of the atmosphere. Over a significant time period, a change in climate has

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been observed to have spatial as well as temporal dependence, influenced not only by natural factors but also anthropogenic activities.[1]

The World Meteorological Organization in 1988, partnering UN Environment Programme, created the Intergovernmental Panel on Climate Change with the mandate to conduct an extensive assessment of climate-change. The joint panel was tasked to formulate recommendations for potential climate-change response strategies to help policymakers scientifically assess their climate control initiatives and supplement existing knowledge with future risk potentials while devising adaptive practices to mitigate the ill-effects.

That humans negative influence on the climate system is amply clear due to the fact that recent greenhouse gas emissions are the highest in history of earth. The repercussions of these changes occurring in climate are eventually found to extend extensively to not only humans but to natural systems as well.[2]

As global temperatures rise and the frequency of extreme environmental events increases, climate-change is recognized to have adverse effects on biodiversity, ecosystems, food security, public health, and water resources. CC has altered the duration, magnitude, and frequency of extreme events such as drought, forest fires, and heat waves in recent years.[3] Besides these, the changes befalling in photosynthetically active radiation as well as air and water temperature are expected to have a significant impact on the World's agricultural production.[4] Because biodiversity and ecosystems are regarded as the foundation of all important human services, any change in these will inevitably have an impact on provisioning, regulating, supporting, and cultural activities, and human well-being.[3]

Between 1980 and 2016, an increase of approximately 64.05 ppm of CO_2 has been observed in the global atmosphere which is primarily attributed to the combustion of fossil fuels. Overall, ever since the onset of industrialization, there has been a rise of 42.8% in CO_2 concentration. Of these, agricultural land use accounted for 19-20% of global greenhouse gas (GHG) emissions, while aquaculture ponds were found to emit GHGs, with a greenhouse effect potential of 15.86 t CO_2/hm2, indicating their contribution to global warming.[5,6,7] However, it is surprising to note that shrinking of suitable habitats is another major consequence of climate-change, and by the year 2100, it is estimated that 57% of all available plants and 34% of all animals will be confined to only half of their current geographical distribution.[8] Climate-change is rapidly disrupting even the evolutionary dynamics of plants. Despite the fact that many factors influence/cause this CC, most studies only manipulate one factor at a time. Hamann and his colleagues have highlighted the interactions between the various factors causing climate-change, as these factors interact not only with one another, but also with biotic pressures, resulting in altered evolutionary processes.[9] The current review elucidates the existing and future effects of CC on plants, ecosystems, humans, and the environment. Climate-change is therefore seen to affect all aspects of our lives, from natural resources to health and economy, and major areas of concern are shown in Figure 1.

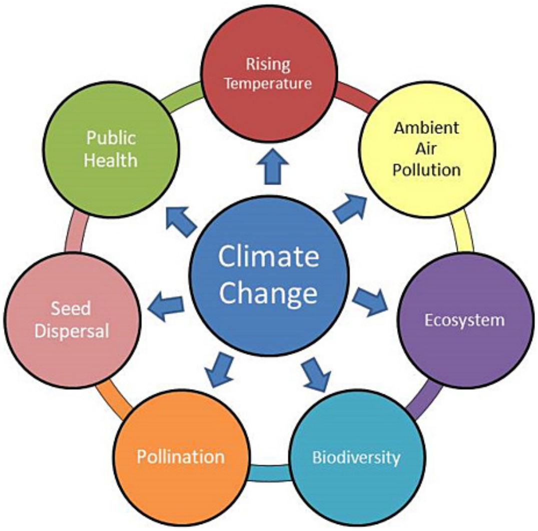

Fig.1: Various aspects of life that are directly affected due to climate-change

Through comprehension of the causes and consequences of climate-change, we can undertake measures to diminish greenhouse gas emissions, foster the adoption of renewable energy sources, safeguard vulnerable ecosystems, and enact policies that foster sustainability and resilience. The research conducted on climate-change plays a crucial role in providing valuable information to decision-makers, policymakers, and stakeholders.

This information enables them to make well-informed decisions regarding how to tackle the intricate and interconnected challenges posed by climate-change. By offering insights into various aspects of climate-change, such as its impacts, causes, and potential solutions, climate-change research empowers these key stakeholders to develop effective strategies and policies. It equips them with the knowledge needed to address the complexities of climate-change and its far-reaching consequences. With the help of climate-change research, decision-makers can better understand the implications of their choices and take proactive measures to mitigate and adapt to climate-change. This research acts as a valuable resource for shaping sustainable practices, promoting resilience, and fostering informed decision-making in the face of the climate crisis.

The Green House Gases

The collection of "greenhouse gases" in our ambient is primarily responsible for this human-induced climate-change. These anthropogenically generated gases absorb and re-emit infrared radiation, causing our atmosphere to retain heat.

While a significant portion of greenhouse gases, including carbon-di-oxide, methane, water vapor, and nitrous oxide, naturally occur in the atmosphere, there are additional gases generated by human activities. These include chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The processes of industrialization and urbanization have significantly amplified the concentrations of both natural and anthropogenic gases in the Earth's atmosphere in recent decades. As the global population continues to grow, our dependence on fossil fuels, such as kerosene oil, coal, and natural gas, has surged, leading to a substantial increase in their presence in the environment.[10] The primary greenhouse gas, carbon-di-oxide, is emitted into the atmosphere through the combustion of organic matter, fossil fuels, solid waste, and deforestation activities. Chemical industries, including cement production plants, also contribute to CO_2 emissions. As a part of the biological carbon cycle, plants play a role in mitigating CO_2 levels by converting CO_2 into O_2 through the process of photosynthesis; a process known as sequestration, which highlights the significance of plants. Methane is an additional potent greenhouse gas that is predominantly released during production of oil, coal mining and exploration of natural gas. In addition, organic material decomposition at landfill sites, by livestock and other agricultural practices also lead to methane emission. Other GHGs, including NOx, SOx etc. are emitted by automobiles, agricultural and/or industrial activities. Due to their potency, even though the bulk of fluorinated GHGs are emitted in miniscule quantities, yet they constitute the category of High Global Warming Potential gases (HGWP gases). Some of the constituents of these HGWP gases including chlorofluorocarbons, hydrochlorofluorocarbons and halons, are known to deplete stratospheric ozone. The effect of each of these gases on climate-change is proportional to their atmospheric concentration and/or their abundance. Depending on their concentration / abundance, these gases are known to exist in the atmosphere from days to years. When they remain in the atmosphere for a sufficient amount of time, they combine well, resulting in uniform concentrations all over the world, becoming global gases as opposed to local gases and hence, their individual sources of emission become irrelevant. Depending on their capacity to retain heat, certain GHGs have a greater warming potential than others and these include the HGWP gases, which absorb more energy per pound than lower GWP (LGWP) gases.[11]

The ongoing rate of greenhouse gas (GHG) emissions is projected to lead to further global warming. These persistent changes in every aspect of the climate system are expected to increase the likelihood of severe, enduring, and widespread impacts on both human populations and ecosystems. Mitigating climate-change is contingent upon a significant reduction in GHG emissions.

The Rising Temperatures

Since the pre-industrial era, the global temperature on an average has increased by approximately 1°C, and it is projected to rise even further by the end of the century, causing widespread concern globally. It is evident that this rate of warming cannot be solely attributed to natural variations but is primarily driven by human activities. These anthropogenic factors have contributed significantly to the escalation of weather and climate extremes worldwide in recent decades.

It has been reported that by 2100, the Mediterranean basin average air temperatures would shoot up to 5.1°C from the current 2.2°C, while precipitation will drastically decrease resulting in drought, heat waves and flooding via unbridled melting of glaciers. Extremely high temperatures are likely to trigger ice cover breakdown, leading to a large rise in sea level, potable water scarcity and an increase in forest fire occurrences, particularly in arid regions. Human health and the various ecosystems are anticipated to change as a result of all the observable shifts.[12]

According to a recent report on climate-change published by NASA, key indicators of this human induced climate-change include rising sea levels, loss of ice at the poles and mountain glaciers, acidification & warming of oceans, frequent occurrences of hurricanes, wind pattern & precipitation changes, heatwaves, wildfires, droughts, floods, changes in terrestrial & marine ecosystems, besides changes in cloud and vegetation cover.[13]

The year 2019 has been recorded as the second-warmest year on record, with concentration levels of CO_2 and other GHGs reaching an all-time high. Several nations suffered from crashing national economies and loss of lives because of this sudden increase. Although GHG emissions decreased significantly in 2020 due to the COVID-19 pandemic, resulting in lock-downs, travel bans, and economic slowdowns, this change was only temporary, and now that all restrictions and lock-downs have been lifted, the rate of climate-change has returned to its original alarming levels. Across all assessed emission scenarios, it is projected that the average surface temperature will increase in the forthcoming decades, exceeding 1.5°C by the end of the century. This rise in temperature will bring about more frequent and prolonged heat waves, as well as an increase in extreme precipitation events. Additionally, as the oceans continue to warm and become more acidic, a further rise in the global average sea level is expected.

Recently, Krishnan and group during their evaluation of climate-change throughout the Indian region have outlined in their finding, an enhancement in 0.7°C average temperature in India in the period between 1901 and 2018.[14] This surge is attributed to indiscriminate use of gasoline fuels, anthropogenic aerosols and changes in land use patterns, all of which resulted in an increased concentration of GHGs. In North Central India, these rising temperatures have resulted in a major decline in summer monsoon rainfall, particularly towards the end of the century gone by, ultimately leading to deteriorated water security and severe socioeconomic effects.[15] This weakening of the monsoon in India caused by both natural and human factors has also been connected to the increasing sea surface temperatures in the Indian Ocean.

Katzenberger and others have researched the impact of diminishing monsoons on the yields of crops like rice, and on people's means of subsistence.[16] According to their statement, the presence of a weakened Indian monsoon is a matter of considerable concern due to its critical role within the global climate system and its responsibility for ensuring water availability in the densely populated South Asian region. The Indian summer monsoon (ISM) provides for over 80% of the Indian subcontinent's yearly precipitation, affecting the livelihoods of more than one-fifth of the population in the entire world. The timing and position of ISM (usually June to September) has a substantial impact on agriculture and other economic activities besides impacting availability of water for humans and animals alike. Floods and droughts are two of the most obvious outcomes of climate-change. The yields of several crop species, particularly rice, have declined towards the end of the later part of 20th century resulting from significantly lower rainfall in summers. The primary reason for this weakening of the monsoon is the modifications in land-use patterns, especially deforestation caused by agricultural growth.

On the contrary, in 2019, the monsoon season in India lasted one month longer than usual, with the augmented precipitation leading to hardship to all. These torrential rains triggered floods displacing 1.8 million people and killing 1,800 individuals in 14 states. In summary, not only did the strong monsoon affect 11.8 million people, but it also inflicted an estimated 10 billion dollars in economic damage. In addition, the year 2019 witnessed heightened cyclone activity in the Northern Indian Ocean, making it one of the most active years with a total of eight tropical storms. Among these, six cyclones in May were categorized as "very severe," with Cyclone Fani being the most powerful. The impact of Cyclone Fani alone resulted in the devastation of over 28 million individuals, causing 90 fatalities in Bangladesh and India and led to significant economic losses of the order of 8.1 billion USD.17 Despite the fact, that India has only contributed 2% of global carbon emissions, mostly through the use of fossil fuels over the past century, the country is set to face the brunt of these "extreme weather" occurrences caused by climate-change.[18] The rising temperatures and changing precipitation patterns are anticipated to lower food production and increase sea levels. In India, the coastal states of West Bengal, Gujarat, Tamil Nadu, Odisha and Andhra Pradesh besides Puducherry (UT), are the hardest struck by cyclone activity year after year (Tautke and Yaas being the most recent examples). Inundation of fertile coastal areas with salty sea/ocean water diminishes the fertility of this cultivable land, resulting in economic and food losses. Anticipated resource limitations are expected to pose substantial challenges to climate-sensitive sectors in India, including agriculture, water resources, and forestry, as a direct consequence of climate-change.[18] Table 1 summarizes the scientific work depicting the effect of rising temperatures on climate-change.

Table 1: Summary of the scientific work depicting the effect of rising temperatures on climate change.

S. No.	Investigation	Group	Country	Important Results	Reference
1.	The investigation of various volatile organic compounds and nitrogen oxides along with their sources, affecting air quality, and the diverse technologies employed to limit pollutant emissions.	Bensouilah *et.al*	Tunisia	To fulfill the energy needs, promotion for establishment of sustainable energy sources like solar energy and wind power is advised	[12]
2.	As part of NASA's endeavor to gather evidence on the causes and impacts of climate-change, they monitor critical indicators of CC such as ice sheet volume, global temperature, atmospheric carbon- di-oxide, and sea ice extent.	https://climate.nasa.gov	USA	Climate-change refers to the enduring alteration in the typical weather patterns that characterize the local, regional, and global climates of Earth.	[13]
3.	Understanding the detrimental effects of human-induced climate-change in the Indian subcontinent is based on an examination of scientific literature, observations, climate model forecasts, and published reports from the Intergovernmental Panel on Climate Change (IPCC).	Krishnan *et.al*	India	The report offers comprehensive information on various observed changes, including precipitation patterns, temperature variations, monsoon behavior, drought occurrences, sea level fluctuations, tropical cyclones, extreme weather events, and other related aspects	[14]
4.	This study investigates the significance of the reduction in summer monsoon rainfall	Jin *et.al*	USA	Based on diverse observational data sets, a noteworthy	[15]

	in northern and central India in the latter part of the 20th century. The decline in rainfall is considered a possible risk to water security and is projected to have far-reaching socioeconomic consequences.			decrease in monsoon rainfall in India, averaging at 1.34 mm per day per decade since 2002 is reported.	
5.	A research study was undertaken to investigate the crucial role of seasonal rainfall in shaping India's agricultural productivity and influencing various aspects of life.	Katzen berger *et.al*.	Germany, USA	The research includes examining impact of seasonal rainfall on the livelihoods of one-fifth global population.	[16]
6.	The research establishes the Global Climate Risk Index and identifies the most susceptible group of organisms affected by extreme weather events.	Eckstein *et.al*	Germany	The report outlines the level of susceptibility of countries to the impacts of weather-related loss events, including storms, floods, heat-waves, and more. It provides an assessment of the extent to which countries are at risk from these events and their potential consequences.	[17]
7.	The study evaluates the ill-effects of climate-change on humans, including direct and indirect consequences such as the heightened transmission of vector-borne and water-borne diseases, cardiovascular ailments, respiratory allergies, malnutrition, and more.	Amutha *et.al*	India	The review analyzes the relationship between various diseases and changes in the atmospheric environment and climate conditions.	[18]

Climate Change Arising Due to Air Pollution

Air pollution and climate-change are closely interconnected phenomena. Frequently occurring earthquakes, erupting volcanoes, dust storms and meteorites falling onto the Earth's crust are some of the direct manifestations of this climate-change. There exists a close connection between air pollution and climate-change, and the adoption of resource-intensive lifestyles in the present significantly contributes to both these issues.[19] In addition to GHGs, ozone, nitrous oxides, sulphur oxides and particulate matter contribute significantly to air pollution. The National Institute of Environmental Health Sciences, NC, USA defines air pollution as a mixture of natural and man-made pollutants found in the air we breathe. Despite the fact that the combustion of fossil-fuels produces pollutants such as fine particles, nitrogen oxides, sulphur dioxides, and chemical vapours; other anthropogenic activities produce ozone, fine particles, and a variety of other noxious gases.[20,21] Due to ensuing climate-change, the frequency of protracted dry periods without precipitation has increased tremendously, leading to a rise in summer evaporation and undergrowth desiccation coupled with prevalence of hot and dry air conditions, which have eventually augmented the frequency and intensity of forest fires. The most severe fires have occurred in recent times in the Amazon forests, Italy, and Australia. Of late, cyclones including Vayu, Nivar, Burevi, Taukte, and Yaas have made India's exposure to the harsh reality of climate-change very evident. Scientific studies on climate-change, air pollution, and the resulting health risks holds utmost importance in current times, with these phenomena increasing the exposure of humans to particles and pollutants, eventually impacting the health, well-being, and mortality of all.

Bo and others have investigated how localized climate-change relapses have led to biomass loss for energy reasons and influenced the dynamics of urban air quality.[22] Air pollution and high temperatures severely affect human health gravely affecting mortality and morbidity rates. Air pollution, exacerbated by climate-change, is acknowledged to kill hundreds of thousands of people annually due to an overall augmentation of heart, lung, and other medical diseases. According to a 2013 study by MIT, 26.5% of all deaths attributable to air pollution were caused primarily by particles from car and truck exhausts.[23] Compromised cardiovascular and respiratory systems in humans owing to air pollution, result in diseases spanning the entire COPD spectrum including asthma, recessional infections, lung cancer, brain stroke, bronchitis and heart diseases. Besides considerably impacting the population mortality and illness, air pollution also causes depletion of ozone, acid rain and of course, global warming. According to Pucer and Strumbelj, the level of air pollutants in the atmosphere is influenced by not only emissions but also the day-to-day weather.[24] Meteorological conditions have the largest influence on PM_{10} levels, whereas stringent emission limits are responsible for a drop in SO_2 and NO_2. It is observed that toxic gases including ozone and carbon monoxide, as well as soot particles, have a significantly more detrimental effect on human health than methane, nitrous oxide, carbon-di-oxide, and CFCs.

Because GHGs remain in the atmosphere for protracted durations, they eventually become a component of the global atmosphere. Particulate matter released into the atmosphere by internal combustion and diesel engines after considerable circulation in atmosphere may end up in the most inaccessible locales, including the polar region. When such particles reach the ground, they slightly discolour the ice and snow. The darkened ice and snow reflect less sunshine into space, adding to global warming. Now, slightly warmer temperatures in the sub-arctic cause plants to expand their surface area. When these plants emerge from the snow, millions of smaller plants come under their shadow, thus darkening the planet's surface and subsequently contribute further to warming.[1]

According to a recent assessment presented by the UNEP in 2019, if proactive measures are not taken to address the ongoing crisis of air pollution, the number of deaths attributed to air pollution in India is projected to increase from 1.1 million in 2015 to 1.7 million in 2030, and further escalate to 3.6 million by 2050. This highlights the urgent need for combined research on climate change, air pollution, and energy security policies, as well as exploring the potential synergies among them. Scientists worldwide have studied the effects of air pollution on climate change, and some of their findings are outlined in Table 2.

Table 2: Summary of the scientific work depicting the relation between air pollution and climate-change.

S. No.	Investigation	Group	Country	Important Results	Refe rence
1.	The effect of various atmospheric pollutants on climate-change	https://www.unep.org	United Nations	The study describes resource-intensive lifestyles contributing to air pollution and global warming.	[19]

2.	Climate-change's interdependence on air pollution and its adverse health effects.	Walter, W.M.D.	United Nations	The report highlighted that each year, over 7 million premature deaths are linked to air pollution, underscoring the significant public health impact. Alarmingly, approximately 9 out of every 10 individuals worldwide, especially those residing in urban areas, breathe air that fails to meet the standards set by the WHO.	[20]
3.	Investigation on traffic-related air Pollution, ozone, and toxic gases, PM, VOCs and PAHs, and their harmful effects on climate-change are discussed.	NIEHS - 'Air Pollution.' 2019	USA	According to the report, it was observed that air pollution exposure is associated with oxidative stress and inflammation in human cells, which could potentially contribute to the development of chronic diseases and cancer.	[21]
4.	The investigation recounts a forest fire in the Italian Alps in the midst of a persistent drought, underlying the causes of wildfires and their harmful impact on air quality	Bo *et. al.*	Italy	The study employed PM monitors and optical particle counters to assess the effects of wildfires on the regional wood biomass energy supply chain.	[22]
5.	Examining emissions at ground level originating from various sources including industrial smokestacks, vehicle tailpipes, marine and rail operations, as well as commercial and residential heating.	https://news.mit.edu	USA	Researchers from the MIT concluded that vehicle emissions are the leading cause of premature deaths.	[23]
6.	The study looked at changes in Slovenia's climate between 2002 and 2017 to ascertain if lower levels of air pollution were caused by higher limits on emissions or by changes in the weather.	Pucer *et.al*.	Slovenia	The findings indicate that variations in the meteorological conditions had the greatest impact on PM_{10} levels whereas the decline in NO_2 and SO_2 levels is attributed to emission ceilings.	[24]

7.	The study investigated high air pollution incidents in Asia with transport, agricultural, industrial sectors, household energy, and waste management methods being the primary causes.	https://www.unep.org	United Nations	The authors recommended collaborative efforts to be spearheaded by local and national governments, with the backing of existing mechanisms and global expertise, to alleviate the adverse impacts.	[25]

Climate Change Affecting Ecosystem Services

Ecosystem services encompass a wide range of benefits derived from the processes and functions of ecosystems. These services include provisions such as food, drinking water, wood, and non-timber products, as well as ecological functions like carbon sequestration and the aesthetic value of landscape. Inadvertently, climatic and socioeconomic factors are exerting an ever-increasing pressure on essential services that support human well-being.[26] It has been shown that climate- change along with altered pattern of land usage has damaged around sixty percent of the world's ecosystem services. The exponential population growth and rising food demand are compelling farmers to adopt a more land-intensive food production method.[27,28] The increased demand for agricultural land is turning natural landscapes into cultivable land, threatening ecosystems and making them more prone to degradation and destruction. Climate-change is altering the summer and winter discharge of water as a result of increased snow melt and precipitation in the summer and a decreased snow storage and increased evapotranspiration in the winter, as well as hampered agricultural production leading to increased crop losses and diminished food provisioning services.[29] Approximately 10 percent of the Earth's surface is covered by the cryosphere, which encompasses various elements such as snow, glaciers, permafrost, and lake and river ice.[30] Changes in glacier melting, varying seasonal precipitation, and increased water flow in rivers and groundwater have an effect on both water quality and quantity. Saline water from the oceans has flooded low-lying places. As a result of acid rain, permafrost thawing, and erosion, a number of chemical contaminants in the environment are also deposited into our valuable water supplies. This has raised the turbidity and temperature of the water, allowing microbiological pollutants to emerge. With the melting of ice owing to rise in temperatures, all the freshwater, floods the rivers and plains, creating enormous devastation. The thawing of permafrost is the principal cause of water flow into streams and rivers. Not only is the melting of glaciers a problem for Arctic communities, but also for the economic sustainability of a number of nations.[31,32]

Due to recurrent droughts, the combination of rising temperatures and decreasing summer precipitation is anticipated to limit agricultural production. The harm done to ground water supplies by these periodic droughts has yet to be documented. Low water levels in regions with a high concentration of organic soils accelerate the degradation of these soils, resulting in the loss of significant carbon reserves.[33] Inability of receding water tables to keep soils moist eventually leads to soil deterioration.

Global warming and the consequent changes in climate have had a substantial impact on arid and semi-arid ecosystems, resulting in a decrease in species richness, deterioration of population structure, and alterations in the behaviour and activities of numerous other species.[34,35] Precipitation, temperature, drainage, the mineral content and the soil type, all influence the vegetation in any particular place.[36] Damaneh and team studied the ill-effects of changing climate on vegetation and concluded that periodic assessments of ecosystems are necessary and valuable for future ecosystem planning.[35]

Though several land cover changes, such as reforestation, agricultural intensification, urban growth, and reservoir construction, in recent times have taken place in accordance with our sustainable development objectives, the changes in land use/land cover practices adopted in earlier times have resulted in land fragmentation and land management, which have had an effect on the intensity of wildfires in various regions of the world.[37]

The heightened occurrence of heat waves, droughts, and prolonged dry spells contribute significantly to an extended duration and intensified severity of the fire season across much of Southern Europe. In addition to being predominantly caused by intense heat, drought, low precipitation, and strong winds, forest fires are yet another consequence of changing weather patterns. While the whole world was battling the pandemic of the Corona virus in 2020, Australia was grappling with a health emergency brought on by the terrible black summer bushfires which were worse for Australians than the corona virus outbreak.[38]

The detrimental effects of both land-use and climate-change on ecosystem services are widely recognized. Climate-change affects natural ecosystems by altering the distribution, productivity, and population dynamics of organisms. On the other hand, land-use change directly influences ecosystem processes by modifying physical characteristics including changes of the land surface, involving evapotranspiration, surface roughness, and albedo.[39]

Climate-change may potentially represent a hazard to agroecosystems by endangering biodiversity, not only through extremes in weather circumstances but also through management practices aimed to compensate for crop yield declines.[40,41] These agro-ecosystems, not only preserve local biodiversity and sequester carbon, they also significantly contribute in providing food, wood, and shelter to the masses.

Ecosystems also have the ability to play a positive role in climate-change adaptation processes, since some ecosystem services can mitigate the effects of extreme events and disturbances such as wildfires, floods, and droughts.[42]

Climate Change and Biodiversity

Human-induced climate-change has been recognized as a pervasive threat to biodiversity on a global scale.[43] In the last century, the fall in biodiversity driven by climate- change and habitat loss has been unparalleled. This loss of biodiversity is attributable to a shift in food chain patterns, which has an immediate effect on ecosystem equilibrium. Under the demand to produce more to feed the world's expanding population, meadows and woodlands have been turned into croplands for the cultivation of economically important crops. The usage of natural resources for fundamental requirements such as food, fibre, and fuel has considerably risen.

Furthermore, the release of GHGs directly into the ambient, introduction of non-native species for human consumption and use, and adverse climatic conditions are exerting a detrimental influence on biodiversity.[44] Because of these environmental changes induced by humans, there has been a significant loss of biodiversity, resulting in the sixth mass extinction event.[45]

This interplay of changing weather patterns and variation in land-cover might increase the number of affected birds and mammals by up to 43 and 24 percent, respectively. It is also anticipated that this would alter the spatial distribution of species. Furthermore, it has been established that the threat rating of global biodiversity hotspots is influenced by the relationship between climate-change and habitat loss.

Multiple studies have provided evidence that climate-change leads to a decline in community beta diversity, resulting in a reduction in the overall number of species within local ecosystems. Specialist species (usually with localized distributions) are on the verge of extinction, and their place is being taken by generalist species occupying wide geographic areas, believed to be upsetting the natural ecological balance.[46]

Endangered species are the most susceptible to climate-change because they are confined to a single geographic place and are generally unable to relocate, migrate, or adapt to climatic changes. The Galapagos Islands are one of the most prolific marine environments on the planet, with a unique biodiversity.[47] Extreme weather patterns, including La Niña and El Niño have had a substantial impact on the biodiversity and productivity of these islands. This has also led to the disturbance of a number of natural processes in this unique ecosystem.

Gaining insight into the causes and effects of changing climate on oceans along with biodiversity is of utmost importance. Talukder and group explored how ocean warming, acidification, and deoxygenation caused by climate-change have affected ocean biodiversity and global health.[47] Biodiversity, known to improve a number of agricultural activities and services, merits a higher profile in the food system.[48] Table 3 provides a summary of the research conducted to study the adverse effects of changing climate on biodiversity.

Table 3: Summary of the studies undertaken to understand adverse effects of changing climate on biodiversity.

S. No.	Investigation	Group	Country	Important Results	Reference
1.	Loss of mammalian species and biotic homogenization were found in the studies conducted in the Cerrado Biodiversity Hotspot	Hidasi-Neto *et.al.*	Brazil, Italy	Using ENM approach a detailed analysis of the impact of anthropogenic and natural processes on the broader communities of an endangered Biodiversity Hotspot is carried out	[43]
2.	The study examines and deliberates on the impacts of climate change on biodiversity and the consequential shifts in major biomes.	Kumar *et.al.*	India	The authors findings link climate-change induced biodiversity loss to disruptions in the food chain within ecosystems, directly impacting the ecological balance	[44]
3.	Ongoing research is focusing on the adverse impacts of changing climate on biodiversity and its implications for human well-being.	Shivanna *et.al*	India	The author reports that the world is on track for a 3-4 °C temperature increase by the end of the century. Neverthe-less, even with the implemen-tation of the COP-26 commitments, the projected temperature rise is still estimated to be around 2.4 °C.	[45]
4.	The effect of changing climate on the biological variety in Galapagos Islands is studied.	Dueñas *et.al.*	Netherlands, Ecuador	Findings of the authors describe in detail the extensive consequences of climate-change on the Galapagos Islands.	[46]
5.	Loss of ocean biodiversity and the associated planetary health impacts influenced by climate-change have been investigated	Talukder *et.al.*	Canada, USA	The report helps comprehend the origins and consequences of climate change on the ocean and its biodiversity. The discussion delves into future strategies to mitigate the loss of ocean biodiversity due to climate-change, aiming to promote a healthy planetary ecosystem.	[47]
6.	Priorities for study and policy develop	Ortiz *et.al.*	UK	The report highlights the limitations that impede a	[48]

-ment concerning the interplay of biodiversity, agriculture, climate change, and global trade are outlined.	holistic comprehension of the interconnections, trade-offs, and harmonies among bio -diversity, agriculture, climate change, and global trade.

Climate Change and Pollination

According to a growing number of studies, climate-change is real and one of the gravest anthropogenic dangers to our ecosystems today. Due to the cumulative disastrous impact of emission of GHGs, use of gasoline based fuels, and worldwide warming, scientific interest in the evolutionary and ecological implications of climate-change on biotic species has assumed importance.[49] Though it is believed that the magnitude of climate-change's effects will vary by location and season, rising temperatures are expected to have a greater impact on tropical pollinators than on those at other latitudes, primarily because these tropical pollinators are already living at temperatures close to their maximum tolerance range, above which they may not survive. As a result, effect of changing climate on pollination and pollinators will have the greatest magnitude on tropical crops, resulting in substantial crop losses and subsequent food scarcity.

Blooming phenology too, is affected by climate-change, impacting various plant characteristics such as leaf emergence, flowering period, and seed germination. It is anticipated that these shifting environmental conditions would have an effect on the regional ranges and local abundances of a number of species, producing spatial and temporal mismatches in their interactions with their important pollinators. Recently, large number of studies focusing on the consequences of warming on changes in phenology and distribution, as well as the influence of climate-change on flowering plants and their pollinators are being reported. As almost 88% of angiosperms depend on animals for pollination, it is well known that these interactions between flowering plants and their pollinators are ecologically and economically significant. Any interruption in this connection could have devastating effects on ecological systems, impacting frugivores, seed dispersal mechanisms, and plant recruitment. Each year, pollinators deliver an environmental benefit worth $220 billion worldwide. Understanding the physiological consequences of climate-change on pollinators, their floral food resources (pollen and nectar), and the mutualistic interactions (coupling) between plants and pollinators in changing climatic conditions is therefore of the utmost importance. There has been recent emphasis on the potential occurrence of mismatches between the timing of flower blooming and pollinator emergence, drawing attention to this phenomenon.[50]

The influence of climate-change on tripartite relationships between below ground mutualists (such as soil bacteria and fungus), flowering plants, and their accompanying pollinators has been a fascinating and significant area of study leading to phenological and distributional alterations in soil bacteria, further ensuing a decline in mutualistic interactions between microbes and plants.[51] The distribution of below ground mutualists is anticipated to vary laterally and vertically attributable to change in climate leading to a dramatic reorganization of soil microbial communities and, ultimately, symbiont switching by host plants, which could have a considerable effect on pollination rates.[51,52]

Thimmegowda and his coworkers conducted an extensive study on bees, chief pollinators in the tropical areas, over a three-year period in Bangalore. They observed that the bees from polluted areas were covered in huge volumes of particulate matter replete with hazardous heavy metals such as arsenic and lead.[53] Four out of every five bees gathered from polluted areas perished within one day, which is double the number of bees collected from non-polluted areas. In addition, bees exposed to hazardous dust made fewer number of visits (approximately 50%) to flowers in comparison to their unpolluted counterparts, hence decreasing the likelihood of successful pollination. In addition, contaminated bees had irregular heartbeats and reduced blood cell counts, indicating a compromised immune system and poor cardiovascular health. This study also indicated that the deteriorating health of honey bees as a result of pollution drives them to operate under extreme stress. Air pollution also slowed bees' everyday activities, their well-being and is expected to affect their life cycle.

Pollination services are widely recognized as vital ecosystem services globally, with pollinators playing a pivotal role in sustaining and propagating both wild plant species and crop yields in a wide range of agricultural crops.[54] This catastrophic drop of insect populations across the globe have also been attributed to habitat degradation caused by destruction, fragmentation, or pollution. The considerable decline in bees feeding on flowers in increasingly polluted areas, according to bee researchers at Simon Fraser University, establishes a direct link between pollution and its environmental consequences. Fewer bees on flowers results in inadequate pollination, leading to considerable low food output and ecological integrity losses.

Over thirty percent of domesticated honey bee colonies perish annually due to poor nutrition, disease transmission, pesticide exposure, transportation stress, and climate-change. The rising global temperatures have forced plants to bloom earlier each spring, creating timing mismatches with pollinator species. Such an incongruous link between plants and pollinators hinders plant reproduction and lowers the food resources necessary for pollinator survival.

Additionally, it is recognized that elevated temperatures change the physiology of flowering plants, leading to altered flower, nectar, and pollen production. Climate-change amplifies the harmful effects on pollinators when paired with other stressors such as excessive pesticide use, disease, and habitat loss. Individual life duration, foraging activity, and mature body size of the pollinators are all affected by global warming.[55] Nevertheless, there is a scarcity of comprehensive research exploring the impact of temperature on the emergence patterns of solitary bees and the initiation of flowering in economically important food crops.[56] These temporal phenological alterations as a result of climate-change not only put mutualistic species out of sync, but they also affect antagonistic partners, resulting in a modified community structure. This temporal misalignment between plants and pollinators stresses both plants and pollinators in terms of survival and reproductive production.[57] In addition to decreasing pollinator visits, these mismatches are responsible for a reduction in pollen production, nectar production, and pollen deposition. During the initial stages of the season, temporal mismatches often lead to adverse effects as alternative interaction partners that could potentially replace the original partner are not yet available. Certain species, on the other hand, profit substantially from this temporal mismatch, as phenological variations interrupt their connection with other competitors. Conversely, when co-occurring plant species undergo non-synchronized phenological transitions, it can result in an increased competition among pollinators during extended periods of flowering overlap. Therefore, precise timing of phenological events is essential not only to maximize temporal overlap with mutualistic partners but also to minimize temporal overlap among competing species.

In 1982, Dr. Andrea Holzschuh and students at the University of Würzburg found a breach in a mutually advantageous relationship between the flower of *Pulsatilla* vulgaris and its pollinator, the bee. The blooms of *Pulsatilla vulgaris* have been shown to be extremely sensitive to rising temperatures, and as a result, each year they bloom sooner than usual. However, a kind of solitary bee, which is one of the plant's primary pollinators, does not keep up with this advancement in time of flowering by hatching earlier, and this mismatch reduces the plant's seed output due to lower pollination and slightly worse reproduction. However, with the absence of *Pulsatilla* flowers, the bee must forage on other plants to make up for the loss of food.[58]

The plant-pollinator relationship is particularly vulnerable to climate-change as plant species often rely on a specific pollen vector or pollinator. An illustrative case is the orchid *Leporella fimbriata* and its pollinator, *Myrmecia urens*. With the forecasted temperature change, the orchid's distributional range is likely to change, resulting in a large loss of niches of the pollinator ant. Eventually, the shift in the orchid's range is expected to reduce the amount of interaction between the orchid and its pollen vector. It is anticipated that the absence of these pollen carrier ants will bring down the reproductive output, posing a severe threat to the orchid's survival.[59]

Numerous studies have examined the effects of extreme changes in climate on distribution and production of popular beverage coffee, either due to severe weather events or alterations in pollinator efficiency. The plant-pollinator interactions between the coffee plant and its pollinators in Ethiopia have revealed a geographical mismatch in the distribution of plants and pollinators due to climate-change.[60] To enhance insect pollination ecosystem services and safeguard biodiversity in the wake of changing climate there is a growing imperative to emphasize the importance of conducting studies on plant and pollinator interactions. If the temporal appearance and feeding behaviour of pollinators change, plants with specialized pollinators are especially susceptible to a lack of reproduction.[61] Because the majority of crop species depend on pollinators, the scientific community needs to comprehend the consequences of change in land-use pattern and climate on crop production and its monetary value. There may be a trade-off between protecting endangered pollinators and plants, and providing adequate agricultural pollination. Despite the fact that changes in land use patterns and climate, harm both the pollinators and plants in the surrounding environment, the availability of plentiful common or generalist pollinators may be sufficient to pollinate at least certain crops, hence preventing human famine.[62]

Approximately 20-30% of known species are predicted to be threatened by climate-change, leading to their eventual extinction. Important components of agroecosystems, the populations of honey bees and other pollinators are also dropping. The seed establishment, productivity, and quality of diverse crops are all dependent on pollinators as a result of pollination services.[63] Almost 75 percent of the world's food plants have increased fruit or seed production as a result of increased insect activity. The projected yearly economic value of these services is around $ 153 billion. Pollinators aid humanity not only by enhancing agricultural yield and food security, but also by preserving environmental diversity. However, forecasted climate-change would result in the loss of both pollinators and food security.

Increased CO_2 levels and decreasing precipitation are further factors of climate change that impact insect pollinators. Several floral characteristics, including nectar content, pollen protein concentration, and so on, can be altered by an increase in carbon-di-oxide levels affecting the fitness of insect pollinators.[64,65] The lifetime of *Bombus terrestris*, a very important pollinator has been significantly diminished. It is anticipated that weather patterns would have a deleterious impact on nectar secretion in numerous flowering plants. This is particularly true in the Mediterranean, where a large increase in temperature is anticipated. Reduced nectar secretion in conjunction with phenological changes in flowering plants can disrupt plant-pollinator interactions, hence impacting the overall ecosystem.[66]

Giannini and others (1994) hypothesize that bees with medium and restricted geographic distributions are likely to experience much greater losses in their occurrence areas. Species with wide-ranging habitat preferences will survive the transition. Pollination services will be negatively affected by the disappearance of some crop-pollinating species.[67] The maximum daily temperature, the number of days with a mean temperature above a given threshold, and the total length of the day are environmental signals that affect the phenology of bees. As ectothermic insects, bees require a high body temperature in order to fly, and their foraging behaviour is similarly dependent on temperature. The time necessary for thermoregulation at temperatures above normal interferes with foraging. As the changing climate also affects flower development, nectar and pollen production, all these directly influence the foraging and development activities of the bees. To survive the severe winter, bees must store sufficient honey. A climate that is too dry, lowers pollen production and degrades pollen's nutritional value, negatively impacting bees in that environment. Due to their inability to hide and store sufficient pollen in the fall, bees are deprived of nourishment during the winter. Lack of food weakens bees' immune systems, making them more susceptible to diseases and decreasing their longevity.

Besides climate-change, pollinator populations have also declined as a result of the loss of pollinator habitats, monoculture practices, reduced crop diversification, and increased pesticide use. 'Farming with alternative pollinators,' (FAP) a novel strategy, gives new hope for making up for the loss of actual pollinators. FAP enhances pollinator habitat on farms, resulting in higher agricultural profitability and production, promoting a mutually beneficial relationship between crops, pollinators, and humans. This method is utilized for commercially significant species, including spices, oil seeds, fruits, crops, berries, and medicinal plants, in order to ensure that farmers profit from their entire fields.[68]

Climate Change and Seed Dispersal

Global warming is believed to jeopardize plant viability.[69] As climatic or environmental circumstances change, it is well known that plant populations must adapt to survive.[70] While there has been extensive research on plant adaptation to diverse abiotic conditions, our comprehension of the changing climate on seed dispersal remains limited. Recent observations of plants migrating towards the poles and higher elevations show that they are attempting to survive. Increased mortality, decreased growth, and diminished reproductive activities, along with low recruitment rates, suggest that these plants are likely to survive and flourish at higher elevations. In pursuit of survival, the plant species must either adapt to warmer conditions or disperse their seeds to cooler locations.[69] Despite numerous reports of plants relocating to higher altitudes in response to global warming, such adjustments are occurring at a rate that is insufficient to keep up with the fast-changing climate.[71]

Droughts and high temperatures have been demonstrated to negatively impact the development, maturity, and quality of the seeds in rice plant, *Oryza sativa* L. Though temperature has a major influence on the quality of seeds, the quantity and time of precipitation also cannot be neglected. If they overlap with crucial phases of crop development, brief spells of severe temperature or precipitation might potentially prove to be hazardous.[72]

In many tropical and subtropical climates, seed yields are predicted to decrease with rising temperatures. In addition to crop output, climate-change is anticipated to negatively affect not only seed germination but also seed dormancy. It is predicted that a rising temperature will shift seed germination from spring to October. The shifting environment has also naturally altered seed dormancy, resulting in seed germination at an inconvenient time. Temperature has been identified as the most influential element in determining seed dormancy.[73] Even when conditions are not optimal for healthy growth, seeds sprout earlier than normal due to higher temperatures. A few days of abnormally warm weather during an otherwise severe winter can cause some seeds to germinate, but the severe winter eventually kills them. In addition to an increase in temperature, an increase in soil moisture also expedites the germination of some seeds. It's easy to affirm that variations in temperature and precipitation directly influence germination and growth of seeds by modifying their micro-environment. In addition, this shifting microenvironment of seeds also encourages the proliferation of seed diseases, resulting in seed damage. Changing climate alters the soil acidity, which in turn is responsible for the expansion of non-native diverse microbial and pathogen populations. The presence of excess nitrogen in the soil, which is also a result of changing environmental conditions, permits some plant species to dominate others and leads to a drop in total species diversity, which translates to a reduction in the variety of seeds in the ground. Footitt and colleagues' findings indicated that in a scenario of global warming, there was a decrease in both dormancy relief and seedling emergence in *Alliaria petiolata* (garlic mustard), accompanied by a significant rise in seed mortality. This change could be attributed to the higher soil temperatures, primarily because the increasing average temperatures may not fully meet the chilling requirement necessary for dormancy relief.[74]

To prevent a decline in both, the quality and yield of seeds, the seed industry has to necessarily adapt to climate-change by altering seed production sites, seed sowing dates, and producing cultivars with features that enable them to adapt to climate-change circumstances.

Effect of Changing Climate on Public Health

Changing climate has led to the emergence of systemic risk, which stands as one of the foremost health concerns confronting our society in the present day.[75] This phenomenon poses a significant threat to human health, impacting various aspects such as food and water security, biodiversity, air quality, species distribution, and the potential extinction of pollinators. Climate-change is rapid as well as irreversible which endangers global public health. Extreme weather variability attributable to climate-change may represent a new health risk to developing nations already susceptible to environmental degradation, resource depletion, overcrowding, and even geographic position.[76] This ensuing change in climate disproportionately affects vulnerable people, especially those in low-resource environments, such as children, the elderly, and those burdened by disease or health disparities.[77] The rapid increase in temperature will have a pronounced effect on urban societies in comparison to the rural ones. Though numerous health disorders are caused by climate-change, the primary injuries and fatalities are those inflicted by extreme weather events; respiratory and cardiovascular diseases caused by worsening air pollution, infectious diseases caused by changes in vector biology, water, and food contamination, malnutrition caused by insufficient food security, etc. Indirect concerns encompass mental health issues, population dislocation, socio-economic effects and civil conflict, although data to support these projections are less available and uncertainties obviously are greater.

According to the World Health Organization, environmental variables account for 23% of all fatalities worldwide, with an anticipated increase of 250,000 climate-related deaths year by 2030.[77] In recent years, the increased frequency and severity of heatwaves and other strong weather events have contributed to an increase in mortality, particularly from vector-borne diseases such as dengue, malaria, kala-azar, Japanese encephalitis, filaria, and chikungunya.[78] Individuals with cardiovascular and respiratory diseases are more susceptible to adverse impacts caused by extreme weather conditions due to their compromised immunity and reduced resistance. Not only is the number of vector-borne and water-borne diseases increasing, but they are also spreading to new regions. It is anticipated that effluent discharges and river salinization caused by rising sea levels will further enhance the prevalence of water-borne infections.

The effect of changing climate on human health can manifest in various ways, including the exacerbation or increased occurrence of pre-existing health issues and the emergence of previously unforeseen health problems directly attributable to climate-change. All of these climate and weather-related health consequences are aggravated by pre-existing health issues, socioeconomic status, and age. It is anticipated that climate-change would worsen the health burdens of individuals whose health is already compromised, in addition to those with a poor socioeconomic position. These diseases are caused by an increase in ambient and interior air pollution, desertification, heat stress, wildfires, and the geographical and temporal dissemination of pollens, fungi, and infectious agents.[79]

Climate-change is no longer only a risk factor but a dark reality.[80] According to the quantitative risk assessment conducted by the World Health Organization, this change is expected to lead to an extra 2,50,000 deaths over the next three decades (2030 – 2050).[81] Over and above this an additional 5,29 000 adult deaths are envisioned by 2050 due to food insecurity resulting from changing climate. WHO estimates that the number of deaths caused by climate-change will be for more than those caused by all previous public health emergencies combined.

Even though wealthy and industrialized nations release the most greenhouse gases, the poor and emerging nations will face the brunt of all the negative health repercussions of global climate-change. This change is likely to bring out forced human migration, displacement, and deliberate relocation due to rising sea levels, extreme weather, and the disruption of livelihoods.[82] Changes in food production, water scarcity, disease transmission, and vector ecology are all indirect consequences of climate-change on human health. The most severe health repercussions include malnutrition, heat-related ailments, mental health issues, and deaths.

Exposure to harsh weather conditions is also connected with physical and mental health consequences, as elucidated by a number of empirical investigations. Surprisingly, all such investigations have only been undertaken in affluent nations, excluding information from more susceptible developing nations. Unfortunately, this continuing rise in temperature is expected to result in substantial health losses, especially in developing nations, so largely offsetting the improvements in life expectancy due to technological and medical advancements. Such losses represent a vicious cycle of economic underdevelopment, poor population health, susceptibility, and non-adaptation in underdeveloped nations.

Mitigation

Scientists caution that without substantial reductions in greenhouse gas emissions, the average global temperature could increase by approximately 5°C or more by the close of this century. Even if all the commitments outlined in the 2015 Paris Agreement are met, it is expected that global warming would still exceed 3°C by the end of this century, although regional variances may arise.

Climate-change seems unavoidable and likely to intensify over the next several decades in the absence of a concerted worldwide effort to dramatically decrease greenhouse gas emissions. Our health is proportional to the health of our living environment. In order to safeguard our ecosystem from the fury of climate-change, which is harming the quality of drinking water, breathable air and our food, we must make prudent decisions. In addition, climate-change has a negative effect on our ecosystems, eventually leading to a rise in sickness and mortality rates.

The adoption of the 'Paris Agreement' in 2015 aimed to bolster worldwide response to the growing challenges of changing climate. Its aim was to arrest the increasing temperature to not more than 35.6 degrees Fahrenheit in this century. The agreement strives to enhance nations' capacity to include effects of changing climate through mechanisms such as financial support, technology advancement, and capacity-building initiatives.[83] The scientific community must promptly contribute to the crucial task of developing resilience strategies to alleviate the impacts of changing climate on health. Time is crucial and we cannot afford delays.[84] Currently, two interconnected strategies, namely mitigation and adaptation, are seen as the primary approaches to study impacts of changing climate. Mitigation focuses on reducing the causes of climate-change, while adaptation involves proactive measures to transform and derive benefits from anticipated climate-change.[85] Mitigation efforts encompass actions aimed at reducing greenhouse gas emissions.

Taking action to alleviate the effects of changing climate in urban areas is of utmost importance to safeguard the quality of life, health, and well-being of urban populations. The shift caused by climate-change poses a serious threat, and urgent steps must be implemented. In recent times, the significance of tree planting as a climate-change solution has gained traction among policymakers, scientists, the media, and the general public.[86] By carefully designing and managing the planting of urban green spaces, specific plant communities capable of thriving in the challenging urban conditions can offer a promising solution for both climate-change adaptation and mitigation.[87] Teixeira and co-workers gathered data on plant characteristics for climate adaptation and mitigation in north western Portugal for 287 plant species belonging to 75 botanical groups and 206 genera.[88] The data serves as a starting point for the selection of plant species for all types of urban green areas in order to prevent climate-change. Suryanarayanan and Uma Shaankar studied the significance of the plant microbiome in climate-change adaptability of plants and asserted that fungal endophytes, an essential component of the plant microbiome, may be the secret to plants' ability to adapt to environmental stresses.[89] The quick adaptation of endophytes and their ability to "transfer" resistance to their hosts may speed the adaptation of plants to climate-change.

Globally, innovative measures are being developed to offset the consequences of climate-change and maintain sufficient food supplies for the world's expanding population. One such initiative was taken by Bokor and his colleagues who studied the role of various chemical forms of silicon in alleviating the detrimental effects of numerous abiotic stresses on the induction of resistance in plants exposed to drought, salinity, UV radiation, temperature stress, carbon-di-oxide, and heavy metals/toxic elements.[90]

Kalele and colleagues propose the involvement of governments and other stakeholders in assessing the need for increased investment in infrastructure and knowledge. This investment would aim to enhance the development and adoption of water, crop, and soil technologies that can serve as effective solutions to address the challenges posed by climate-change.[91]

Implementing 'Integrated Pest Management' (IPM) strategies could potentially be a viable option for maintaining pollinator health, enhancing pollination services, supplementing bee farming practices, and so enhancing system productivity. IPM focuses primarily on pest management using eco-friendly techniques that minimize the usage of synthetic pesticides.[92]

To tackle the monster known as climate-change, the current situation demands an integrated approach centered on fresh understanding, public awareness and societal action. To address this existential dilemma, societal transformation is essential.

Conclusion

This comprehensive review article on climate-change highlights that an increase in temperature is indeed leading to a diverse array of environmental issues. These include elevated sea levels, heightened frequency and severity of weather events, melting glaciers, degraded ecosystems and a decline in biodiversity. All these changes are already having a significant impact on ecosystems and the living organisms including economic consequences arising from loss of crops and livestock, besides reduction in the availability of resources. It also exacerbates severe health conditions leading to COPD, cancers, respiratory ailments etc. These consequences can lead to increased poverty, social unrest, and political instability in the near future.

It is noticed that one of the most significant ways in which the green plants can help mitigate climate-change is by acting as a carbon sink. Trees can absorb large amounts of CO_2 over their lifetimes, storing it in their trunks, branches, leaves, and roots. Afforestation or reforestation efforts, which involve planting more trees, are a powerful strategy for mitigating climate-change. In addition to sequestering carbon, green plants also provide a host of other environmental benefits that can help mitigate climate-change like maintaining biodiversity, being a source of renewable energy, prevention of soil erosion, regulating water cycles etc. Large surface areas provided by trees provide a landing ground for various pollutant particles where the particulate matter gets absorbed or even adsorbed and is temporarily or permanently eliminated from the atmosphere

In conclusion, green plants are recognized as a significant component of the solution in mitigating the effects of climate-change. However, it is critical to recognize that they are just one piece of the approach towards mitigation. Addressing the adverse impacts of climate-change necessitates a collaborative endeavor involving individuals, businesses, and governments across the globe. Primarily there is a need for environmental literacy so that humans can reduce carbon footprint, conserve energy, invest in renewable energy and plant more trees.

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