

REVIEW

Global Effect of Climate Change on Seasonal Cycles, Vector Population and Rising Challenges of Communicable Diseases: A Review

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ABSTRACT

This article explains ongoing changes in global climate and their effect on the resurgence of vector and pathogen populations in various parts of the world. Today, major prevailing changes are the elevation of global temperature and accidental torrent rains, floods, droughts, and loss of productivity and food commodities. Due to the increase in water surface area and the longer presence of flood water, the breeding of insect vectors becomes very high; it is responsible for the emergence and re-emergence of so many communicable diseases. Due to the development of resistance to chemicals in insect pests, and pathogens and lack of control measures, communicable zoonotic diseases are re-emerging with high infectivity and mortality. This condition is becoming more alarming as the climate is favoring pathogen-host interactions and vector populations. Rapid changes seen in meteorology are promoting an unmanageable array of vector-borne infectious diseases, such as malaria, Japanese encephalitis, filarial, dengue, and leishmaniasis. Similarly, due to unhygienic conditions, poor sanitation, and infected ground and surface water outbreak of enteric infections such as cholera, vibriosis, and rotavirus is seen on the rise. In addition, parasitic infection ascariasis, fasciolosis, schistosomiasis, and dysentery cases are increasing. Today climate change is a major issue and challenge that needs timely quick solutions. Climate change is imposing non-adaptive forced human migration territorial conflicts, decreasing ecosystem productivity, disease outbreaks, and impelling unequal resource utilization. Rapid climate changes, parasites, pathogens, and vector populations are on the rise, which is making great threats to global health and the environment. This article highlighted the necessity to develop new strategies and control measures to cut down rising vector and pathogen populations in endemic areas. For finding quick solutions educational awareness, technology up-gradation, new vaccines, and safety measures have to be adopted to break the cycle of dreadful communicable diseases shortly.

Keywords: Global climate change; Biodiversity loss; Loss of life; Habitat; Economic losses; Biomarkers; Challenges and solutions

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1. Introduction

Today's most important challenge is altered climatic conditions at a global level that is imposing adverse effects on human health and the environment. Changing climate is disrupting the economic and social structure of society and breaking the natural association between man and wild animals. There is a tug-of-war between those countries which are producing high emissions and contributing the least to climate control. People are facing growing adversities of climate change, mainly due to shifting weather patterns, rising sea levels, and more extreme weather events such as cyclones, typhoons, and tsunamis. The climate is dynamic and undergoes a natural cycle all the time. Several slow-moving natural forces contribute to climate change. Continental drift, volcanoes, ocean currents, the tilt of the globe, comets, and meteorites are a few of the more noticeable ones. The atmospheric quantities of water vapor, carbon dioxide, methane, and nitrous oxide—all greenhouse gases that help trap heat at the earth's surface—have significantly grown as a result of industrialization, deforestation, and pollution. Carbon dioxide is being released into the atmosphere by humans much more quickly than it can be taken up by plants and oceans. Even if such emissions were stopped today, the atmosphere would still contain these gases for years, which would delay the onset of global warming. Any variation or change in the natural environment brought by human action is referred to as climate change (IPCC). However, it contrasts with the Framework Convention on Climate Change (FCCC), which states that over comparable periods, any change in the composition of the global atmosphere may be caused either directly or indirectly by human activities. From the re-industrial era to 2005, the global atmospheric concentration of carbon dioxide, methane, and nitrous oxide increased, according to IPCC. Global average CO₂ concentrations set a new record of 414 ppm in 2020, 417.2 parts per million (ppm), up 2.5 ppm from 2021 levels ^[1]. Atmospheric CO₂ concentrations are now 51% above pre-industrial levels ^[2].

At present world climate system has been altered

due to the addition of greenhouse gases and aerosols into the atmosphere. These significant effects are caused due to industrial and automobile emissions, delayed precipitation, massive deforestation, melting of glaciers, and poorly managed land use patterns. All these changes finally affected the balance of the climate system. A deviation in natural incoming and outgoing energy in the earth-atmosphere system has been noted. The increase in global atmospheric temperature is due to accelerating anthropogenic activities. Though, natural factors like extreme radiation and ozone depletion are also responsible for the warming or cooling of the global climate ^[3]. These are environmental gases that trap long-wave radiation reflected from the earth's surface. These are enhancing the global mean temperature of the atmosphere. This phenomenon is popularly known as the "Greenhouse" effect. Water vapor is by far the most significant greenhouse gas. However, carbon dioxide contributes significantly, and ozone, methane, and nitrous oxide have less of an impact. It is well known that atmospheric levels of carbon dioxide, methane, and nitrous oxide are rising, and in recent years, other greenhouse gases, namely chlorofluorocarbons (CFCs), have been significantly increased ^[4]. The subsequent climatic impacts are difficult to predict with any degree of certainty. Since 1860, anthropogenic activities have increased greenhouse gases, mostly CO₂ and methane, which have caused an increase in the global mean surface temperature of around 0.5 EC. Based on forecast concentrations, the temperature should be limited to 1.5 °C, and all efforts should be made to it zero by 2050. For this purpose "Global net human-caused emissions of carbon dioxide (CO₂) would need to fall by about 45 percent by 2030 and carry it up to zero in next 20 year" ^[5]. The maintenance of the environment's temperature is mostly dependent on vegetation and forest cover. Local and regional climate variations have an impact on soil temperature, biological activity, physical composition, nutrient uptake, and plant output. The Amazon basin's forest cover has an impact on the flux of moisture into the atmosphere, regional convection, and regional rainfall. In the majority of

African countries, drought is primarily caused by warmth and the degradation of local vegetation ^[6].

Today, climate change is a serious problem that requires prompt responses. Climate change is driving inequitable resource use, decreased ecosystem productivity, non-adaptive forced population migration, disease outbreaks, and territorial conflicts. Temperature, precipitation, clouds, and wind are all variables in the annual weather. The weather varies from one year to the next and from one place to another. A few unthinkable changes in air and ocean temperatures have led to an increase in sea level and the rapid melting of pole-located snow and ice caps. Global warming has been occurring for the past 60 years, and the fundamental cause is human interference with the planet's various primary ecological divisions ^[7].

Marine, aquatic, and terrestrial lives are all being negatively impacted by significant ongoing climate change. Even while there are many consequences already apparent, there may be a few unexpected effects in the future. As a result, each of these consequences has been identified one at a time, and projects have been set up to identify answers. The accumulation of large volumes of carbon dioxide in the atmosphere is the effect that is most obvious. As a result of the greenhouse effect, it is raising the average world temperature and causing unintentional natural disasters everywhere. The survival of terrestrial, freshwater species, primarily planktons and bottom-dwellers, is being hampered; in the marine environment, coral reefs, algae, and fish fauna belong to various taxa. Due to the ocean's inability to absorb additional carbon dioxide, the food chain in the ocean is more likely to be disrupted. Micro-flora and micro-fauna along the seashore are drastically declining. Large-scale disturbances have resulted from it, including biodiversity loss, habitat damage, forest depletion, land degradation, floods, and draughts in terrestrial environments. On the other side, unexpected weather changes can cause permanent damage because of hurricanes, typhoons, storms, lightning, floods, and tsunamis, which are often on the rise ^[8]. Breakdowns in the economy and

the environment are happening more frequently and are lasting longer.

There is a substantial increase in temperature and heat-related deaths in dry and semi-arid regions. Climate change is making people's issues worse as more hurricanes, blizzards, tornadoes, floods, droughts, tornadoes, earthquakes, and losses to human life, health, physical riches, habitat devastation, and resilience occur practically every year. Land degradation, soil erosion, and destructive floods that produce landslides are all increasing dramatically. The biodiversity of hydrophytes, pollinators, symbiotic bacteria, coral reefs, fish, amphibians, reptiles, mammals, and invertebrates—primarily insects—has been severely damaged. Coral bleaching brought on by seawater warming contributes to the mass collapse of corals. The effects of climate change and global environmental stress must be evaluated in terms of their ecological, meteorological, socio-economic, political, thermal, biophysical, and biological impacts. Action must then be taken to find the best solutions and to mitigate these effects on a worldwide scale.

Long-term changes in weather patterns and extreme weather event frequency are referred to as climate change. It could increase already existing health issues and change the threat to human health. The scientific data on how climate change affects human infectious diseases are examined in this review. Climate change has reached a critical level in recent years, affecting plant and animal species as well as making people more vulnerable and posing possible health risks in numerous eco-climatic zones. To quickly identify answers, it is necessary to investigate the health effects of particular diseases, the shifting spectrum of infectious diseases, and novel clinical and ecological operational approaches. In order to forecast future health effects associated with climate change, current research must concentrate more on the causes of infectious diseases, climate variables, the development of control warning systems, and the use of improved methods ^[9]. The involvement of human society, the scientific community, economists, stakeholders, healthcare profes-

sionals, and policymakers must come together on a single platform to educate the public about how to reduce greenhouse gas emissions and use energy and materials safely in order to find quick solutions [10]. The effect of climate change on seasonality, population biology of parasites, pathogens, and vectors, and their interactions with the environment have all been highlighted in the current review article in an effort to find innovative approaches to the current and foreseeable challenges of communicable diseases. The Coronavirus recently infected a sizable portion of the global population; it struck forcefully and caused millions of fatalities. The recent COVID-19 outbreak has put individuals in danger and had a negative impact on the global economy. The primary challenge is due to massive and multiple pharmaceutical interventions and climatic changes going on in micro-organisms, primarily viruses, and bacteria, which are making genomic changes mainly

drug and vaccine resistance nowadays. The second problem is how to combat mixed infections, mostly bacterial and fungal infections. The recent pandemic made it abundantly evident that current clinical and therapeutic approaches are insufficient to manage disease transmission, treatment, and control of an influx of new infectious diseases (Figure 1). The main objective of this review is to sketch out possible climatic pressure on the microbial genome to have new changes in DNA or mutations for gearing up new adaptations to ensure their survival in presence of diverse pharmaceuticals and climatic conditions. The main objective of this study is to find out the most appropriate treatment for communicable diseases in the near future. This article emphasizes the need for improvement of the cultural environment, new strategies, and control measures to cut down rising vector and pathogen populations in endemic areas.

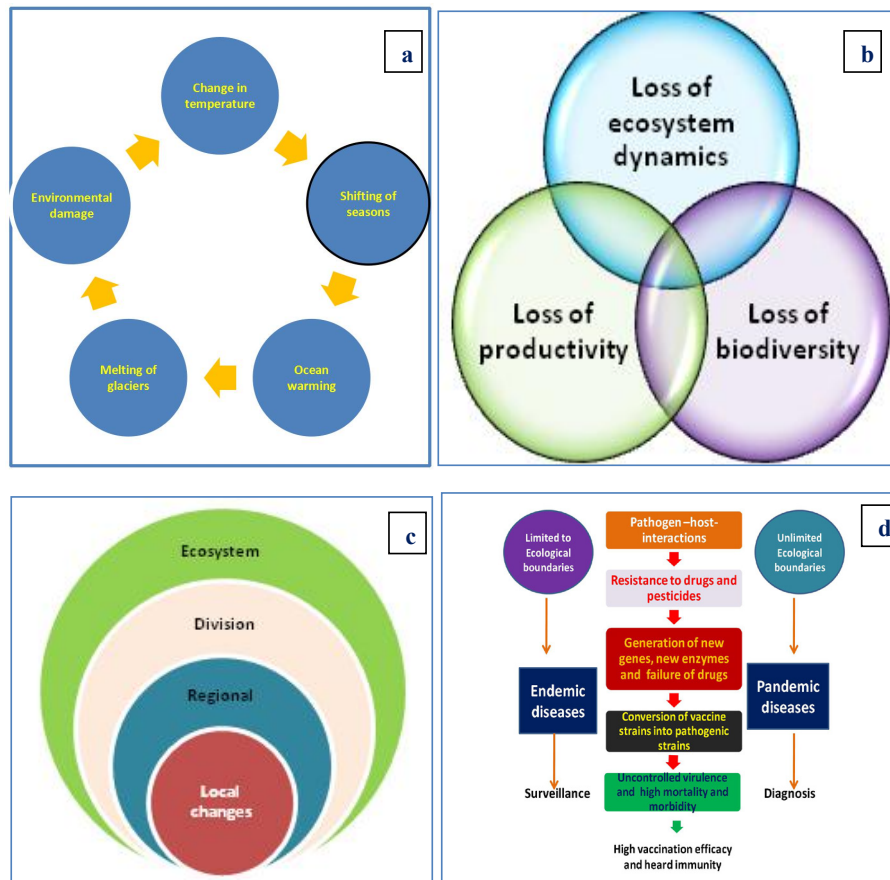


Figure 1. (a) cyclic changes in seasons (b) loss faced due to climate change (c) rising impact of climate change (d) unlimited virulence and infectivity are cause of endemic and pandemic diseases.

Materials and methods

For writing this comprehensive research review on the global effects of climate change on seasonal cycles, vector population, and rising challenges of communicable diseases various databases were searched. All concerned information was collected from different reference books, journals, encyclopedias, survey reports, and databases available on world climate and environment were read. For collection of data on climate change and climate-imposed risks, possible levels of gas emissions, and their impact on seasonal cycles and human life Climate Change Knowledge Portal (CCKP) was searched. For a collection of relevant information specific terms “climate change and its impact on the environment and human life were used such as key text words,” published till 2022 were used in MEDLINE. Most especially for retrieving all articles about climate-related changes, electronic bibliographic databases were searched and abstracts of published studies with relevant information on the present topic were collected. All important IPCC reports on climate change, climate action plans, impacts, adaptation, vulnerability, Climate Change Statistics, and Indicators were studied. Findings of the Kyoto Protocol & Paris Agreement, United Nations Framework Convention on Climate Change, and Key reports on climate impacts and solutions from around the United Nations are also considered for furnishing more recent information on the present topic of the review article. For updating the information about a subject and incorporating recent knowledge, relevant research articles, books, conference proceedings, and public health organization survey reports were selected and collated based on the broader objective of the review. Three important findings included climate justice and climate ambition and a temperature change of 1.5-degree temperature limit by 2030 and zero up to 2050. Relevant terms were used individually and in combination to ensure an extensive literature search. Most relevant information on this topic was acquired from various scientific databases, including SCOPUS, Science Direct Web of Science, EMBASE, Pubmed central,

PMC, Publon, Swissprot, and Google Scholar. From this common methodology, discoveries and findings were identified and summarized in this final review.

2. Seasonal cycles

The movement of the earth on its axis at a fixed angle causes seasonal cycles because there are two opposed points. It is decided by the position of the sun which remains year-round in the Northern and Southern Hemispheres. The lengths of the day and night shifts are decided as a result of the earth’s rotational motion. Each of the four seasons—spring, summer, fall, and winter—has its own cycle. Weather-based seasons, such as wet or dry ones, also exist on Earth. Similarly to this, tornado and hurricane seasons coincide in some regions with two seasonal changes. The monsoon season in the northern Indian Ocean is caused by this characteristic pattern, which also underlies other periodic cycles.

Droughts and floods are happening more frequently as a result of global climate change. The rotation of the globe has a significant impact on the troposphere’s wind patterns. The monsoon season in the northern Indian Ocean is caused by this characteristic pattern, which also underlies other periodic cycles. There are two distinct seasonal cycles: “El Nino”, is a warm ocean current that begins in late December. An opposite cycle called La Nino has milder winds. Additionally, La Nino provides stronger trade winds while “El Nino”, diminishes them. Because heated air near the earth’s surface rises swiftly and moves far, tornadoes also follow a yearly cycle. During the spring and summer, when this hot air becomes actively warm near the surface, it becomes more buoyant and quickly forms tornadoes^[11]. Seasonal cycles therefore occur within a calendar year, while spans of time that are shorter or longer than a year are possible. Occasionally throughout the course of a calendar year, regular predictable and unpredictable shifts in climate regimes take place during the varying seasons. Seasonal refers to any predictable variation or pattern that recurs or repeats over the course of a year.

A season can refer to either a commercial season,

like the Christmas season or to a calendar season, such as the summer or winter. Changes in the atmosphere caused by eco-climatic factors or variations in the weather have a negative impact on human health, animal behaviour, pathogen-host interactions, and economic growth. Seasonal cycles have an impact on economic, social, biological, and environmental variables. Seasonal cycles periodically fluctuate, which has an impact on animal and plant life. Despite the fact that forecasting techniques and projections are available, loss of life, economic loss, and loss of plant and animal life occur virtually year. Unexpected seasonal changes and difficulties due to any climatic element are the problems. Thermal waves and extreme droughts have a negative impact on the flow of sap and nutrients in sapwood and phloem vessels. The principal effects of seasonal variations have been seen in arid zone plants and plants on hilly slopes. Due to a drastic reduction in water supply brought on by dry lands and poor rainfall, a nutrient concentration is negatively impacted in hot thermal waves ^[12].

Conifers and flowering vegetable plants' leaves display dehiscence and wilting symptoms including sunburn and significant soil water loss. High temperatures have a significant impact on juvenile meristematic tissues in buds, tendrils, stem tips, plumules, cambia, and roots as well as on growing seeds. In dry soil, it causes a 90% crop loss. Due to the impact of the aquatic and marine environment surface temperature, rising temperatures and scorching winds also enforce tidal energy and enclosing waves. Every season's fall brings changes in the wind's direction, the amount of sunlight, the humidity, and the surrounding temperature. Typhoons, tides, and seasonal and diurnal cycles all have an impact. Seawater and air interface temperature differences of 1°C between day and night are also noted ^[13]. Diurnal cycles in the upper ocean are being impacted by rising sea surface temperature, which has a significant impact on the diversity of plankton, corals, mollusks, and fish. Due to the increase in temperature, similar effects have been observed in estuaries or in shallow river waters. It causes the sea level to rise, which is one of the

main reasons for the loss of biodiversity and productivity (**Figure 1**).

3. Effect of seasonal cycles on soil climate, fauna and flora

Soil formation takes thousands of years, and most soils are still developing following changes in some of these soil-forming factors, particularly climate and vegetation, over the past few decades. Though, it depends on so many interactions and a number of forces, including climate, relief, parent material, and organisms, all acting over time. Climate is one of the most important factors affecting the formation of soil with important implications for its development, use, and management perspective. Climate severely affects soil functions like a significant change in organic matter turnover and CO₂ dynamics. The impact of climate change on soils is a slow complex process because soils not only are strongly affected by climate change directly. For example effect of temperature on soil organic matter decomposition and indirectly, for example, changes in soil moisture via changes in plant-related evapotranspiration but also can act as a source of greenhouse gases and thus contribute to the gases responsible for climate change.

Most soils are currently evolving as a result of changes in some of these soil-forming elements, particularly temperature and vegetation, over the past few decades. Soil development takes thousands of years. Although, it depends on a variety of elements that participate throughout time, such as the climate, relief, parent material, and organisms. One of the most significant elements influencing soil formation is climate, which has significant implications for their development, usage, and management. Climate has a considerable impact on soil processes like CO₂ dynamics and organic matter turnover. Because soils are indirectly influenced by climate change in addition to being directly affected, the impact of climate change on soils is a slow, complex process. Indirectly, for instance, changes in soil moisture due to variations in plant-related evapotranspiration), but they can also operate as a source of greenhouse gases and

so contribute to the gases that are responsible for climate change (**Figure 1**).

Climate change is affecting soil formation, torrent rains and accidental floods are depleting the upper layer of fertile soil with massive soil erosion in semi-arid and agricultural fields and hilly areas. The final impact of all these physical and chemical factors is affecting soil microbial nutrient availability and loss of productivity year after year. Due to anthropogenic interventions and carbon inputs to the soil from crop biomass decreasing with massive changes in soil climate, and rate of organic matter digestion has been decreased due to rising temperature and shifting of seasonal cycles in subtropical climatic areas. Water availability to forest soil in hot summer and dry winter is unbalanced which is hard heating on CO₂ dynamics and O₂ release from photosynthetic plants (**Figure 1**).

Massive soil erosion in semi-arid, agricultural fields and hilly places is a result of climate change, which also affects the formation of soil. Torrential rains and unintentional floods are removing the top layer of fertile soil. The cumulative effect of all these physical and chemical factors affects the availability of nutrients for soil microbes and their productivity loss year after year. The rate of organic matter digestion has decreased due to rising temperatures and shifting seasonal cycles in subtropical climate zones due to anthropogenic interventions and carbon inputs to soil from crop biomass, which is decreasing with significant changes in soil climate. Unbalanced water availability to forest soil throughout the hot summer and dry winter has a negative impact on the dynamics of CO₂ and the release of oxygen from photosynthetic plants.

As constant inputs to the soil from vegetation depend on temperature, precipitation, and evaporation. More often, losses of soil carbon affect soil functions like soil structure, stability, topsoil water holding capacity, nutrient availability, and erosion. The loss of soil carbon is also accelerated by the increase in temperature. Further, climate also indirectly affects changes in growth rates or water-use efficiencies, through sea-level rise, through climate-induced de-

crease or increase in vegetative cover, or anthropogenic intervention. Soil pollution interaction of the various soil-forming processes, particularly biological ones, makes it difficult to quantify the changes (**Figure 1**). Increased rainfall could increase atmospheric N deposition to soils, and may promote soil disturbances, flooding, and subsidence which changes in wetland and waterlogged habitats and also enhance soil erosion, potentially leading to the pollution of surface waters. Increased rainfall enhances bypass flow and downward movements. Increased environmental temperature affects evapotranspiration and photosynthesis in C3 plants. Increased CO₂ affects fertilization and flowering in both C3 and C4 plants. Both climatic warming and rising CO₂ levels in the atmosphere will enhance tree growth in the short term.

Temperature, precipitation, and evaporation are all constant inputs to the soil from vegetation. More frequently, soil functions like soil structure, stability, topsoil water holding capacity, nutrient availability, and erosion are impacted by losses of soil carbon. The rise in temperature also hastens the loss of soil carbon. Additionally, changes in growth rates or water usage efficiency are indirectly impacted by climate through sea level rise, changes in vegetation due to the climate, anthropogenic interference, or both. It is challenging to measure the changes as a result of soil pollution since different soil-forming processes, particularly biological ones, interact with one another. Increased precipitation has the ability to increase atmospheric nitrogen (N) deposition on soils, encourage soil disturbances, flooding, and subsidence, which can affect wetland and waterlogged habitats. It can also increase soil erosion, which has the potential to pollute surface waters. Rainfall that is more abundant is enhanced by downward movements and pass flow. Elevated ambient temperature has an impact on C3 plants' evapotranspiration and photosynthesis. Both C3 and C4 plants' fertilization and flowering are impacted by increased CO₂. In the short term, both climate warming and growing CO₂ levels in the atmosphere will promote tree growth (**Figure 1**).

4. Factors responsible for communicable diseases

In the last twenty years series of virus generated infectious diseases have been emerged and re-emerged. The zoonotic microbes are continuously evolving and acquiring adaptations, and showing high infectivity and mortality at global level. Severity and risks of communicable diseases have been increased due to human movement, trade, recreation activities and dense population structures. Presence of pathogens in human community and its easy exposure is providing new hosts while eco-climatic conditions favoring microbial growth, transmission and infectivity. Further, evolution of new mutant variants of these pathogens has acquired high infectivity and generating catastrophic effects in human population. There are rising incidences of virus generated disease, flu, dengue, hepatitis, chikungunya, rabies, polio, gastroenteritis and encephalitis throughout the globe (**Figure 1**).

There are external factors that support disease occurrence, among them few important factors are heavy rains, water logging, high humidity, temperature difference, urbanization, deforestation, human migration, settlement of slums, relief camps, and nomadic movements. There is a lack of clean drinking water, cooking, and washing. Lack of sanitation, presence of disease vectors, and contaminated food and waste disposal are responsible for the spread of communicable diseases. Among non-communicable diseases, diabetes is one of the important diseases that kill roughly 30 million people per year worldwide. Three major challenges are i.e. development of insecticidal resistance in insects/vectors of potentially communicable diseases, and drug resistance in microbes and parasites. Cases of lung infection, liver, kidney, and gastrointestinal tract, and child diarrhea are rapidly increasing in developing ^[14]. Besides, this incidence of child diarrhea ^[15], neonatal jaundice Click et al., 2013 ^[16], Collier J et al., 2010 ^[17], and helminths parasitic infections are spreading in developing and in third-world countries.

Some infectious disorders caused by viruses have originated and returned throughout the past twenty

years. The zoonotic microorganisms exhibit significant infectivity and mortality on a global scale as well as ongoing evolution and adaptation. Human migration, trade, recreational activities, and dense population patterns have all contributed to an increase in the severity and hazards of communicable diseases. As new hosts are being created by diseases in the human population and their ease of exposure, microbial development, transmission, and infectiousness are encouraged by the eco-climatic conditions. Furthermore, these infections have evolved novel mutant versions with great infectivity that has disastrous impacts on the human population. Around the world, there are increasing numbers of viral illnesses such as the flu, dengue, hepatitis, chikungunya, rabies, polio, gastroenteritis, and encephalitis. There are environmental factors that encourage the spread of disease. A few of the most significant ones are heavy rainfall, standing water, high humidity, temperature variations, urbanization, deforestation, and human migration, as well as the establishment of slums, relief camps, and nomadic movements. Cooking, washing, and access to clean drinking water are all lacking. The causes of the spread of communicable diseases include poor sanitation, the existence of disease vectors, contaminated food, and improper waste disposal. Diabetes is one of the major non-communicable diseases that kill about 30 million people worldwide each year. The development of insecticidal resistance in insects and possible disease vectors, as well as medication resistance in bacteria and parasites, are three key challenges. In emerging nations, cases of child diarrhea, and liver, kidney, and gastrointestinal tract infections are rising quickly. In addition, helminths parasitic infections, newborn jaundice, and infant diarrhea are all on the rise in third- and developing-world nations.

Due to climatic effects and drug resistance and new mutations in pathogens disease burden has been exacerbated enormously at the global level. In all cases, helminths, protozoans, fungi, bacteria, virus pathogens, and parasite's available drug structure seem to be failed or their usefulness has been much reduced due to the evolution of new mutant vari-

ants with multiple drug resistance. There are serious failures at the level of operation, management, and control of the disease. The utmost failure is due to a lack of appropriate vaccines, drug regimens, clinical care, and awareness among people. These are major reasons that are why diseases become uncontrolled and unmanageable. Year after year new mutant variants or climate-induced microbial pathogen genotypes are emerging; these are not only challenging existing drugs but also challenging vaccine efficacy. This disastrous situation can be overcome by having new potential drug structures, control strategies, and methods. For finding quick solutions all biomedical researchers should arrange drug repurposing, testing, diagnosis, and treatment methods with a focus on major human parasitic and microbial diseases. In this article, major zoonotic infections/communicable diseases have been explained with their specific etiology, transmission and epidemiology, and control/preventive measures. More specifically effect of climate on disease occurrence, vector population, drug and insecticide resistance, and generation of new genotypes of microbial pathogens and parasites have been described.

The disease burden has significantly increased globally as a result of climate effects, treatment resistance, and new pathogen mutations. Helminthes, protozoans, fungus, bacteria, virus pathogens, and parasites all appear to be resistant to the available drug structures, or at least their efficacy has been greatly diminished as a result of the emergence of novel mutant versions with multiple drug resistance. At the level of operation, management, and disease control, there are significant problems. The greatest failure is brought on by the absence of the proper vaccine, drug regimens, clinical care, and public awareness. These are the main causes of diseases becoming unmanageable and out of control. Every year, new mutant variants or genotypes of climate-induced microorganisms pose a threat to the efficiency of vaccines as well as to the effectiveness of currently available medications. By coming up with new prospective medicine structures, control tactics, and methodologies, this dreadful scenario can be

remedied. All biomedical research should set up drug repurposing, testing, diagnostic, and treatment procedures with an emphasis on the most common human parasite and microbial disorders in order to identify speedy fixes. Major zoonotic illnesses and communicable diseases have been described in this article along with details on their genesis, transmission, epidemiology, and control/preventative strategies. The impact of climate on the occurrence of disease, the population of disease-carrying vectors, drug and pesticide resistance, and the emergence of new genotypes of microbial diseases and parasites have been documented in more detail.

5. Seasonal climate changes and disease occurrence

Global health largely depends on seasonal changes felt and faced during the calendar year. Temperature variability, rainfall, and sunlight put a direct impact on human health^[18]. Mostly increased cases of leptospirosis, campylobacter infections and cryptosporidiosis have been noted after devastating floods. Global warming affects water heating, rising the transmission of water-borne pathogens. Pathogens transmitted by vectors are particularly sensitive to climate change because they spend a good part of their life cycle in a cold-blooded host invertebrate whose temperature is similar to the environment (**Figure 1**). A warmer climate presents more favorable conditions for the survival and the completion of the life cycle of the vector, going as far as to speed it up as in the case of mosquitoes. This is the main reason for the upspring of malaria and other viral diseases. Tick-borne diseases have increased in the past years in cold regions because rising temperatures accelerate the cycle of development, the production of eggs, and the density and distribution of the tick population^[19].

Seasonal changes experienced and confronted over a year have a significant impact on global health. The direct effects of temperature variation, rainfall, and sunlight on human health are also observed^[20]. Following disastrous floods, a rise in leptospirosis, campylobacter infections, and cryp-

tosporidiosis cases has been seen. Water heating is impacted by global warming, which increases the spread of water-borne infections. Because they spend a significant portion of their life cycle in a cold-blooded host invertebrate whose temperature is similar to the environment, pathogens spread by vectors are especially vulnerable to climate change. A warmer environment offers better chances for the vector to survive and complete its life cycle, even hastening it as in the case of mosquitoes. This is the primary cause of the spread of viral infections like malaria. Cold regions have seen a rise in tick-borne infections in recent years because warming temperatures speed up the tick life cycle, egg production, density, and distribution ^[19].

Most pandemics and endemic diseases happen in favorable climates and seasons to disease vectors. Climate induces reproduction in adults of vectors and infectivity in the human population. In the rainy season, more cases of Cholera, malaria, diarrhea, and dysentery rise at their peak while, cough cold and asthma, chicken pox, and smallpox in the winter and spring season. Thus both regular seasonal cycles and weather factors play either direct or indirect roles in disease occurrence and infection rate ^[20-23]. Cholera cases shoot up during rainy or monsoon season when river water level and surface area get increased ^[24]. During the rainy season sudden rise in vector population primary transmission of *Vibrio cholerae* from an aquatic environmental reservoir get increased manifold in endemic regions ^[25]. It also varies due to physical and biological parameters ^[26,27]. Warm temperature, sunlight, nutrients and winds in the aquatic environment influence the growth of phytoplankton and aquatic plants. These factors alter dissolved O₂ and CO₂ content and pH of the surrounding water and help to accelerate *Vibrio cholerae* growth rate and transmission. High phytoplankton production produces food for zooplankton, to which *V. cholerae* attaches for protection from the external environment and proliferates.

The majority of pandemics and endemic diseases occur during times of the year when disease vectors thrive. Climate influences adult vector reproduction

and human population infectiousness. Cholera, malaria, diarrhea, and dysentery cases increase significantly during the rainy season, whereas cough, cold, asthma cases, chicken pox, and smallpox cases peak in the winter and spring.

6. Multiplication of vector and pathogen population

Reproduction and development of disease vectors widely depend on climatic conditions, and changing weather conditions significant effect on risk from vector-borne diseases. Disease occurrence is climate-dependent as it is proved by recent climate change. It is very difficult to enumerate both the over- and underestimated effects of climate change on pests. In a few parts of the world, the insect pest population is uncontrolled the best examples are mosquitoes, house flies, termites, and locusts. Few direct effects of climate on pesticides are responsible for resistant pest populations. The recent corona pandemic, monkeypox, dengue, and malaria are the best examples of vector-borne diseases due to climate change. Climate-independent factors or dependent factors are directly related to changing risk of climate change ^[28]. These significant regional changes in vector and pathogen occurrence are mostly seen in Arctic, tropical, temperate, peri-Arctic and subtropical climatic zones. In future there is a possibility that both climate changes and human behavior will result in more conflicts within the society and rest of the animal world as pressure is heavily targeting wildlife and forests.

Climate has a big impact on how disease vectors develop and reproduce, and shifting weather patterns have a big impact on the risk of contracting diseases spread by vectors. Recent climate change has demonstrated that disease occurrence is climate-dependent. It is highly challenging to list both overestimated and underestimated pest consequences of climate change. The best examples of an unregulated insect pest population are mosquitoes, house flies, termites, and locusts. The population of pests that are resistant to pesticides is caused by a few indirect effects of climate. The best examples of vector-borne diseases

caused by climate change are the recent corona pandemic, monkey pox, dengue, and malaria. Changes in risk from climate change are directly correlated with factors that are reliant or independent of the climate^[28]. The Arctic, tropical, temperate, peri-Arctic, and subtropical climatic zones are where these notable regional differences in the occurrence of vectors and pathogens are most prevalent. As pressure intensifies on wild life and forests, it is possible that both climate change and human behavior could lead to increased conflicts within humanity and among other animals in the future.

Shrinking resources, habitat destruction, and changes in soil, water, and aerial climate are making the condition more intolerable. All physical factors like light, temperature, and winds are creating accidental disturbances that are making a loss of life, goods, agriculture, economy, and people are forced to migrate. The demand for commodities is increasing while the risks of natural calamities are increasing. There is a significant alteration in disease occurrence, fatalities, and morbidities in marginal agriculture-based societies. Recent genetic resistance in insect pests and pathogens defeated the drugs and clinical treatments, loss of action in broad-spectrum drugs, incidence rate, and sudden pandemics have destroyed public services, human behavior; and political stability and conflicts. Recent challenges related to drug and insecticide resistance, and the resurgence of the pest population are on the rise, however, to control the existing and emerging communicable diseases, more funds and grants are required with new pharmaceuticals and clinical facilities at the global level^[29].

Resources are being depleted, habitats are being destroyed, and soil, water, and aerial climate changes are making the situation increasingly untenable. All physical conditions, including light, temperature, and winds, cause unintentional disturbances that result in the loss of life, property, agricultural production, the economy, and the need for population migration. Commodity demand is rising, and so are the chances of natural disasters. In marginal agriculture-based cultures, disease incidence, mortality, and morbid-

ities have significantly changed. Recent pandemics are going on due to genetic resistance to infectious agents and insect pests. These changes have resulted in the loss of efficacy of broad-spectrum medications and devastated public services, human behavior, political stability, and conflicts. However, additional funding and grants are needed for new medications and clinical facilities at a global level to manage to exist and emerging communicable illnesses. Recent issues connected to drug and pesticide resistance, and a rebound of the pest population are on the rise^[29].

Changing weather conditions are imposing direct and indirect impacts on human health and increasing risks. Climate-sensitive infections pose a disproportionate burden and ongoing risk to both smaller and large human communities, hence, surveillance, diagnosis and prevention of diseases become highly important to minimize or prevent infections^[30]. Severe risks of infectious disease are also made after forced displacement due to disasters from rural sites to urban-poor areas; labor migration and illegal human trafficking add new types of risks. Therefore, disease diagnosis and treatment are highly essential for migrants, because, in lack of these, they convert into epicenters of epidemic diseases. Hence, the administration should try to understand and respond to the health impacts of all infectious disease cases found in migrant populations and host communities^[31]. All three parameters changing ecology and transmission dynamics of infectious disease and treatments methods available must be rechecked and advanced.

The risks associated with changing weather are rising and having both direct and indirect effects on human health. Smaller and larger human societies are equally in danger from climate-sensitive illnesses, making disease surveillance, diagnosis, and prevention crucial for reducing or eliminating infections^[30]. After forced relocation from rural sites to urban-poor areas owing to disasters, labor migration, and any illicit human trafficking add additional sorts of risks, severe infectious disease risks are also created. For this reason, sickness diagnosis and treatment are absolutely crucial for migrants, as without them,

they become the centers of epidemic diseases. As a result, management should attempt to comprehend and address the health implications of all infectious disease cases discovered in migrant groups and host communities^[31]. All three variables, which include the dynamics of evolving infectious disease ecology and transmission, as well as current treatment options, need to be reviewed and improved.

6.1 Flies as vectors

Arthropods mainly spiders, scorpions, ticks, and mites; lice, fleas, bedbugs, flies, bees, and ants, these insects impose allergies, morbidity, and mortality in human beings worldwide^[32]. Bites of these insects are major mode of transmission of disease pathogens, their stings cause allergies and impose life threatening physiological and biochemical changes. Flies are known vectors for a variety of infectious diseases mainly Aleutian disease in animals. *Fannia canicularis* (L.) (Diptera: Muscidae) is a vector of Aleutian mink disease virus in mink farms^[33]. *Cochliomyia hominivorax* is a fly that causes oral myiasis or fly-blown disease that is found in tropical and subtropical areas^[34]. This disease is characterized by symptoms of severe pain, swelling, itchy sensations, and the feeling of something moving in the mouth^[35]. Japanese encephalitis (JE) is a viral disease predominantly located in South East Asia. It is transmitted by the mosquito *Culex tritaeniorhynchus*. The disease is causing severity due to geography, climate change, and urbanization^[36]. Trachoma is a keratoconjunctivitis caused by flies *Chlamydia trachomatis*, in Botucatu Sao Paulo State, Brazil. This is a leading cause of blindness in the world^[37].

Insect stings can trigger allergies and have potentially fatal physiological and biochemical effects. Insect bites are a significant way that disease infections are transmitted. Humans develop allergic reactions when some insects including bugs, fleas, mites, and ticks are present, and their salivary proteins do the same. The class Arachnida of arthropods, which includes spiders, scorpions, ticks, and mites, and the class Insecta, which includes lice, fleas, bedbugs, flies, bees, and ants, are responsible for a significant

portion of sickness and mortality among humans worldwide^[32].

Flies have known vectors for a variety of infectious diseases mainly Aleutian disease in animals. *Fannia canicularis* (L.) (Diptera: Muscidae) is a vector of the Aleutian mink disease virus in mink farms^[33]. Oral myiasis or fly-blown disease is caused by *Cochliomyia hominivorax* a fly that is found in tropical and subtropical areas^[34]. The main symptoms of oral myiasis are severe pain, swelling, itchy sensation, and the feeling of something moving in the mouth^[35]. Japanese encephalitis (JE) is a viral disease predominantly located in South East Asia. It is transmitted by the mosquito *Culex tritaeniorhynchus*. The disease is causing severity due to geography, climate change and urbanization^[36]. In Botucatu, Sao Paulo State, Brazil, flies carrying the keratoconjunctivitis virus *Chlamydia trachomatis* are the source of trachoma. According to Meneghim et al.^[37], this is a major cause of blindness worldwide.

Cattle hypodermis (warble fly infestation) is a notorious veterinary problem throughout the world. Larvae of *Hypoderma* species cause subcutaneous myiasis in domesticated and wild ruminants. This disease is caused by, *Hypoderma bovis*, *Hypoderma lineatum* in cattle whereas, *Hypoderma diana*, *Hypoderma actaeon*, and *Hypoderma tarandi*, affect roe deer, red deer, and reindeer, respectively. Adults of the cattle grub are commonly known as heel flies, warble flies, bomb flies or gad flies. The biology of hypodermis is complex because it passes through ecto- as well as endoparasitic stages in the life cycle^[38]. Myiasis caused by Hypodermatinae flies is an economically important disease affecting domesticated and wild ruminants in countries of the Mediterranean and Indian subcontinent. Adult female insects lay eggs on the coat of animals. *Hypoderma* spp. primarily lay their eggs on cattle, buffalo, roe deer, red deer and reindeer, while *Przhevalskiana* spp. lay eggs on the coat of goats^[39]. *Hypoderma tarandi* larvae infect early-age calves of reindeer *Rangifer tarandus tarandus* skin of the back^[40]. Dengue hemorrhagic fever (DHF) virus or Dengue virus (DENV) is a mosquito-borne virus mainly *Aedes* sp. mosquitoes

from an infected host to non-infected ^[41,42].

A well-known veterinary issue worldwide is cattle hypodermis (infestation with warble flies). Domesticated and wild ruminants that are exposed to *Hypoderma* species' larvae develop subcutaneous myiasis. *Hypoderma diana*, *Hypoderma actaeon*, and *Hypoderma tarandi*, which affect roe deer, red deer, and reindeer, respectively, are the causes of this disease in cattle. *Hypoderma bovis* and *Hypoderma lineatum* are the causes of the condition in humans. Heel flies, warble flies, bomb flies, or gad flies are common names for the adults of the cattle worm. The life cycle of hypodermis includes both ecto- and endoparasitic stages, which complicates its biology ^[38]. Myiasis, a disease brought on by Hypodermatinae flies, affects both domesticated and wild ruminants in the Mediterranean and Indian subcontinent nations. On the fur of animals, adult female insects deposit their eggs. While *Przhevalskiana* spp. lay eggs on the coat of goats, *Hypoderma* spp. primarily lay their eggs on cattle, buffalo, roe deer, red deer, and reindeer ^[39]. The skin on the back of young calves of reindeer *Rangifer tarandus* is infected with *Hypoderma tarandi* larvae ^[40]. The virus that causes dengue hemorrhagic fever (DHF) or dengue (DENV) is spread by mosquitoes, primarily *Aedes* sp. mosquitoes, from an infected host to an uninfected host ^[41,42].

Francisella tularensis is a bacterium that causes Tularemia an endemic zoonotic infection mostly seen in North America and parts of Europe and Asia. This disease is transmitted by ticks and deer flies ^[43]. Similarly, sleeping sickness or trypanosomiasis is a vector-borne disease caused by a protozoan parasite *Trypanosoma brucei*, *T gambiense*, Human African trypanosomiasis. This disease is caused by bites of tsetse flies *Glossina palpalis*. Infection with *Trypanosoma brucei rhodesiense* leads to the acute, zoonotic form of Eastern and Southern Africa ^[44]. Arthropod vectors transmit African and American trypanosomiasis, and disease containment through insect control programmes is an achievable goal ^[45]. Cutaneous leishmaniasis is a disease caused by various *Leishmania* spp., which are transmitted by phlebotomine sand flies. This fly has seven species, with *Phlebotomus*

perniciosus (76.2%), *Ph. papatasi* (16.7%) and *Ph. sergenti* (5.0%) being the most common species, representing together 97.9% of the collected specimens. The remaining specimens were identified as *Sergentomyia minuta*, *Se. fallax*, *Ph. longicuspis* and *Ph. perfiliewi* ^[46].

In North America, some regions of Europe, and Asia, *Francisella tularensis* is a bacterium that causes tularemia, an endemic zoonotic infection. Ticks and deer flies are the carriers of this disease ^[43]. In a similar vein, trypanosomiasis, also known as sleeping sickness, is an infection brought on by the protozoan parasites *Trypanosoma brucei*, *T gambiense*, human African trypanosomiasis. The tsetse fly, *Glossina palpalis*, which transmits this disease, bites humans. The acute, zoonotic variant of *Trypanosoma brucei rhodesiense* infects people in Eastern and Southern Africa ^[44]. African and American trypanosomiasis are transmitted by arachnid vectors, making disease containment through insect control programs a realistic objective. In 2003, *Leishmania* sp., which is spread by phlebotomine sand flies, cause cutaneous leishmaniasis, a disease ^[45]. There are seven different species of this fly, with *Phlebotomus perniciosus* (76.2%), *Ph. papatasi* (16.7%), and *Ph. sergenti* (5.0%) making up the majority and accounting for 97.9% of the specimens gathered. *Sergentomyia minuta*, *Se. fallax*, *Ph. longicuspis*, and *Ph. perfiliewi* were named for the remaining specimens ^[46].

6.2 Tick vectors

Ticks (Acari: Ixodida) are ectoparasites that rely on a blood meal from a vertebrate host at each developmental stage for the completion of their life cycle. Ticks are serious health threats to humans and both domestic and wild animals in tropical and subtropical areas. These cause severe economic losses both through the direct effects of blood-sucking and indirectly as vectors of pathogens. Tick feeding causes transmission of pathogens and evokes severe infections, morbidity, and immune reactions in man. Feeding by large numbers of ticks causes a reduction in live weight gain and anemia among domestic animals, while tick bites also reduce the quality of

hides. However, the major losses caused by ticks are due to the ability to transmit protozoan, rickettsial and viral diseases of livestock, which are of great economic importance worldwide ^[47].

Ectoparasite ticks (Acari: Ixodida) require a blood meal from a vertebrate host at each stage of development to complete their life cycle. Ticks are serious health threats to humans and both domestic and wild animals in tropical and subtropical areas. Ticks are responsible for severe economic losses both through the direct effects of blood-sucking and indirectly as vectors of pathogens. Animal health is impacted by the tick feeding cycle because it results in hide damage, secondary infections, immunological reactions, and diseases brought on by the spread of pathogens. Domestic animals who are heavily tick-fed experience reduced weight gain and anemia, and the quality of their hides is also compromised by tick bites. The ability of ticks to transmit livestock diseases including protozoan, rickettsial, and viral infections, which are extremely important economically around the world, is what causes the majority of losses ^[47].

Brown tick *Ixodes hexagonus* live on the bodies of domestic and wild animals and vegetation. It transmits *Theileria parva* a protozoan parasite, which causes the tick-transmitted disease East Coast fever in cattle mainly in ruminants ^[48]. Tick-borne anaplasmosis and ehrlichiosis are clinically important emerging zoonoses of ticks belonging to three genera (*Rhipicephalus*, *Hyalomma*, *Haemaphysalis*). Tick-borne relapsing fever in North America is primarily caused by the spirochete *Borrelia hermsii*. Babesial vector tick defensin against *Babesia sp.* parasites ^[48]. Ticks possess sticky nature and ixodid ticks stick over the body of migratory birds, particularly passerines, infected with tick-borne pathogens, like *Borrelia spp.*, *Babesia spp.*, *Anaplasma*, *Rickettsia/ Coxiella*, and tick-borne encephalitis virus. The prevalence of ticks on birds varies over years, seasons, locality and different bird species. Adult *Ixodes ricinus* is red-brown, but the female ticks are light gray when engorged. Before feeding, sheep tick males are approximately 2.5-3 mm long and females 3-4 mm long. When they are engorged, the females can be as

long as 1 cm. Their palps are longer than the base of the gnathostome.

Black ticks live on the bodies of both domestic and wild animals as well as on flora, *Ixodes hexagonus* are. It spreads the protozoan parasite *Theileria Parva*, which is the primary cause of East Coast fever in cattle and other ruminants ^[48]. Emerging zoonoses ticks from three genera are clinically significant carriers of anaplasmosis and ehrlichiosis. In North America, the spirochete *Borrelia hermsii* is the main cause of tick-borne relapsing fever, Babesial vector tick defensin against *Babesia sp.* parasites Ixodid ticks, which carry infections like *Borrelia spp.*, *Babesia spp.*, *Anaplasma*, *Rickettsia/ Coxiella*, and tick-borne encephalitis virus, adhere to the bodies of migratory birds, especially passerines. Tick prevalence in birds varies depending on the year, season, location, and type of bird. *Ixodes ricinus* adults are red-brown, whereas engorged female ticks are pale gray. Male sheep ticks are roughly 2.5-3 mm long, whereas females are 3-4 mm long before feeding. The females can grow up to 1 cm long when they are engorged. Their palps extend farther than the gnathostome's base.

Ixodes ricinus is a major pest of sheep, cattle, deer, dogs and humans. A few medically important ixodid ticks include *Amblyommaspp*, *Anomalohimalayaspp*, *Bothriocrotonsp*, *Cosmiommasp*, *Dermacentorspp*, *Haemaphysalis spp*, *Hyalommaspp*, *Ixodesspp*, *Margaropuspp*, *Nosommasp*, *Rhipicentorspp*, and *Rhipicephaluspp*. *Ixodes ricinus* a free-living tick has been intensively studied ^[49,50]. The nymph of the western black-legged tick (*Ixodes pacificus*) is an important bridging vector of the Lyme disease spirochete (*Borrelia burgdorferi*) to humans in the far-western United States ^[51]. These show horizontal and vertical movements of host-seeking *Ixodes pacificus* (Acari: Ixodidae) nymphs in hardwood forests.

Ixodes ricinus is a serious pest to humans, dogs, cattle, sheep, and deer. *Amblyommaspp*, *Anomalohimalayaspp*, *Bothriocrotonsp*, *Cosmiommaspp*, *Dermacentorspp*, *Haemaphysalisspp*, *Hyalommaspp*, *Ixodesspp*, *Margaropuspp*, *Nosommasp*, *Rhipicen-*

torsspp, and *Rhipicephalusspp* are a few ixodid ticks that are significant medically. In-depth research has been done on the free-living tick *Ixodes ricinus* ^[49,50]. In the far western United States, the nymph of the western black-legged tick (*Ixodes pacificus*) is a crucial bridging vector of the Lyme disease spirochete (*Borrelia burgdorferi*) to humans ^[51]. These depict the movements of host-seeking *Ixodes pacificus* (*AcriiIxodidae*) nymphs in a hardwood forest in both the horizontal and vertical planes.

Mites, nematodes and spirochaetes, feed on ticks, as they carry diseases as the primary hosts of pathogens. These organisms could not reach their secondary hosts. The diseases caused may debilitate their victims, and ticks may thus be assisting in controlling animal populations and preventing overgrazing ^[52]. Ticks remain attached to the body of mobile hosts and reach new far distant locations, best example is bird hosts, which even carry ticks across the sea. The infective agents can be present not only in the adult tick but also in the eggs produced plentifully by the females. Many tick species have extended their ranges as a result of the movements of people, their pets, and livestock. With increasing participation in outdoor activities such as wilderness hikes, more people and their dogs may find themselves exposed to attack ^[53]. Lyme disease transmission cycles are maintained by different vector species *Ixodes scapularis* and *Ixodes pacificus*, respectively. Though these show differences in transmission efficiency can be used to identify vector competence contributes to variable Lyme disease risk ^[54].

Since ticks are the main hosts for the pathogens that cause diseases, mites, nematodes, and spirochaetes prey on them. The secondary hosts of these organisms were out of reach. Ticks may be helping to manage animal populations and prevent overgrazing because the diseases they spread may render their victims helpless ^[52]. The longer period that a tick remains attached, during which the mobile host can be transported across great distances or, in the case of hosts that are birds, across the ocean, enhances the spread of the disease. The infectious pathogens can be found in both the adult tick and the female ticks'

copious amounts of eggs. Because of the mobility of people, their pets, and cattle, many tick species have expanded their geographic ranges. As more people engage in outdoor activities like wilderness hikes, more people and their dogs may become vulnerable to attack ^[53]. Lyme disease transmission cycles are maintained by different vector species *Ixodes scapularis* and *Ixodes pacificus* respectively. Though these show differences in transmission efficiency can be used to identify vector competence contributes to variable Lyme disease risk ^[54].

6.3 Mosquito vectors

Malaria is a worldwide disease; the spectrum of this disease is increasing at the global level. Global warming induced by human activities has increased the risk of vector-borne diseases such as malaria. During the last three decades, its incidences have enormously increased in South East Asian countries, African countries, and Australia as changing climates have favored the reproduction and survival rate in vector populations. Rising temperature, rainfall, presence of host and parasite enhanced epidemiological risks of malaria. In the last two decades, the human malaria parasite has rapidly changed its genome according to the type of human host and vector population and ongoing climatic variations. Anopheline mosquitoes have developed resistance against variations in temperature, salinity, pesticides, and against plasmodium the malaria parasite ^[55]. There are four strains of malaria parasite infections with *Plasmodium falciparum*, *Plasmodium yoelii* and *Plasmodium berghei* parasites among which newly emerged *Plasmodium knowlesi* disease is more fatal, its natural primate hosts are *Macaca fascicularis*, *M. nemestina*, *M. inus*, and *Saimiri scirea*. All these are transmitted by 70 species of mosquitoes among which 41 are more prominent and dominant vectors which that transmit the malaria parasite ^[55]. The reason behind rising cases of malaria is genetic resistance developed by the parasite, human migration, failure of drug formulae, eco-climatic changes, poor health policies, human migration, and pesticide resistance in malaria vectors ^[55]. The rise in the

anopheline mosquito population are floods, urbanization, hygiene, tropical forests, and humidity. Insecticide resistance is the main problem and hurdle that is lowering the effectiveness of vector-borne disease management ^[56]. However, molecular investigations are required to diagnose mechanisms involved in the development of the parasites in New World vectors ^[57]. The intensity of transmission is dependent on the vectorial capacity and competence of local mosquitoes (Table 1) ^[55].

Malaria is a disease that affects people all around the world and its range is expanding globally. The likelihood of vector-borne illnesses like malaria has increased due to global warming brought on by human activity. Because of the changing climate, the vector population's survival and reproduction rates have increased significantly during the past three decades in South East Asian, African, and Australian nations. Increasing temperatures, precipitation, the presence of a host and a parasite, and malaria

Table 1. Major communicable diseases with their vector and reservoir hosts.

Diseases	Vector	Infected Population	Main Reservoir	Affected Area
Dengue Fever	Ades	Human	None (Primates)	Africa Asia America (Inter -tropical zone)
Yellow Fever	Ades	Human	Monkey	Africa, America (Inter -tropical zone)
West Nile encephalitis	Ades, culex	Human (Horse)	Birds	Africa,Middle East Southern Europe, America
Tick-borne encephalitis	Ticks	Human	Wild Animals cervids, Rodents	Central Europe Scandinavia
Japanese encephalitis	Ades, culex	Human (Pigs)	Birds (Pigs)	Far East
Chikungunya fever	Ades	Human	Monkey	Africa,South Europe,
RVF Virus (Phlevo virus)	Ades	Human (Sheep,cattle,goat, canines,felines)	Sheep,cattle	Equatorial Africa
Hantavirus	Rodents	Human	Rodents	Asia (Hantaan virus) America (Sin Nombre Virus)
Lymphatic filariasis	<i>Culex/ Anopheles</i>	Human	Human	Sub-Saharan Africa
Rift Valley fever	<i>Aedes</i>	Human	Mosquitoes	eastern and southern Africa, sub-Saharan Africa, Madagascar, Saudi Arabia and Yemen.
Zika	<i>Anopheles</i>	Human		Africa to Asia
Malaria	<i>Anopheles</i>	Human		North America
Onchocerciasis (river blindness)	Blackflies	livestock such as cattle, sheep, goats, buffalo, and camels.	Human	Africa, with additional foci in Latin America and the Middle East.
Plague (transmitted from rats to humans)	Fleas	Human	Rats	Africa, Asia and the United States
Tungiasis	Fleas	Human	pigs	Mexico to South America, the West Indies and Africa.
Typhus	Lice	rats, cats, or opossums	Human	Southeast Asia, Japan, and northern Australia
Louse-borne relapsing fever	Lice	Human	Dog	north-eastern Africa
Leishmaniasis	Sandflies	Human		Mexico, Central America, and South America
Sandfly fever (phlebotomus fever)	Sandflies	Human	rodents,	Mediterranean, Middle East, northern African and western Asian countries

Table 1 continued

Diseases	Vector	Infected Population	Main Reservoir	Affected Area
Crimean-Congo haemorrhagic fever	Ticks	wild and domestic animals, such as cattle, goats, sheep and hares	Hard ticks	the Mediterranean, in northwestern China, central Asia, southern Europe, Africa, the Middle East, and the Indian subcontinent
Lyme disease	Ticks	wild and domestic animals, such as cattle, goats, sheep and hares	white-footed mouse (<i>Peromyscus leucopus</i>)	Northeast, mid-Atlantic, upper Midwest, and West Coast.
Relapsing fever (borreliosis)	Ticks	wild and domestic animals, such as cattle, goats, sheep and hares	Human	North America, plateau regions of Mexico, Central and South America, the Mediterranean, Central Asia, and much of Africa.
Rickettsial diseases (eg: spotted fever and Q fever)	Ticks	wild and domestic animals, such as cattle, goats, sheep and hares	Human	Hawaii, California, and Texas.
Tularaemia	Ticks	wild and domestic animals, such as cattle, goats, sheep and hares	rabbits, hares, and muskrats	south central United States, the Pacific Northwest, and parts of Massachusetts, including Martha's Vineyard.
Chagas disease (American trypanosomiasis)	Triatome bugs	wild and domestic animals, such as cattle,	Human	Americas
Sleeping sickness (African trypanosomiasis)	Tsetse flies	wild and domestic animals, such as cattle,	Human	central Africa and in limited areas of West Africa

epidemiological risks. The human malaria parasite has quickly altered its genome during the past 20 years in response to the many human hosts, vector populations, and ongoing environmental changes. Anopheline mosquitoes have evolved resistance to insecticides, plasmodium, temperature fluctuations, and salinity changes ^[55]. There are four different types of malaria parasite illnesses, including *Plasmodium berghei*, *Plasmodium yoelii*, and the recently discovered *Plasmodium knowlesi* disease, which is more deadly and has *Macaca fascicularis* as its natural monkey host. M. Nemestine as well as Saimiri science. All of them are spread by 70 different kinds of mosquitoes, of which 41 are the most common and effective vectors for the malaria parasite ^[55]. The parasite's genetic resistance, human movement, medication formula failure, eco-climatic changes, inadequate health policies, human migration, and pesticide resistance in malaria vectors are all contributing factors to the increase in instances of malaria ^[55]. Floods, urbanization, sanitation, tropical forests, and humidity all contribute to an increase in the anopheline mosquito population. The primary issue and roadblock limiting the efficiency of managing

vector-borne diseases is insecticide resistance ^[56]. However, to identify the processes involved in the growth of the parasites in New World vectors, molecular analyses are necessary ^[57]. The competence and vectorial potential of the local mosquito population determine how intense the transmission will be ^[55] (**Table 1**).

6.4 Pesticide resistance in insect vectors

Resistance to currently-used insecticides varied greatly between the four-vector species. While no resistance to any insecticides was found in the two *Aedes* species, bioassays confirmed multiple resistance in *Cx. p. quinquefasciatus* (temephos: ~20 fold and deltamethrin: only 10% mortality after 24 hours). In *An. gambiae*, resistance was scarce: only moderate resistance to temephos was found (~5 fold). resistance levels of four major vector species (*Anopheles gambiae*, *Culex pipiens quinquefasciatus*, *Aedes aegypti* and *Aedes albopictus*) to two types of insecticides: i) the locally currently-used insecticides (organophosphates, pyrethroids) and ii) alternative molecules that are promising for vector

control and come from different insecticide families (bacterial toxins or insect growth regulators) [58]. The emergence of genetic engineering is used to improve human health using genetic manipulation techniques in a clinical context. Gene therapy represents an innovative and appealing strategy for the treatment of human diseases, which utilizes vehicles or vectors for delivering therapeutic genes into the patient's body. However, a few past unsuccessful events that negatively marked the beginning of gene therapy resulted in the need for further studies regarding the design and biology of gene therapy vectors, so that this innovating treatment approach can successfully move from bench to bedside (Table 1) [59].

6.5 Insect vectors that exhibit pesticide resistance

The four-vector species showed very different levels of pesticide resistance. The two *Aedes* species had no pesticide resistance, while bioassays showed that Cx had multiple insecticide resistance. *P. quinquefasciatus* (mortality after 24 hours for temephos was 20-fold lower than for deltamethrin) In *An. gambiae*, resistance was limited; only a mild resistance to temephos (5-fold) was discovered. *Anopheles gambiae*, *Culex pipiens quinquefasciatus*, *Aedes aegypti*, and *Aedes albopictus* are four major vector species. Resistance levels to two types of insecticides have been studied: The locally prevalent organic phosphates and pyrethroids and alternative molecules that are promising for vector control and come from different insecticide families (bacterial toxins or insect growth regulators). Through the use of clinically relevant genetic alteration techniques, the development of genetic engineering is being used to enhance human health. Gene therapy, which uses carriers or vectors to transport therapeutic genes into patients' bodies, is a cutting-edge and alluring approach to treating human ailments. However, a few prior instances of failure that adversely affected the development of gene therapy necessitated additional research into the design and biology of gene therapy vectors in order for this ground-breaking therapeutic strategy to successfully transition from bench to bedside [59].

6.6 Drug resistance in microbes

In normal environmental conditions mainly temperature imposes mutations that confer resistance to a drug that is rare and undetected. The genetic switches found in bacteria are more susceptible to altering the behavior of genes accordingly as the target drug is set right and its action is foiled in two steps. In an environment with the addition of drugs, the drug-resistant mutants favored and replaced the normal bacteria. There occurs directive selection in bacteria that non-pathogenic strains are converting into pathogenic and later on into resistant one. It might be thought that the mutations conferring resistance are caused or induced by the drug, but this is not true. It is a natural phenomenon that drug-resistant mutations occur in bacterial cells irrespective of the presence or absence of the drug. This is the nature of bacterial cells that mutation occurs simultaneously without drug exposure. This is an open race between man and microbes to sabotage each other to acquire fitness through natural selection. Both shield and attack are becoming more advanced and are proving lethal tools for each other. Though, in the past and even today microbes have attained the required resistance against thousands of synthetic drugs by making changes in the genetic system. Microbes are UN-conquered warriors on this earth because of their adaptations, flexibility in the mode of feeding, and behavioral and genetic selection than any other organism. It has also ascertained their survival in extreme climatic conditions both outside host or exotic conditions. Among microbes most of the species belong to various groups which are pathogenic to man and their ultimate survival comes through the creation of a pathogen city to the host.

Mutations that confer drug resistance are uncommon and go undiscovered in typical environmental conditions, when the temperature is the dominant environmental constraint. The genetic switches present in bacteria are more likely to change gene behavior as the target drug is corrected and its function is thwarted in two steps. The regular bacteria were preferred and replaced by drug-resistant mutants in an environment where drugs were added. Directive

selection occurs in bacteria, resulting in the transformation of non-pathogenic strains into pathogenic and then resistant ones. Contrary to popular belief, the medication does not actually cause or trigger the mutations that confer resistance. Regardless of whether a medicine is present or not, drug-resistant mutations in bacterial cells are a common occurrence. Bacterial cells naturally undergo simultaneous mutations without being exposed to drugs. Mankind and germs are engaged in a competitive race to sabotage one another in order to improve their fitness through natural selection. Shield and assault are both evolving and proving to be deadly instruments for one another. However, both in the past and in the present, bacteria have developed the necessary resistance to countless man-made medications by altering their genetic makeup. This is a reality that infectious agents have increased their selection against existing drugs and vaccines available and becoming unbeatable combatants on our planet. Additionally, it has been demonstrated that they can survive in hostile environments or under ideal conditions regardless of the climate. Most microbe species belong to groups that are harmful to humans, and they ultimately survive by developing pathogen cities in their hosts.

There is a strong tug-of-war between pathogenic genes and medicine mainly broad-spectrum chemical agents. It is the finest work of pharmacists and chemists but has a worthless future. There is negative and positive selection seen in newly altered genes due to mutations providing strong biological scissors against bacterial pathogens in spite of the fact that new medicines are coming generation after generation with much-enhanced lethality. There is no drug that can absolutely kill drug-resistant bacterial strains. This is because microbes are developing resistance through evolutionary selection patterns and new enzyme system is becoming stronger and stronger. Are we ready to fight against nature-supported microbes as we are opting for artificial selection and losing our own fitness and adaptation by living in artificial conditions? For nature man is a societal wise animal that is living luxurious life without knowing its consequences and is facing many risks, there is no

way to make protection against the sudden evoking of pathogenic endemics. Man has self compromising genetic system, and having noncompromising attitude toward nature and her organisms. A large pile of the drug has been proven worthless and it could not able to kill even a single resistant strain of bacteria, viruses, fungi, PPLOs, and Prions.

Pathogenic genes and largely broad-spectrum chemical drugs are engaged in a fierce battle. Despite being a pharmacy and chemist's finest achievement, it has little future value. Despite the fact that new medications are being developed every generation with significantly increased lethality, there is still negative and positive selection found in newly altered genes as a result of mutations that gave strong biological scissors against bacterial infections. Drug-resistant bacterial strains cannot be completely eradicated by any medication. This is due to the fact that novel enzyme systems are getting increasingly potent and that microorganisms are evolving resistance through patterns of evolutionary selection. Are we prepared to fight back against the germs that nature supports, as we are choosing the artificial selection, losing our own fitness, and failing to adapt to our environment? Since man is a socially intelligent animal who leads a lavish lifestyle without considering the implications and is exposed to numerous risks, there is no way to be protected from the rapid emergence of pathogenic endemics. Man has a genetic system that compromises him, and he has a non-compromising attitude toward nature and her creatures. Numerous drugs have been shown to be useless and unable to eradicate even one resistant strain of bacteria, virus, fungus, PPLOs, or Prions.

It is considerable truth that seventh-generation anti-microbials are highly lethal to microbes, but microbes generated the capability to gain resistance by employing genes to synthesize new enzymes to cleave drug formulae. Only very few allelopathies we intake in daily meals hence, could not achieve sizable resistance. In other words, we receive all utilizable from 30-40 plant species but bacteria have interacted with thousands of plants and animal species and have generated more sensitivity and identi-

fication capacity against medicinal molecules which could be sued by a human being as a drug.

Seventh-generation anti-microbials are undoubtedly effective tools for controlling microorganisms, but they also use a genetic system that coordinates thousands of genes to produce new enzymes. Only a very small number of the allelopathy we consume daily might thus not generate significant resistance. In other words, we get what we need from 30-40 plant species, whereas bacteria have interacted with thousands of plant and animal species, increasing their sensitivity to and the ability for identifying drugs that humans might use.

6.7 Gene transfer, virus vectors and drug resistance

Viral vectors are promising gene carriers for cancer therapy. These new genes delivered for therapeutic purposes are increasing safety risks to human health^[60]. Adeno-associated virus (AAV) vectors are important delivery platforms for therapeutic genome editing but are severely constrained by cargo limits^[61]. These Ad vectors evade pre-deployed immunity. There is a need to make genetic and chemical modifications capsid for modulation of vector–host interactions of Ad-based vectors^[62]. Transgenesis and paratransgenesis are highly important molecular methods to control insect-borne diseases. These methods easily decrease insect vectorial capacity, and break the transmission of pathogens such as *Plasmodium sp.*, *Trypanosoma sp.*, and Dengue virus. Vector transgenesis relies on direct genetic manipulation of disease vectors making them incapable of functioning as vectors of a given pathogen. In addition, genetically modified insect symbionts are also used to express molecules within the vectors that are deleterious to pathogens they transmit^[63]. Finally new genetic additions may induce linear functional responses from hosts and vectors that might increase disease transmission potential in vectors and longevity in the pathogen cycle within the body of hosts. But for control of transmission of the behavioral ecology of insects, molecular changes in pathogens must be studied^[64]. Further, the use of virus vectors

for the transfer of silencing genes preferable integration sites must be searched with stable expression models^[65,60]. For increasing translation efficiency there is a need to improve the quality of oversized vectors^[66].

Over one million people die each year as a result of nearly 20% of infectious diseases that are vector-borne. Recently, a few virus-based vectors were employed to create possible vaccines to fight the COVID-19 disease and protect people's immune systems. Finally, new genetic additions might cause hosts and vectors to respond linearly, which could increase the possibility of disease transmission in the vectors and lengthen the pathogen cycle within the body of the hosts. However, molecular modifications in the pathogen must be investigated to control the transmission of insect behavioral ecology^[64]. Additionally, stable expression models must be used to search for the best integration locations when using viral vectors to deliver silencing genes^[65,60]. It is necessary to raise the caliber of large vectors to increase the translation efficiency of these^[66].

The capacity of lentiviral protein transfer vectors (PTVs) for targeted antigen transfer directly into APCs and thereby induction of cytotoxic T cell responses. PTVs can be used as safe and efficient alternatives to gene transfer vectors or live attenuated replicating vector platforms, avoiding genotoxicity or general toxicity in highly immunocompromised patients, respectively. Thereby, the potential for easy envelope exchange allows the circumventing of neutralizing antibodies, e.g., during repeated boost immunizations^[67]. The integrated vector management plan, including all the good practices, learned from previous experiences^[58]. Almost 20% of all infectious human diseases are vector-borne and, together, are responsible for over one million deaths per annum. Recently few of the virus-based vectors were used for the generation of potential vaccines to fight against COVID-19 disease, the immune safety of people.

Lentiviral protein transfer vectors' (PTVs') ability to transfer specific antigens directly into APCs and consequently trigger cytotoxic T-cell responses.

PTVs can be employed as effective and safe substitutes for live attenuated replicating vector platforms or gene transfer vectors, preventing genotoxicity or general toxicity in severely immunocompromised individuals, respectively. As a result, the possibility of simple envelope exchange enables the avoidance of neutralizing antibodies, for instance, during repeated booster immunizations^[67]. A comprehensive vector management strategy that takes into account all the wise decisions made in the past^[58]. Almost 20% of all infectious human diseases are vector-borne and, together, are responsible for over one million deaths per annum. Recently few of the virus-based vectors were used for the generation of potential vaccines to fight against COVID-19 disease, the immune safety of people.

6.8 Drug resistance, virus vectors, and gene transfer

Promising gene carriers for cancer therapy are viral vectors. These spread genes for therapeutic purposes but raise security concerns and bring about the emergence of new virus strains as a result of gene fusion and conversion^[60]. Although cargo restrictions severely restrict the use of Adeno-Associated Virus (AAV) vectors as therapeutic genome editing delivery platforms^[61]. These advertisement routes avoid deployed immunity. Ad-based vectors' capsids require genetic and chemical alterations in order to control the interactions between the vector and the host^[62]. Insect-borne disease control uses transgenesis and paratransgenesis, two crucial molecular techniques. These techniques can reduce the ability of insects to transmit disease and stop the spread of viruses like the Dengue virus, Trypanosoma species, and Plasmodium species. By directly altering the genetic code of disease vectors, vector transgenesis renders them unable to spread a specific pathogen. The goal of paratransgenesis is to use genetically altered insect symbionts to express chemicals that are harmful to the infections they transmit within the vector^[63].

7. Host immunity and pathogen antigens

New interactions between plasmodium and mosquito vectors have been observed related to the mechanism of innate immune defense responses in anopheline mosquitoes. The body of these mosquitoes makes an innate immune defense and is applied to confine and kill malaria parasites under migration and development. It could be used as one of the effective strategies to control malaria vectors^[68]. Mosquitoes and other insects lack adaptive immune defense but they respond to different bacteria and fungi with the same innate immune system by using different defense peptides. *Anopheles gambiae* mosquito vector contains transition stages of midgut invasion and relocation of sporozoites from the oocysts to the salivary glands. After invasion mosquito innate immune system is activated that kills plasmodium parasite inside salivary glands^[69].

The mechanism of innate immune defense responses in anopheline mosquitoes has revealed new interactions between the plasmodium and insect vector. These mosquitoes' bodies produce an inherent immune defense that is used to contain and eliminate malaria parasites while they are migrating and developing. It could be one of the most successful methods for controlling malaria vectors^[68]. Although mosquitoes and other insects lack adaptive immune protection, they nonetheless use the same innate immune system to respond to various bacteria and fungus by employing various defense peptides. The mosquito vector *Anopheles gambiae* has intermediate stages of midgut invasion and sporozoites that go from the oocysts to the salivary glands. Following the invasion, the innate immune system of the mosquito destroys the parasite plasmodium inside the salivary glands^[69].

There is one important question *Anopheles* mosquitoes have developed mechanisms to confront Plasmodium infections during feeding, if vector immune competence may be explored it will help to prevent pathogen transmission^[70]. There are three important points seasonal variations, new variants of parasites, and new defense molecules in vectors are

avored by a climate that leads to increased transmission, high infectivity, and mortality in hosts even after clinical care and vaccine-based prophylaxis. Further, climatic and other environmental factors affecting biological systems and inducing molecular changes in parasites and vectors towards a more resistant life, while almost no change or slow changes in hosts are the main driving forces that have increased resistant malaria across different Spatio-temporal regions ^[71]. Infection by extracellular bacteria induces the production of humoral antibodies, which are ordinarily secreted by plasma cells in regional lymph nodes and the sub-mucosa of the respiratory and gastrointestinal tracts. The humoral immune response is the main protective response against extracellular bacteria. The antibodies act in several ways to protect the host from the invading organisms, including the removal of the bacteria and the inactivation of bacterial toxins. Extracellular bacteria can be pathogenic because they induce a localized inflammatory response or because they produce toxins.

One crucial issue is how *Anopheles* mosquitoes combat *Plasmodium* infections during feeding; if vector immune competence can be investigated, it will aid in preventing pathogen transmission ^[70]. There are three crucial reasons. Climate-favored seasonal changes, novel parasite variants, and novel vector defense molecules result in increased transmission, high infectivity, and mortality in hosts even in the presence of medical care and vaccine-based prophylaxis. Additionally, climatic and other environmental conditions have an impact on biological systems and cause molecular changes in parasites and vectors that make them live longer and more robustly. While modest or nearly no changes in hosts are the primary factors that have increased malaria resistance across various spatiotemporal regions ^[71]. Humoral antibodies are often released by plasma cells in local lymph nodes and the sub-mucosa of the respiratory and gastrointestinal tracts in response to external bacterial infection. The primary defensive reaction against extracellular germs is the humoral immune response. The antibodies have a variety of protective effects on the host, including the elimi-

nation of pathogens and the inactivation of bacterial toxins. Because they trigger a localized inflammatory response or because they produce toxins, extracellular bacteria have the potential to be harmful.

Need of most appropriate vaccines

Today risk of microbial infection has been increased due to a lack of control of pathogens and vectors. Both transmissions of pathogen and host availability become easier. These are the main reasons for the spread of deadly pathogens which are causing malaria, diarrhea, Ebola, meningitis, tuberculosis, HIV/AIDS, and many other viral, parasitic and fungal infections. Poor countries are major victims of these diseases as inappropriate health services and lack of prophylactic vaccinations are two major issues related to clinical care ^[72]. On the other side, those countries which have done prophylactic vaccination are free of these diseases or kept under control. Vaccination has helped in the eradication of diseases like polio, hepatitis, diphtheria, meningitis, and measles in most developed countries ^[73]. Despite irrational and dangerously erupting anti-vaccine movements that fuel the dwindling public confidence ^[74], therapeutic vaccines have also been effective at the intersection of infections and cancer ^[75], as shown by the successful human papilloma virus vaccine ^[76]. However, screening, testing, diagnosis and vaccination are major facts to adopt rather than adopting medicine of the medieval ages ^[74]. However, both traditional and new vaccination technologies ^[77] are to be required to establish herd immunity for wider protection of the people ^[78] for preventing the speedy expansion of local infectious diseases and their conversion into global pandemics ^[79,80]. For successful vaccination disease status, infection rate, eco-climatic changes, geographical, seasonal infectious disease epidemiology and mathematical analysis of routine and pulse vaccination programmes must be done ^[81].

Today risk of microbial infection has been increased due to a lack of control of pathogens and vectors. Both transmissions of pathogen and host availability become easier. Malaria, diarrhea, Ebola, meningitis, TB, HIV/AIDS, and several other viral,

parasite, and fungi infections are just a few of the devastating diseases that hold less developed nations prisoner. The measles' spectacular recent resurgence, even in affluent nations, shows that health authorities have been ineffective in educating the public about the benefits of preventative and prophylactic immunization^[72]. The success of prophylactic immunization over 200 years makes a strong case for the advantages. In most affluent nations, vaccinations have eliminated diseases including polio, hepatitis, diphtheria, meningitis, and measles^[73]. Therapeutic vaccinations have also been successful at the nexus of infections and cancer^[75], as proven by the successful human papilloma virus vaccine, despite irrational and dangerously exploding anti-vaccine movements that fuel the waning public confidence^[74,76]. However, anti-vaccine campaigns have frequently been louder than scientific evidence and have demonstrated how harmful "alternative facts" communication tactics can persuade even intelligent people, sometimes regressing medicine to the Middle Ages^[74]. Traditional and modern immunization methods are significant^[77] and will be necessary to build herd immunity, a crucial barrier to preventing the spread of regional infectious illnesses into worldwide pandemics^[78]. To combat drug-resistant tuberculosis, the tuberculosis vaccine is crucial^[79,80]. According to Nicholas C. Grassly and Christophe Fraser, mathematical analysis of routine and pulse vaccination programs must be done in order to determine illness status, infection rate, eco-climatic variations, geographical, seasonal infectious disease epidemiology, and vaccine success.

8. Migration of people

The worst condition of human social groups is climate-induced forced migration. Changing weather conditions, on two sides of the world are alarming, on one side there is ice shelling in Northern American countries, and people are facing super cool temperatures while in Australia there are no rains, and people are facing longer droughts and rising temperatures. Such climate-related population displacements have been seen in the Caribbean basin

where people are facing negative climatic exposure. Artificial physical structural dependence makes the system less sensitive to the environment. Because of rising sensitivity and minimum adaptive capacity anthropogenic climate changes, have increased the vulnerability and given rise to territorial conflicts. Over-industrialization has changed the scenario as the climate-based weather cycle has changed the life of the people and all-around pollution and global effects of rising temperature have imposed climate-related migration. Today these effects are vulnerable but in the future, these will become more hazardous, and anthropogenic climate change will displace people in spite of their economic richness. Hence future population movements will be riskier as random territorial conflicts will be increased.

Forced migration brought on by climate change is the worst situation for human social groups. Awkward weather changes are occurring on opposite ends of the globe. In northern American countries, people are dealing with extremely cold temperatures, while in Australia, where there have been no rains, people are experiencing extended droughts and rising temperatures. In the Caribbean basin, where people are exposed to adverse climate conditions, such population displacements connected to climate change have been seen. As a result of artificial physical structural dependence, the system is less environment-sensitive. Anthropogenic climate change has raised vulnerability and led to territorial conflicts due to rising sensitivity and low adaptive capability. Over-industrialization has altered the situation just as people's lives have been altered by the climate-based weather cycle, and global warming's effects on pollution and pollution everywhere have forced people to migrate. These effects are already dangerous, but as anthropogenic climate change displaces people regardless of their economic wealth, future population movements will become riskier as the number of sporadic territorial conflicts rises.

Post-migration establishment also depends on climate-based stimulus-response, the interaction of environmental changes or events with human social, economic, and cultural processes^[82,83]. In the field

of climate change research, interactions between climate and migration are increasingly situated within the context of human vulnerability to climate change, which is in turn identified as being a function of exposure to the impacts of climate change, the sensitivity of communities or socioeconomic systems to such impacts, and the capacity of those exposed to adapt. Migration responses to climate change may therefore be treated as one of the ranges of possible ways by which people may adapt to the adverse impacts of climate change or take advantage of resultant opportunities. Though there are migrations in the long historic past that were not so destructive because the need of people was minimum, post-industrialization has increased the population pressure because of development.

Climate-based stimulus-response, the interaction of environmental changes or occurrences with human social, economic, and cultural processes, and post-migration settlement are all factors that influence [82,83]. Climate and migration interactions are increasingly seen in the context of human vulnerability to climate change in the field of climate change research. This vulnerability is then understood to be a function of exposure to the impacts of climate change, the sensitivity of communities or socioeconomic systems to such impacts, and the capacity of those exposed to adapt. Therefore, one of the many potential means by which individuals may cope with the negative effects of climate change or seize associated possibilities is through migration responses to that change. Migration has existed for a very long time, but it was not as harmful then since there were fewer needs for people. However, post-industrialization has increased population pressure due to development.

There are both spatial and temporal patterns of climate-related migration. Displaced people need, societal well-being in a new environment, but it is only possible if state policy is inclusive. If it is not inclusive then in such a condition more vulnerable groups will be formed. Hence, extremes of climate change possibilities kept in mind before making any policy. All climates-induced adverse effects and ex-

trems need more prompt actions to find timely solutions. Besides, ecological factors human interaction in groups, and their living in different social systems, communities, and households within particular systems also shape few differences. These differences are shaped by a variety of factors including the particular nature of climate impacts; the degree of exposure to such impacts; the sensitivity of human systems to such changes; and the capacity of the exposed population and its socioeconomic systems to adapt [84,85]. For abatement of climate-related effects and controlling disease incidences ecological effects related to human behavior and climate must be studied in a broad sense [86-88]. All climate-related environmental issues which are affecting human health and socioeconomic systems must be resolved early as possible to save humanity. More often, include poor countries which have agricultural and natural resource dependence and living in low-lying coastal areas, small island states, and other settings where exposure to climate-related risks is high and human livelihood possibilities are limited should give priority [89,90].

Migration that is influenced by the climate has both spatial and temporal trends. In order for society to thrive in its new surroundings, displaced individuals must be included in state policies. If it isn't inclusive, more vulnerable groups will develop as a result. Therefore, before implementing any policies, the extremes of possible climate change were considered. More immediate steps are required to address the negative effects and extremes that climate change has caused. In addition, ecological factors influence how people interact in groups, how they live in various social systems, and how communities and households differ within certain systems. These disparities are influenced by a number of variables, such as the specific nature of climatic impacts, the extent of exposure to such impacts, the sensitivity of human systems to such changes, and the adaptability of the exposed population and its socioeconomic systems.

Some socioeconomic systems are intrinsically more susceptible to changes in the environment

brought on by climate change, which increases the likelihood of adaptive migration. These include those in low-lying coastal areas, tiny island states, and other environments where danger from climate change is high and human livelihood options are constrained. These systems are characterized by a reliance on agriculture and natural resources.

9. Induction of communicable diseases

9.1 Protozoan diseases

Protozoans are unicellular organisms most of them are internal parasite infections of man. Rotozoa is single-celled organisms classified as eukaryotes (organisms whose cells contain membrane-bound organelles and nuclei). These accidents directly or indirectly reach the human host and evoke dreadful diseases. In the past, the most prevalent and deadly human diseases were caused by protozoan infections. These dreadful diseases are African sleeping sickness, amoebic dysentery, and malaria. Common infectious diseases caused by protozoans include Malaria, Giardia, and Toxoplasmosis. These infections are found in very different parts of the body. There are drug resistant strains of *Entamoeba histolytica*. It is a major health problem in the whole of China south-east and Western Asia and Latin America, especially Mexico. It is generally agreed that amoebiasis affects about 15 percent of the Indian population. An estimated 10% of the world's population is infected with *E histolytica*. The highest prevalence is in developing countries with the lowest levels of sanitation. This results in 50-100 million cases of colitis or liver abscesses per year and up to 100,000 deaths annually (**Figure 2**).

Filariasis is seen mainly in developing countries. Lymphatic filariasis is often associated with urbanization, industrialization, illiteracy, poverty and poor sanitation. The migration of people favored the spread of filariasis. *Giardia lamblia* starts its invasion in gut toxoplasmosis can be found in lymph nodes, the eye, and also (worryingly) the brain. After ingestion of mature cysts (infective dose var-

ies from 10-100 cysts) via contaminated water or food, the trophozoite emerges in the small intestine, rapidly multiplies, and attaches to the small intestinal villi ^[91]. Trophozoites do not survive outside the body. Another intracellular parasite of the genus *Leishmania* attacks macrophage cells and causes leishmaniasis or Kala Azar. The parasite is transmitted by a variety of sand fly species belonging to subfamily Phlebotominae. This parasite largely affects macrophages and causes enlargement of the spleen and liver (**Figure 2**).

Most protozoans, which are unicellular creatures, infect people as internal parasites. As eukaryotes (animals whose cells have membrane-bound organelles and nuclei), protozoa are single-celled organisms. These unintentionally reach the human host, either directly or indirectly, and cause terrible diseases. The most common and lethal human diseases in the past, including malaria, amoebic dysentery, and African sleeping sickness, were brought on by protozoan infections. Malaria, Giardia, and toxoplasmosis are a few common infectious disorders brought on by protozoans. These infections can be seen in many different body parts. *Entamoeba histolytica* strains exist that are resistant to medication. It is a significant public health issue throughout all of China, south and west Asia, and Latin America, particularly Mexico. It is the cause of amoebiasis. It is commonly accepted that roughly 15% of Indians are affected by amoebiasis. The prevalence of *E histolytica* is highest in poorer nations with the poorest sanitation, where it affects an estimated 10% of the world's population. This causes up to 100,000 fatalities annually and 50 to 100 million instances of colitis or liver abscesses (**Figure 2**).

Most cases of filariasis occur in underdeveloped nations. Lymphatic filariasis is frequently linked to industrialization, urbanization, poverty, illiteracy, and inadequate sanitation. The spread of filariasis was aided by population migration. The infection of *Giardia lamblia* begins in the intestines. The lymph nodes, the eye, and (worryingly) the brain can all be affected by toxoplasmosis. The trophozoite emerges in the small intestine, multiplies quickly, and attaches to the tiny intestinal villi following

ingestion of mature cysts (infective dose varies from 10-100 cysts) through infected water or food. Trophozoites are incapable of surviving outside of the body. Leishmaniasis or Kala azar is caused by an additional intracellular parasite of the species *Leishmania* that attacks macrophage cells. A variety of sand fly species belonging to the subfamily Phlebotominae transmit the parasite. This parasite mostly affects macrophages and results in spleen and liver enlargement (Figure 2).

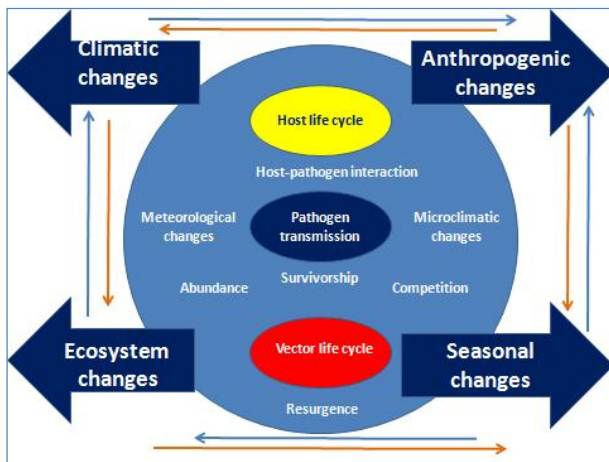


Figure 2. Inter-relationship of anthropogenic and climate change on ecosystem dynamics and host pathogen interactions.

Malaria is a very dreadful protozoan disease caused by a ciliate i.e. *Plasmodium*, its five species (*Plasmodium falciparum*, *Plasmodium knowlesi*, *Plasmodium malariae*, *Plasmodium ovale*, and *Plasmodium vivax*) are identical but its environmental induced variants are different according to eco-climatic zones. Parasite shows high antigenic variation and acquired both climatic adaptations and drug resistance against the conventional drug spectrum. The level of parasitemia varies according to region, person and endemicity. The disease is controlled but its reemergence is occurring at an interval of two-three years. There is two-way problem; on one side mosquitoes have developed resistance against insecticides and parasite has developed resistance against anti-malarial drugs. In both cases changing climatic conditions, urbanization, migration and slums have supported the severity of incidence. A new species *Plasmodium knowlesi* has been identified during the last decade in Malaysia^[92]. Its natural hosts or reser-

voir hosts are monkeys *Macaca fascicularis*, *M. nemestina*, *M. inus*, and *Saimiri scireia*^[92]. This shows increased disease severity and parasitemia. This seems to be co-evolved due to vectorial competence and climatic adaptability^[57].

Although the five *Plasmodium* species (*Plasmodium falciparum*, *Plasmodium knowlesi*, *Plasmodium malariae*, *Plasmodium ovale*, and *Plasmodium vivax* species) are identical, their environmental variants vary depending on the eco-climatic zones, making malaria a highly terrible protozoan disease. In addition to acquiring ecologic adaptations and therapeutic resistance against the standard treatment spectrum, the parasite exhibits considerable antigenic variation. The severity of parasitemia varies by area, individual, and endemicity. Although the condition is under control, it reemerges every two to three years. On one side, parasites have become resistant to anti-malarial medications, and on the other, mosquitoes have become resistant to insecticides. Slums, urbanization, migration, and changing climatic circumstances have all contributed to the severity of the incidence in both cases. Over the past ten years, Malaysia has seen the discovery of new *Plasmodium* species hosts or reservoir hosts^[92]. This demonstrates increasing parasitemia and illness severity. Due to vectorial competency and environmental adaptation, this appears to have co-evolved (Figure 2)^[57].

African sleeping sickness is caused by *T. brucei gambiense* and *T. brucei rhodesiense* in man. The vector which transfers this parasite from an infected person to an unaffected person is tsetse fly. Another species of trypanosome causes *T. cruzi* American trypanosomiasis or chagas diseases. This disease is spread by vector bugs of the genus *Rhodnius* and other arthropods such as lice. Sleeping sickness vector is reported in 36 countries, the disease causes serious neurologic effects. Protozoan parasites have different modes of transmission.-*Balantidium*, *Giardia*, *Entamoeba*, *Cryptosporidium*, *Toxoplasma*, *Cyclospora*, *Microsporidia* show Enteric transmission while *Trichomonas* transmitted sexually. *Babesia*, *Plasmodium*, *Leishmania*, *Trypanosoma* is transmitted by insect vectors. *Toxoplasma* is the

only pathogenic fecal-oral transmitted protozoa that have not been associated with gastroenteritis. Trophozoite-staged organisms are more dangerous rather than Spore-forming protozoa (Goodgame RW.). *B. hominis* is pathogenic only when present in large numbers in the intestine. Three distinct morphologic stages are recognized: vacuolar, granular, and ameboid. *B. hominis* inhabits the large intestine and has no evident life cycle in humans (**Figure 2**) (**Table 1**).

T. brucei gambiense and *T. brucei rhodesiense* are the human causes of African sleeping sickness. The tsetse fly is the vector that spreads this parasite from an infected person to an unaffected person. *T. cruzi* American trypanosomiasis and Chagas illnesses are caused by a different species of trypanosome. Rhodnius vector bugs and other arthropods, like lice, are the main carriers of this disease. 36 countries have recorded cases of sleeping sickness, which has devastating neurologic consequences. There are various ways that protozoan parasites are transmitted. *Trichomonas* does not exhibit enteric transmission, although *Balantidium*, *Giardia*, *Entamoeba*, *Cryptosporidium*, *Toxoplasma*, *Cyclospora*, and *Microsporidia* do. Insect vectors are used to spread *Babesia*, *Plasmodium*, *Leishmania*, and *Trypanosoma* diseases. The only pathogenic protozoa that are transferred by feces and saliva that has not been linked to gastroenteritis is *Toxoplasma*. Infants have *Trichomonas hominis*. Rather than spore-forming protozoa, organisms in the Trophozoite stage are more hazardous (Goodgame RW.). Only when *B. hominis* is prevalent in high concentrations in the intestine is it harmful. Vacuolar, granular, and ameboid are characterized as three separate morphologic stages. *B. hominis* lives in the large intestine and doesn't appear to have a typical life cycle in people (**Figure 2**).

9.2 Bacterial infections

Several factors lead to the development of bacterial infection and disease. The environment also plays a role in host susceptibility. Air pollution as well as chemicals and contaminants in the environment weakens the body's defenses against bacterial infection. Fouling or an unhygienic environment

is the first factor that sets in and favors pathogen multiplication. Second is the presence of a host and transmission vector or any agent. These critically determine whether the disease will develop following transmission of a bacterial agent. Another factor is the number of susceptible and exposed individuals in a population group. The health status of the host is one of the important factors that decide the spectrum of pathogenicity caused by an infectious organism. Pathogenic bacteria evade the body's protective mechanisms and use its resources, causing disease. Finally, virulence shows internal changes occurred in physiological pathways inside the organism's body, and its propensity to cause disease. Among internal factors, toxins released by bacteria decide invasiveness and the level of morbidity caused. Other important factors are genetic constitution, nutritional status, age, duration of exposure to the organism, and coexisting illnesses^[93]. There are different bacterial species i.e. *Bacillus anthracis*, *Brucella sp.*, *Coxiella burnetii*, *Francisella tularensis*, *Leptospira*, *Mycobacterium tuberculosis* complex, *Yersinia pestis* major lethal disease. Due to environmental impact as well as high transmission rate they become uncontrolled and unmanageable (**Figure 2**).

Several things can cause bacterial infections and diseases. In addition, the host's environment affects susceptibility. The body's defenses against bacterial infection are weakened by environmental pollutants, toxins, and air pollution. The first element that develops and promotes disease growth is a foul or unsanitary environment. The existence of a host, a transmission vector, or any agent comes in second. These are crucial in determining whether sickness will manifest itself after bacterial agent transmission. The number of vulnerable and exposed people within a population group is another issue. One of the key variables that determine the range of pathogenicity a given infectious bacterium can cause is the health level of the host. The disease is brought on by pathogenic germs that make use of the body's resources while evading its defenses. Last but not least, virulence demonstrates intrinsic changes in physiological pathways within the organism's body

as well as its potential to spread disease. Toxins secreted by bacteria determine the degree of morbidity induced, among other internal factors. The genetic make-up, nutritional status, age, length of exposure to the organism, and co-occurring disorders are additional crucial variables. *Bacillus anthracis*, *Brucella sp.*, *Coxiella burnetii*, *Francisella tularensis*, *Leptospira*, *Mycobacterium tuberculosis* complex, and *Yersinia pestis* are only a few of the numerous deadly bacterial species. They become uncontrollable and unmanageable due to the high transmission rate and environmental damage (Figure 2).

Climate change, lead to an increase in severe weather events resulting in frequent and more severe flooding and surface water contamination. Because flood water carries lots of untreated waste that contains typhoid pathogens in large numbers and disease spreads easily through the environment. Its causative organisms are acquired via ingestion of food or water, contaminated with human excreta from infected persons. Antibiotic resistance is reported in *Salmonella typhi* which causes typhoid fever^[94]. A cholera epidemic is largely supported by climate and changes its rhythms according to environmental variables, as low precipitation and high temperatures in warmer months bacterial replication occurs faster than in other months^[95]. Tuberculosis is a disease more likely to develop due to poor nutrition, overcrowding, and low socio-economic status. Control of multidrug-resistant TB (MDR TB) is the biggest challenge as it becomes resistant to more than one anti-TB drug and imposes more severe multiple pathological changes in patients and results in high mortality^[96]. A different condition is with Pertussis is a severe respiratory infection caused by *Bordetella pertussis*. *Corynebacterium diphtheriae*, Shigellosis is an infection of the intestine; it is caused by a group of bacteria called *Shigella*, *M. leprae* has acquired multidrug resistance, Anthrax is a zoonotic disease, that is transmitted from animals to humans. Plague is a disease that affects humans and other mammals. It is caused by the bacterium, *Yersinia pestis* (formerly *Pasteurella pestis*). It is caused by a Gram-positive rod-shaped bacterium *Bacillus anthracis*, transmitted

by a bite of an Oriental rat flea (*Xenopsylla cheopis*) (Table 1) (Figure 2).

Surface water contamination and frequent, more severe flooding are outcomes of climate change, which causes an increase in extreme weather occurrences because typhoid bacteria are abundant in untreated sewage carried by floodwater, and because the disease is readily contagious. The organisms that cause it can be consumed through drinking or eating things that have been contaminated with human excreta from sick people. Typhoid fever is brought on by *Salmonella typhi*, which has been linked to antibiotic resistance. Because of limited precipitation and high temperatures in warmer months, bacterial reproduction happens more quickly than in other months, which supports the cholera outbreak in a major. Poor nutrition, overcrowding, and low socio-economic position are the three main risk factors for the disease tuberculosis. The main problem is controlling multidrug-resistant tuberculosis (MDR-TB), which is resistant to various anti-TB drugs, causes severe numerous pathological alterations in patients, and has a high mortality rate. The severe respiratory infection pertussis is brought on by *Bordetella pertussis*. Shigellosis is an intestinal infection brought on by a collection of bacteria known as *Shigella*, *M. leprae* has developed multidrug resistance, and *Corynebacterium diphtheriae*. The zoonotic illness anthrax spreads from animals to people. Both humans and other mammals can contract the plague. *Yersinia pestis*, a bacteria, is the culprit (formerly *Pasteurella pestis*) *Bacillus anthracis*, a Gram-positive rod-shaped bacteria that causes it, spreads through the bite of an Oriental rat flea (*Xenopsylla cheopis*) (Figure 2).

9.3 Fungal infection

Fungi are especially sensitive to climate extremes. Persistently warmer temperatures at increasingly higher latitudes are contributing to the ongoing expansion of the geographic ranges of known fungal pathogens. Alongside fungal species' advancement into new territories, many can develop thermotolerance. Different types of fungus cause

a variety of fungal infections in monsoon season. Fungal spores and mycelia normally grow in high humidity and on unclean surfaces. Opportunistic fungal infections happen due to the massive use of antibiotics. These fungi are nonpathogenic but grow in the upper respiratory tract flora or ear of the immunocompetent host; Aspergillosis is an infection that affects the respiratory system. It is caused by a type of mold (fungus) *Aspergillus*. Mucormycosis (previously called zygomycosis) is a serious but rare fungal infection^[97]. This is an invasive opportunistic fungal disease caused by a group of molds (mucormycetes) *Rhizopus* species, *Mucor* species, *Rhizomucor* species, *Syncephalastrum* species, *Cunninghamella bertholletiae*, *Apophysomyces* species, and *Lichtheimia* (formerly *Absidia*) species^[98]. Other invasive fungal diseases like pneumocystosis, cryptococcosis, histoplasmosis, and coccidioidomycosis are also most frequently seen in autoimmune or immune-deficient patients. These are also evoked all of sudden due to immunological defects and/or concomitant immunosuppressive therapies^[99]. Fungi dermatophytes parasitize the horny cell layer which results dermatophytosis. The most common dermatophytes are *Trichophyton rubrum* and *Trichophyton mentagrophytes*. Candidiasis is an infection caused by a yeast (a type of fungus) called *Candida* (**Table 1**) (**Figure 2**).

Extremes in climate can be particularly harmful to fungi. The geographic ranges of recognized fungal diseases are continuing to expand as a result of consistently warmer temperatures at higher and higher latitudes. Many fungal species have the ability to develop thermotolerance, which helps them spread into new areas. Various fungal infections are caused by various species of fungus during the monsoon season. Mycelia and fungal spores typically flourish on dirty surfaces with high humidity levels. Antibiotic overuse leads to opportunistic fungal infections. Aspergillosis is an infection that affects the respiratory system; nonetheless, these fungi flourish in the upper respiratory tract flora or in the ears of immunocompetent hosts despite being nonpathogenic. *Aspergillus* is a type of mold (fungus) that causes it.

A dangerous yet uncommon fungal infection called mucormycosis (formerly known as zygomycosis)^[97]. A group of molds (mucormycetes) including the *Rhizopus* species, *Mucor* species, *Rhizomucor* species, *Syncephalastrum* species, *Cunninghamella bertholletiae*, *Apophysomyces* species, and *Lichtheimia* (previously *Absidia*) species is responsible for this invasive opportunistic fungal illness^[98]. Pneumocystosis, cryptococcosis, histoplasmosis, and coccidioidomycosis are some other invasive fungal illnesses that are most frequently observed in auto-immune or immune-compromised patients. These can also appear suddenly as a result of immunological issues and/or concurrent immunosuppressive treatments. The horny cell layer that arises from dermatophytosis is parasitized by fungi dermatophytes. *Trichophyton rubrum* and *Trichophyton mentagrophytes* are the two most typical dermatophytes. The yeast (or fungus) called *Candida* is the source of the infection known as candidiasis (**Figure 2**).

9.4 Virus generated diseases

Many of the root causes of climate change also increase the risk of virus or bacterial pandemics. Climate change is directly or indirectly responsible for global environmental change and zoonotic disease emergence. This is massively affecting human health in Europe, Asia and Africa where so many hotspots of the virus, protozoan and bacterial deadly diseases have been identified. Climate change mainly shifting seasonal cycles has increased the risk of emerging infectious diseases propagating from animals to humans, from humans to animals or vice versa over the last several decades, including the flu, HIV, Ebola and coronavirus. The virus is finding and establishing itself in new hosts with new epidemiological routes of infection. Most of the virus-generated diseases have been evoked due to climatic effects, drug regimens, and resistance acquired by their circulating strains. Most viruses such as Rhinovirus, Respiratory Syncytial Virus, Herpes Simplex Virus, Adenovirus, cytomegalovirus, influenza virus Type A, Type B, parainfluenza virus, SARS corona virus, poliovirus, HTLV-1,

gastroenteritis virus, adenovirus, rotavirus, Norovirus, Astrovirus, coronavirus, pancreatitis coxsackie virus, Hepatitis virus A, B, C, D, E, dengue, and West Nile Virus, Rabies generated disease are on the rise because of attainment of new genetic variations and resistance to therapeutic drugs and vaccines [93]. Recently, WHO has alarmed many countries about new waves of infection caused by Ebola virus, Hantavirus associated with HCPS, Hendra virus, highly pathogenic virus H5N1, Lassa fever virus, lymphocyte choriomeningitis virus, monkeypox virus, Nipah virus, Rabies and Rubella, Rotavirus B, Chikungunia virus and Yellow fever virus. Since 2000 many virus diseases have re-emerged after a prolonged time. Every year incidence rate of sexually transmitted diseases, Herpes simplex virus type 2, human papillomavirus, SARS and H1N1 is increasing. All these viruses changed the intensity of infection, morbidity and mortality rate; even despite clinical and therapeutic care, the mortality rate is not coming down. The major reason for the occurrence of virus and protozoan diseases is the induction of disease transmission vectors in endemic areas. Though no direct evidence of the effect of climate on the transmission of coronavirus has been identified it is well known that climate is supporting vector and pathogen populations and natural boundaries of disease occurrence are extended from endemic to non-endemic areas (**Figure 2**).

Many of the underlying factors contributing to climate change also raise the danger of bacterial or viral pandemics. Environmental change on a global scale and the emergence of zoonotic diseases are caused by climate change, either directly or indirectly. In regions where lethal viral, protozoan, and bacterial illnesses have been identified as hotspots, such as Europe, Asia, and Africa, this is having a significant negative impact on human health. Over the past few decades, climate change has raised the possibility of developing infectious illnesses including the flu, HIV, Ebola, and coronavirus spreading from animals to humans, from humans to animals, or vice versa. With the help of new epidemiological pathways of infection, the virus is locating and estab-

lishing itself in new hosts.. The majority of viral diseases have been brought on by treatment regimens, environmental factors, and resistance developed by circulating strains. The majority of viruses, including the rhinovirus, respiratory syncytial virus, herpes simplex virus, adenovirus, cytomegalovirus, influenza type A, type B, parainfluenza virus, poliovirus, HTLV-1, gastroenteritis virus, rotavirus, norovirus, astrovirus, coronavirus, pancreatitis coxsackie virus, hepatitis virus A, B, C, Recent outbreaks of infection brought on by the Ebola virus, Hantavirus associated with HCPS, Hendra virus, highly pathogenic H5N1, Lassa fever virus, lymphocyte choriomeningitis virus, monkeypox virus, Nipah virus, Rabies and Rubella, Rotavirus B, Chikungunya virus, and Yellow fever virus have alarmed many nations, according to the World Health Organization. Numerous virus-related diseases have returned in large numbers since the year 2000. Sexually transmitted illnesses, human papillomavirus type 2, SARS, and H1N1 all have risen incidence rates each year. Even with clinical and therapeutic treatment, the mortality rate is not decreasing because all these viruses altered the severity of infection, morbidity, and fatality rates. The introduction of disease transmission vectors in endemic areas is the main cause of the occurrence of viral and protozoan infections. Although there is no clear proof that the climate affects coronavirus transmission, it is well-recognized that the climate supports the populations of pathogens and vectors and that the natural bounds of disease occurrence stretch from endemic to non-endemic locations (**Figure 2**).

10. Results and discussion

Climate changes have increased the risk of infections. Diseases most likely to increase in their distribution and severity have three-factor (agent, vector, and human being) and four-factor (plus vertebrate reservoir host) ecology. *Aedes aegypti* and *Aedes albopictus* mosquitoes may move northward and have more rapid metamorphosis with global warming. These mosquitoes transmit the dengue virus, and *Aedes aegypti* transmits the yellow fever virus. Climate change has increased the chances of cross-species

viral transmission risk^[100]. The faster metamorphosis and a shorter extrinsic incubation of dengue and yellow fever viruses could lead to epidemics in North America^[101]. For example temperature-sensitive mutants of Japanese encephalitis virus, Dengue fever, H1N1, Hepatitis B have been detected. Heat-sensitive strains of rotaviruses are causing life-threatening dehydrating gastroenteritis in children and animals.

10.1 Molecular alterations in host-pathogen interactions

For finding quick solutions detailed study of “host-pathogen” interactions is highly important. For this purpose all ecological, physiological and molecular reasons are explored to find out the reasons for disease outbreaks, their progression and the outcome of infections. There is a gap in host-parasite interaction about the origin and route of infection, transmission, latency time, progression, host immunity and defense acquired by viral, parasitic and zoonotic pathogens. For solving the pathogenesis and disease occurrence host immunity^[102] growing resistance in pathogens and co-evolution of microbial antigens and host receptor interactions must be explored^[103]. This is also important for discovering rapid remedies.

Exploring “host-pathogen” interactions will be more useful for understanding the causes, course, and effects of infectious diseases. It will also help in finding the level of host immunity to disease pathogenesis and inadvertent incidences occurring year after year^[102], as how does host immune alterations affect stopping pathogens to invade the host^[103]. During the COVID-19 pandemic, there have been many improper responses that have been observed, either delayed or early^[103]. As a result, there has been an increase in fatalities, economic loss, and clinical health harm.

Host vector interactions and environmental responses must be gauged for disease transmission by infected and non infected vector population in natural ecological divisions. In addition, all effects related to physiology, behavior, and evolution of human disease vectors must be checked according to

genomic data available to map the global health of people (Rinker, David C., 2016). In order to prevent disease transmission by infected and non-infected vector populations in naturally occurring ecological divisions, host vector interactions and environmental reactions must be considered. The host models are required to predict future disease occurrence, epidemiology, genetic invasion of the host and length of pathogen life cycles. Additionally, in order to map the worldwide health of people, all consequences linked to the physiology, behavior, and evolution of human disease vectors must be evaluated^[104]. To forecast future disease occurrence, epidemiology, genetic host invasion, and pathogen life-cycle length, computer-based models are necessary.

10.2 Future planning and solutions

Climate change is an emerging disastrous problem that is creating adversities not only for nature but it is a great challenge to human life and well-being. As seasonal climatic variations occur with the changing weather conditions and the seasonal cycle completes almost every year. Climate change is creating human health-related issues mainly incidences of communicable diseases have increased. Significant elevation in the level of environmental pollutants and their regular exposure caused many human health-related risks. Global climate has severely affected human behavior. Due to contact with contaminated air, water, and food untimely diseases, pathogenic morbidities, gastric problems, and psychosocial stress have increased the vulnerability of humans to pollutants/chemicals. Unfortunately, on one side climate change has increased the chances of droughts that are happening around the globe and developing countries suffering at higher rates. Droughts are highly problematic for all farmers. On the other side, there is simultaneous happening of floods that are affecting agriculture production that resulted in price hike in food commodities and putting a large section of people at higher risk of hunger. Climate change is threatening the world’s food production and supply. Heavy rains and floods also forced people to migrate. It results in the degradation

of farmlands, and loss of seed and crop production. It leads to competition over precious natural resources. Over time, social conflicts displaced entire communities and thrashed to live under life-threatening hunger. Increasing temperature, unavailability of water, and massive hunting are depleting wildlife, deforestation is also very high, and habitat and species loss are on high stakes. Increasing temperatures are problematic for those who own livestock. Year after year sequential cumulative effects of climate change on ecosystem production are worsening; there is devastation due to heavy floods or heavy draughts in croplands (**Figure 3**). This is the main cause of price hikes, poverty, crime, and human migration. This wide impact is increasing in agrarian societies because of the loss of fertile lands and low crop yield. Higher temperatures make it harder for animals to live; if farmers cannot provide enough fresh water to keep their livestock hydrated, they can become diseased or die of dehydration. Loss of glaciers is an important alarm that the earth atmospheric temperature is on the rise and it is causing global warming and showing multiple effects on both human, animal, and plant life (**Figure 3**).

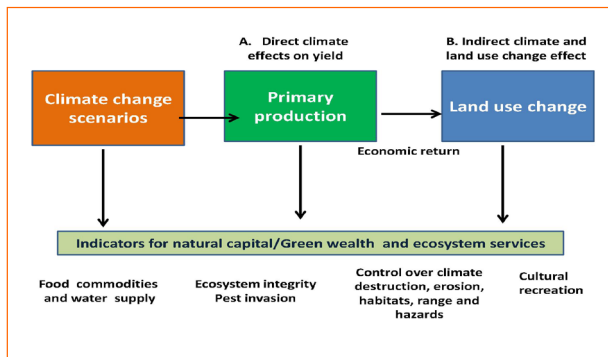


Figure 3. Sequential effects of climate change on ecosystem production and land use.

Climate change is disturbing atmospheric temperature hydro-biological cycle as torrent rains and heavy floods or longer draughts have been seen in so many parts of the world. Due to lesser downpours and precipitation, rainwater, underground water, and hydrologic aquifers are drying out. Agriculture is drying out and irrigated crops are diminishing at a high rate. Due to rising diesel prices, farming be-

comes more expensive and difficult for poor farmers. In all regions, traditional agriculture is no longer practiced because of changing weather conditions and rising temperatures.

For making human society pollution free, cut down all types of pollutants by making source-level inhibition. For prompt action policy, an action plan and budgetary provisions are to be made to solve the problem. Use the most recent technology for automobile vehicles to minimize diesel exhaust particles, carbon monoxide, and particulate pollutants in the air. For vertical mixing of pollutants uses precipitators and power air filters to minimize the air pollution levels in urban cities. To minimize the gaseous air pollutants such as oxides of sulfur, nitrogen and carbon, hydrogen sulfide, hydrocarbons, ozone and other oxidants, fine technology network system and fuel options be made. Maximize the use of electric, solar and nuclear power-operated vehicles. There must be a ban on the production of single-use polymers which are un-biodegradable, polymers, pollutants, toxic gases, and coal ashes.

For economic well being of farmers search, develop and use resistant plant varieties or cultivars by incorporating the genes causing the leaf surface to become coated in wax crystals, repelling water and decrease evapo-transpiration. Search more genes to increase long-term flood tolerance, make CO₂-smart plants to cut down carbon level in atmosphere. Replace synthetic antibiotics by searching new plant origin bio-organic chemicals to end the problem of drug resistance and vicious cycle of remerging communicable diseases. Increase carbon mineralization across the forest communities by using bacterial population to fix more carbon other than large plant species. Grow new perennial forests and convert land use pattern for long sustainable use, cut down use of synthetic pesticides, fertilizers, weedicides, and apply safe integrated agro-ecosystem practices for control of insects, parasites, and predators.

Make policies to facilitate resource-sharing agreements and promote cooperation between communities to reduce conflict, providing a space for people living there to pursue new types of work such

as cooking, cleaning, or construction. Form green governance, and collaborate with local and national governments to improve their ability to manage and prepare for weather-related risks. The income of farmers should increase and they should not give up agriculture in search of other ways/means to bring income to their families. Favor people for learning new technologies, and redesigning their farmland to maximize land productivity and protect the soil in the face of increasingly severe and frequent droughts. Make more adaptation strategies for the operational management of aging dams in a changing climate, together with adequate and timely maintenance. Therefore, long-term policy frame work and environmental management and planning must be made to save the life of the future generation. Therefore, for displaced vulnerable populations proactive adaptive capacity should be made by generating funds and green policies, practices, and laws.

To control ongoing and projected damage to ecosystems and human communities, global warming keeps to a maximum of 2 °C over pre-industrial levels, more than this will threaten human health, water supplies and ecosystems more vulnerable, hence, a warming of at least 1 °C appears unavoidable (**Figure 3**). The main reason for this warming is man-made emissions of carbon dioxide and other heat-trapping gases. These gaseous clouds have made a thick blanket over the earth and are trapping extra sunlight and strong rays are reverting. It resulted in temperatures rising. To find quick solutions there must be a ban on coal-based manufacturing units, and other sources of greenhouse gas emissions must be controlled with efforts to minimize the anticipated effects of climate change. Hence, for developing new safe gourds CO₂ emissions should be minimized and forest cover is being increased to minimize adverse episodic changes in the atmosphere and their impact on human health.

The more suggestible point is to immediately check the combustion of fossil fuels such as coal, oil, and natural gas. Coal is particularly damaging, as it produces 70% more CO₂ emissions than natural gas for the same energy output. Electricity generation is

the single largest source of manmade CO₂, amounting to 37% of worldwide emissions. Efforts of United Nations environmental protection programs are directing every nation to replace CO₂-releasing industrial units with electric power that should be generated from noncoal sources sector to become CO₂-free. It is mandatory for developed, developing, and underdeveloped countries. Organizations responsible for the assessment and management of health risks of chemicals, therefore, need to be more proactive and consider the implications of GCC for their procedures and processes.

For mitigation of automobile-generated aerosols and particulate matter, air purifies and uses alternative sources of fuel other than gasoline and hydrocarbons. Eco-friendly alternatives are CNG, electric vehicles, solar power vehicles, and ethanol as fuel. Automobile engine design and filters can also save environmental oxygen. Cut down the use of CFCs in air conditioners, freezers, and other appliances. Stop using heat-generating plants and think about low-energy processors and liquid fuels which convert into a gas at low ignition temperatures. Utilities can support meaningful global warming legislation, to improve the energy efficiency of power plants, increase their use of renewable energy sources, and halt investment in new coal plants and coal mining. Electricity consumers should opt for “green power” where it is available, demand this choice where it is not, and invest in highly efficient appliances. Policymakers must ease the transition to a carbon-free energy industry by passing legislation that creates favorable market conditions, shaping new frameworks for change, and ensuring that the Kyoto Protocol, the world’s primary legal tool to combat global warming, enters into force as soon as possible.

Ecological modeling, farm track engineering, and urban forestry could play an important role in finding solutions to air pollution soil, erosion control, and noise. Technological development is required to manage industrial wastes, emissions, and wastewater treatment for environmental safety. Pilot projects are required for the management of good recharging, rainwater harvesting, and drip irrigation methods.

These can control problems related to water scarcity. On the other hand, pretreatment of wastewater before its discharge into water bodies will protect the flowing water from pollution. The further cultural environment could be maintained by renewing and preservation of scenic beauty and developing historical sites, airy and making residential development open and using only eco-friendly land use methods for management of climate-related effects. For finding quick solutions local and national governments should cooperate to manage crop production, price rise, and storage with solutions for weather-related risks mainly making society, administration, and government proactive in disaster response. Making environment safety-based policies, and development planning establishing control-warning centers can reduce vulnerability to disasters caused due to climate change.

11. Conclusions

To reverse climatic conditions as normal a 50% cut down must be required in gaseous emissions. Further, to reduce major prevailing major changes in the elevation of global temperature CO₂ emission must be stopped completely up to zero by 2050. It will solve the problem of accidental torrent rains; floods, droughts, and vector population. For control of communicable diseases integrated surveillance, investigation, long term funding is required. It will assist in to study of epidemiological reasons and the identification of pathogen-host-vector interaction at the molecular level. Further, to reduce the burden of infectious diseases as the development of rapid, accurate, low-cost diagnostics; novel therapeutics, and vaccines; innovative vector control and surveillance tools are also required for quick action. An early warning system is required to integrate clinical research, health, and climate operations. More speedy data and knowledge-sharing platforms, outreach and education, response activities, community education, and social mobilization via social media are essentially required. The global health community has many actors that pursue this common agenda, including multilateral organizations; funders, includ-

ing governments and foundations; non-governmental organizations; researchers; and practitioners. Besides following a long route to combat communicable diseases, it will be much better to aware people of their self-protection, vector control, sanitation, and recycling of waste, and approach them to learn health and hygiene principles. Parasites show high antigenic variation and acquired both eco-climatic adaptations and drug resistance against conventional drug spectrum, therefore, new highly effective drug regimens, antibodies, antiserum, and vaccines are required to fight against newly emerging climate-induced microbial diseases. This is highly important to know the ecology, genetics, and molecular mechanisms of disease transmission, host-parasitic interaction and developing drug resistance in microbial pathogens.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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