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The Impact of Climate Change on Vector-Borne Diseases: A Public Health Perspective

Fatima Zahra Abubakar-Otaru*
Galaxy College of Health Technology Bauchi, Nigeria.
Yusuf Yahaya Miya
University of Port Harcourt, Rivers State, Nigeria.
Ummu Tukur
Department of Biology, Shehu Shagari University of Education Sokoto, Nigeria.

****Corresponding author: Fatima Zahra Abubakar-Otaru (fzahrabubakar91@gmail.com)***

Article Info

Abstract

Climate change has significant impacts on human health, particularly on vector-borne diseases (VBDs). VBDs, such as malaria, dengue fever, and yellow fever, are transmitted by vectors like mosquitoes, ticks, and flies. Climate change affects the distribution, behavior, and ecology of these vectors, leading to changes in disease transmission patterns. This paper reviews the impact of climate change on VBDs from a public health perspective. It discusses how climate change affects the transmission of VBDs, including changes in temperature, precipitation, and humidity. The paper also explores how human behaviors, such as migration, urbanization, and land use changes, contribute to the spread of VBDs. The authors highlight the need for integrated approaches to mitigate the impacts of climate change on VBDs. These approaches include vector control measures, such as insecticide-treated bed nets and indoor residual spraying, as well as public health interventions, such as vaccination and disease surveillance. The paper concludes that climate change poses significant challenges to public health, particularly in regions with limited resources and infrastructure. It emphasizes the need for urgent action to address the impacts of climate change on VBDs and to protect human health.

Keywords:

Climate change, vector-borne diseases, Public health, Malaria, dengue fever, Yellow fever.

1. Introduction

Verily, the earth collects shortwave radiation from the sun, and it reflects 1/3 of it, therewith, the remaining radiation is absorbed by the land, biota, atmosphere, ocean, and land. The energy absorbed by other entities from the sun is usually balanced as a result of the outgoing radiation from the atmosphere and the earth. Terrestrial radiation is divulged as long wave infrared radiation energy. However, the process involving a balanced emission and absorption of the sun's radiation is ensured or distorted due to certain factors. Changes in the energy released by the sun, slow variations in the earth's orbit, and the process of greenhouse effect are factors affecting the aforementioned balance (Santra, 2016; WWF,2017). The greenhouse gases include carbon dioxide, methane, nitrous oxide, water vapor, and ozone present in stratosphere and troposphere. These gases have the ability to cause a warming effect on earth's surface. The greenhouse effect largely arises because the atmosphere is transparent to the incoming solar energy radiation and heavily absorbing the outgoing thermal energy radiation coming from the planetary surface and indeed the atmosphere. The inception of industrial or anthropogenic activities in the 21st century escalated the normal natural greenhouse effect, thereby making it an enhanced process (Santra, 2016).

Weather and climate descriptions are related to the atmosphere. Atmosphere is an enclosed entity if the globe containing gases and vapor and as well receiving solar energy, about 966km above sea level is the atmosphere. The atmosphere may be into parts such as the lower or higher parts. The lower part of the atmosphere is called the troposphere and is responsible with the weather. Troposphere extends from earth's surface to about 10km, the higher the altitude the lower the temperature. Lower part of the atmosphere may contain 78% nitrogen, 21% oxygen, 0.003% carbon dioxide, traces of helium, argon, related rare gases and water (about 4% by volume). Varied contents of the atmosphere from varied parts of the world cause varied weather and climate. Noteworthy, the lower part of the atmosphere may contain even the microbes, dust, fossil fuels released gases. The climate change elements largely include, temperature, precipitation, winds, and pressure; while the climatic factors include, latitude, ocean currents, slope, vegetation, and continentiality. Going forward, just after the troposphere there exists the stratosphere, which extends to about 80km or more. Stratosphere is categorically cold, without dust, smoke, or vapor. Then followed the ionosphere that extends about 402km upward, electrically conducts the shortwave radio transmission. Exosphere contains gases or air (Santra, 2016). This paper reviews the impact of climate change on VBDs from a public health perspective.

2. Greenhouse Gases Elicit Climate Change

Greenhouse gases (GHCs) are certain examples of a specific group consisting of gases due to their ability to trap radiation that would otherwise be released put into space, heating the earth's atmosphere. They act like greenhouse that ensures that plants are warmed. The GHCs are important to keep the average global temperature at 15oC not -18oC that is very very cold; therewith, major greenhouse gases include carbon dioxide, methane, nitrous oxide, and others (water vapor and ozone) (Michigan State University Extension, 2011).

Excessive rise in fossil fuels combustion due to various human activities spur a rise in carbon dioxide level in the atmosphere, therewith, coupled with depletion of available carbon sinks. This lead to an increase or rise in global temperature (Sheffran, 2008). Observations through several studies and measurements indicate that, humans are spurring an increasing presence of greenhouse gases including carbon dioxide, nitrous oxide, hydrofluorocarbons, and chlorofluorocarbons in the atmosphere (Sarkingobir et al., 2021). The gases known as greenhouse gases are naturally occurring without causing concern to human existence on earth, until the indiscriminate anthropogenic activities lead to their increase above normal levels. Therewith, the increase in greenhouse gases spur an increase in warming of the planet and ultimately leading to climate change (WHO, 2003; WHO, 2009). Out of the whole solar energy reaching the atmosphere, about 30% is reflected back into the space by the atmosphere (as a result of the

clouds) and the space; 20% of the solar energy is taken in (absorbed) in the atmosphere (due to water vapor, clouds, and as well aerosols); 50% is absorbed (or taken-in) by earth's surface. In order to see a balanced system (steady temperature), the energy absorbed shall be balanced by the radiation energy being emitted away (in form of infrared or heat radiation). If the atmosphere is transparent, the earth will be too cold to support life, but it is not transparent to infrared radiation, it rather recycle the portion of the radiation in order to warm the earth. This process is formally regarded as natural greenhouse effect (MacCraken, 2001). Enhanced greenhouse effect is the greenhouse effect spurred by human activities. Mostly, carbon dioxide and water vapor released to the atmosphere contribute greatly to enhanced greenhouse effect. There are some entities that released carbon to the atmosphere (due to anthropogenic processes) to the atmosphere and are denoted as carbon sources; while, entities that take-in carbon and offset it from the atmosphere are denoted as carbon sinks (United States Environmental Agency, 2017; University of Victoria, 2020). Carbon sources due to fossil fuels combustion release carbon dioxide, nitrogen oxides, to the atmosphere. Likewise, clearing of lands from the forests or vegetation releases carbon to the atmosphere. Similarly, carbon sinks include, oceans, terrestrial biosphere (such as photosynthesis, reduced respiration) (Michigan State University Extension, 2011). Verily in the Tables 1 and 2 various carbon sinks and sources for greenhouse gases are indicated (some greenhouse gases and their human sources are shown in Table 1).

The planet is deemed to be healthy based on its carbon status and carbon cycle through the Earth's air, land, and water (oceans). There is need for a suited balance of how much carbon is released and the amount being stored; but, human-made activities spur an imbalance that is detrimental to all (Lu et al., 2022). Carbon source refers to any activity that release carbon dioxide into the atmosphere. Carbon source divulge more carbon than it takes. Some natural sources of carbon dioxide include fires, volcanoes, decay, breathing, digestion, freshwater bodies, and oceans. Man-made activities as important carbon sources include, drilling and mining of fuels, deforestation or land clearing, and industrial activities. Carbon sink is any kind of activity that take in (absorbs) carbon dioxide, therewith, usually carbon sinks take more carbon than they released. Natural carbon sinks include, oceans, freshwaters, plants (forests), carbonated rocks, and fossil fuels (Santra, 2016; Liu et al., 2022).

Table 1: Some examples of popular carbon sinks and sources

Important sink	Activity	Anthropogenic concern or sources
Forest and land plants	They take-in about 25% of the carbon from the atmosphere via photosynthesis	Deforestation Fires Insect outbreaks Agricultural land clearing Urbanization
Waterbodies (lakes, oceans, seas)	Take-in 25% of the atmospheric carbon dioxide Aquatic plants carry out photosynthesis	Higher temperature cause release of carbon dioxide through evaporation Acidity and effect on some aquatic animals
Soil (underground)	Burying of organic matter Formation of sediment	Agricultural methods like tillage, ploughing, etc expose buried organic matter

Table 2: Some greenhouse gases and their human sources

Number	Gas	Human activity releasing the gas
1	Carbon dioxide	Fossil fuel burning Burning of wood Deforestation Land use enhancement
2	Water vapor	Hydrological cycle inducement
3	Methane	Released from oil, gas or coal burning Fermentation Wetland rice activities Waste incineration Incineration of decay matter or biomass
4	Chlorofluorocarbons (CFCs)	Solvents utilization, aerosol spray propellants, etc
5	Perfluoromethane (CF_4)	Aluminum synthesis
6	Nitrous oxide (N_2O)	Burning of fossils Synthesis of fertilizers
7	Carbon monoxide	Burning of biomass, and fossil fuels
8	Sulphur hexafluoride(SF_4)	Dielectric fluid
9	Non-methane hydrocarbons	Evaporation liquid fuels and solvents

3. Some Impacts of Climate Change

The increase in the free greenhouse gases on earth spur climate change, and consequently some impacts are as follows (Table 3 shows some impacts of climate change):

Rise or change in sea level- Due to global warming rise or change in sea level occurs through the preceding processes viz, thermal expansion, mountain glacier melting, Greenland ice sheet melting, and Antarctic ice sheet melting (Santra, 2016; Morisetti, & Brown, 2021).

Crop yield changes- In some areas the crop yield may be altered by increasing in a tune of 60-80%, because the increased level of carbon dioxide may be converted to sugars, but other factors may lead to offsetting of this increase The C3 crops (such as wheat, barley, soy beans, and rice) may be dominant, they show an

increase yield of about 30% during experiment, but spread of pests (such as insects) and disease pathogens spurred by climate change lead to setbacks (MacCraken, 2001; Kaddo, 2016).

Water balance- Greenhouse effect affects water balance and spur serious problems. The areas in the warm regions are expected to have more water crises, and some areas will have excess water availability (Kaddo, 2016).

Human health- Climate change generally affect health through spurred records of increase spread of disease causing agents. The climate change effects that affect health include, increased temperature (causing illnesses), extreme events, air pollution, drought (malnutrition), poor mental health, and water and food-borne diseases (Heirings, 2010; IPCC, 2014).

Table 3: Some impacts of climate change

S/N	Primary impact	Secondary impact
1	Extreme precipitation	Flooding around river basins Erosion Landslides Diseases spread
2	Cyclones/ stormy events/ hurricanes	Storm surging Heavy windstorms
3	Increased temperature	Heat waves Loss of glaciers Bush fires Loss of ice Drought
4	Ecosystem adaptation	Migration Disease spread (especially vector-borne)
5	Rising sea level	Flooding in coast and fluvial areas Water pollution

4. Infectious Diseases Are Sensitive to Climate Change Elements

The various elements of climate change such as temperature, rainfall, wind, humidity led to changes in infectious diseases transmission as disclosed by several studies (Santra, 2016). Transmission cycles of infectious diseases are determined by the environmental factors that are tilted by the changes brought by climate change. More especially, the diseases spurred by vectors are affected by changes in climate, include the case of malaria and dengue fever. The vectors that aid or facilitate transmission are affected by changes in the external environment. Parable, flooding spurred by climatic changes increase the rate of transmission of water-borne diseases. Cholera caused by Vibrio cholerae infection is increased as a result of poor water hygiene spurred by climate change. Particularly, the climatic factors affecting vector-borne diseases include temperature, precipitation, humidity, level of sea. Vectors living in cold or lower

temperatures environment are harnessed due to increase in temperatures (at a certain levels), thereby altering biting rates, mating, reproduction rate, etc. During high temperatures that are harmful to vectors, they may change geographical locations thereby tilting epidemiology or the vectors, may undergo adaptation changes to thrive. Regards to precipitation, increased in rain falling may increase disease outbreaks by increasing the presence of vectors, expanding larval habitat, giving-out new breeding sites (McMichael et al., 2003; Al-Khatib, 2015).

5. Vector-Borne Diseases and Climate Change

Verily, a vector is the major mode of transmitting infectious diseases from host to host. Ideally, vector-borne diseases are diseases spread by small animal vectors or arthropod. The vector-borne diseases transmission occur in two types, basically, the human-vector-human (otherwise anthroponotic infections) and animal-vector-human (zoonotic infections). The anthroponotic infections include malaria, yellow fever, and dengue fever; while the zoonotic infections include, Lyme disease, Hantaviral disease and most arboviral diseases (Al-Khatib, 2015; European union, 2018). The anthroponotic infections need humans as the only reservoir of the diseases, and spur human to vector and human transmission; while the zoonotic infections utilize animals as the main reservoir of the disease, while humans act as the spillover or secondary hosts; therewith, they do not contribute to the disease transmission cycle (levels of circulating pathogens is insignificant). The vector-borne disease (VBD) possessed 3 crucial elements, viz, susceptible hosts or population, vector (mostly arthropods) and diseases agent (such as virus, bacteria, parasite) (Negev et al., 2015). The VBD diseases occur if the conditions involving the disease cycle are met, and these conditions may be tilted by climate change depending on the areas of the world involved (WHO, 2015ab).

Some vector-borne diseases (VBDs) of concern include the filarial nematodes, some viral diseases, and protozoans, as shown in Table 4.

Table 4: Some vector-borne diseases (VBDs) of concern include the filarial nematodes, some viral diseases, and protozoans

Disease	Pathogen	Vector	Type	Present distribution in the areas of the world	People at risk
Malaria	*Plasmodium spp*	*Anopheles spp*. mosquitoes	Anthroponotic	Subtropics and tropics	270 million
Leishmaniasis	*Leishmania spp*	Lutzomyia and *phlebotomics spp*. sandfiles	Zoonotic		
Chagas diseases	*Tyrypanosoma cruzi*	*Glossina spp*. (tsetse fly) *Triatomine spp*.	Zoonotic		
Dengue	DEN-1,2,3,4 flaviviruss	*Aedes aegypti* mosquito	Zoonotic	Tropics	
Yellow fever	Yellow fever flavivirus	*Aedes aegypti* mosquito	Zoonotic	Tropical South America, Africa	
Encephalitis	Flavi-, alpha- and bunyaviruses	Ticks and mosquitoes	Zoonotic		
Lymphatic filariasis	*Brugia malayi*, *Wuchereria bancrofti*	Anopheles, Culex, Aedes mosquitos	Anthroponotic	Subtropics and tropics	900 million
Onchocerciasis	*Onchocera volvulus*	*Simullium spp*. Blackflies	Anthroponotic	Africa and Latin America	90 million
Sleeping sickness		Tsetse fly		Tropical Africa	25, 000 new cases

Directly the climate change harness the rate or range or abundance of animal reservoirs or arthropods in the case of malaria. Lyme, Schistosomiasis; enhance transmission of arboviruses and West Nile virus. Climate change directly increase the rate of importation of vectors or pathogens in the case of Dengue fever, Chikungunya, and West Nile virus; while it increases risk of trypanosomiasis. The aspect of climate change which include temperature harness vectors, and pathogens. Pathogens are encouraged through reduced length of incubation, transmission season alteration, altered geography, and reduced viral replication. Likewise, precipitation increased vectors survival, create habitat (due to low rainfall), heavy rainfall synchronize vector host- seeking and virus transmission, increased humidity elevates vector survival, and low rainfall harness container growing mosquitoes. In the same vein, vectors are increased by relative humidity, through increased transmission (WHO, 2015).

Nevertheless, human behaviors act as modifying factors in the cases of vector-borne diseases. Climate change affect transmission of diseases through the human behaviors been perpetrated and therefore they act as determinants of diseases. For instance, socioeconomic factors of individuals, groups, and societies such as migration, poor nutrition, environmental hygiene, disease control, drug resistance, and land uses affect the prevalence rates of infectious diseases (Santra, 2016; Sarkingobir & Miya, 2025) as shown in Table 5.

Table 5: Some determinants of infectious diseases amidst climate change

Determinants	Related disease	General pathways
Dams, irrigations, canals	Malaria, schistosomiasis River blindness Helminthiasis	Breeding sites provision Increased contact with humans
Agriculture	Malaria	Vector resistance due to insecticide spread
Urbanization	Cholera Malaria	Poor sanitation Water insufficiency Breeding habitats
High precipitation	Rift valley fever	Pools of mosquitoes
Malnutrition	Diarrheal diseases	Metabolic problem

6. Suggestions

The issue of climate change effects could only be adapted by humans through concerted efforts (Morisetti & Brown, 2021). Some of the suggestions to reduce climate change effects especially on vector-borne disease spread are elaborated in this section.

6.1 Pests Control in Crops and Animals to Aid Public Health Nutrition

Humans require foods from healthy sources such as crops in order to be healthy and be able to fight infections properly (FAO, 2011). However, pest affecting crops are causing a lot of havoc, therefore had to be contained through several methods. The methods of containing some pest of crops are specified in Table 6. Usually, pests are contained or control through physical methods by collecting the pests manually and destroying them such as through using pest traps, burning, and flooding. Cultural methods of pest control include use of tactics to modify the environment so that the growth of pest is not supported, therewith, use of ploys such as crop rotation, bush fallowing, burning, and clearing, are examples (Areola

et al., 2006; Bashar, 2025). In biological methods, enemy organism is used to destroy the pest, for instance use of wasp to kill stem borers. In chemical method of pest control, use of certain biocidal chemicals is required. Certainly, examples of pest control methodologies and crops affected are shown in Table 6.

Table 6: Examples of pest control methodologies and crops affected

Determinants	Related disease	General pathways
Dams, irrigations, canals	Malaria, schistosomiasis River blindness Helminthiasis	Breeding sites provision Increased contact with humans
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Malnutrition	Diarrheal diseases	Metabolic problem

In animals, there is abundance of proteins, minerals, lipids, vitamins, and other valuable nutrients, therefore, nutrition devoid of animal-based foods is insufficient to provide all the nutrients in order to avoid malnutrition (Sarkingobir & Miya, 2024; Bashar, 2025). Thus, controlling diseases of animals is essential, as shown in Table 7 there are some major diseases affecting animal yields that have to be contained.

Table 7: Some major disease in farm animals

Animal	Disease agent	Disease	Containment
Sheep, cattle, goat	Virus	Rinderpest	Vaccination, slaughtering of the affected animal
Poultry	Protozoan	Coccidiosis	Segregation of healthy and unhealthy ones, administration of antibiotics
Cattle	Bacteria	Bovine dermatophilosis disease	Use of resistant animal, culling of infected animals
Poultry	Virus	Newcastle disease	Vaccination, destruction of affected fowls

6.2 Vector Control Approaches

Vectors are animals, but are harmful because they transmit disease causing agents, therefore are to be subjected to control methods in order to safeguard public health. The common vectors include, mosquitoes, lice, flies, and fleas. Mosquitoes are mostly the anopheles, Culex, and Aedes, and they spread

malaria, yellow fever, encephalitis, filariasis, and dengue. Mosquitoes are control by draining of ditches, swamps, pools, and related places; disposing unwanted containers to prevent inhabitation by mosquitoes, spraying of stagnant waters with chemicals such as kerosene; and cleaning of vegetation and weeds around settlement (Negev et al., 2015; Charles et al., 2020). Other method includes sterilization of male mosquitoes. Houseflies are control by burning of garbage, burying of waste, improvement of sewage and waste disposal; methods and application of chemicals to kill adults and larva. Rodents such as rats and mice are controlled through use of chemicals, destruction of their habitats, proper food storage, proper waste disposal, and practicing of personal hygiene (WHO, 2015a). Another main aspect in public health prevention is the personal hygiene which include cleaning the followings: scalp, armpits, nose, eye, hair, groins, hands, finger nails, teeth, feet, nails. A person shall always wash hands properly and frequently especially before and after eating or toilet or food preparation (Negev et al., 2015).

7. Conclusion

In many of the developing communities there are issues of handling of human feces or other forms of waste materials; about 2.5 million people lack adequate system for safe release of human excreta (disposal of human waste). This issue lead to spread of diseases, mortalities, morbidities, healthcare cost, and more impoverishment; especially affecting children, women, and old folks. Therefore, it is important to educate the public about personal hygiene, community hygiene (construction of toilets by individuals, households, families, and communities), ensuring food hygiene, construction and improvement of water supply such as hand-dug well, and pipe-borne water systems. There is indeed need for concerted efforts against poor personal hygiene to placate or resolve vectors. Heat, poverty, overcrowding, humidity should be controlled to alleviate insect and other vectors spread. Elimination of environmental states that encourage vectors is importantly needed. Vector control span efforts such as community awareness, spread of insecticides, covering water containers properly, house-to-house inspection, use of nets repellants by individuals, and improved healthcare system.

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