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L'impact du changement climatique sur les maladies infectieuses à transmission vectorielles :

Bluetongue, Fièvre de la Valleée du Rift

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I would also like to thank the jury members for being part of my graduation.

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Dédicace

To my precious parents, my grandparents, my sisters: Ibtissam and Ilham and my little brother: Sofiane Abdelhek, to my uncles and everyone I love… Thank you for always being there for me and for encouraging me to pursue my goals and dreams.

Special section for my chingudeul: Oumayma and Sabrina, thanks for your chinguShip ^_^

To my lovely friends :Rania, Kenza, Amina, Chahra, Asma,

TABLE OF CONTENTS

STUDY CASES:

Chapter III: Bluetongue diseases

Chapter IV: Rift Valley Fever diseases

Chapter V: Preventive veterinary medicine

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

BT	Bluetongue
BTV	Bluetongue virus
RVF	Rift valley fever
RVFV	Rift valley fever virus
IPCC	Intergovernmental Panel on Climate Change
UNISCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organization
OIE	World Organization for Animal Health
FAO	Food and Agriculture Organization
UNFCCC	United Nations Framework Convention on Climate Change
NOAA	National Oceanic and Atmospheric Administration
SPREP	Secretariat of the Pacific Regional Environment Programme
GHG	Green House Gases
ECDC	European Centre for Disease Prevention and Control
ENSO	El Niño–Southern Oscillation

Introduction

Introduction

Climate is a major environmental driver influencing vector-borne diseases epidemiology.
Climate change is a subset of the larger set of ecosystem changes that are promoting the emergence and re-emergence of animal and human diseases. The complexity of the interconnectedness between a wide range of factors influencing the emergence and re emergence of animal diseases means that uncertainty will continue to be a feature of the future.

Understanding the climate change and global warming phenomena has become the main topic of the century. Scientists have shown that average temperatures will rise between 1 ^{0}C and 3.5 ^{0}C , rainfall patterns will change, and extreme weather events such as storms, flooding, drought and heat waves will become more frequent and more intense. The evidence suggests that human activities contribute largely to warming the planet by generating the greenhouse gases such as CO_2, CH_4 , N_2O.

Extreme weather events might create the necessary conditions for vector-borne viral infectious diseases: Bluetongue and Rift Valley fever to expand their geographical range.
Temperature changes are one of the most obvious and easily measured changes in climate, but atmospheric moisture, precipitation and atmospheric circulation also change as the whole system is affected.

The purpose of this bibliographic study is to simplify the understanding of climate change for veterinarians and highlight the importance of the climate change impacts on the infectious diseases outbreaks and their distribution. Moreover to showcase the role of veterinary medicine in dealing with this topic and preventing these incidences.

Chapter I:

Climate change overview

I. Climate change:

A change in the state of climate can be identified by the changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. **(IPCC, 2012)**

Climate change can also be described as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. **(UNFCCC, 1992)**

II. Causes of climate change:

The principal cause of climate change is global warming, which has many negative consequences on life on earth.

II.1. Global warming:

Global warming is viewed as an overall warming of the planet **(SPREP, 2019)**; it is the long-term rise in the average temperature of the Earth's climate system **(Wikipedia, 2019)**. It can also be refered to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. **(IPCC, 2014)**

According to the Global Climate Summary of **(NOAA, 2018)** the combined land and ocean temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880; however, the average rate of increase since 1981 (0.17°C / 0.31°F) is more than twice as great.

Separately, the global land-only surface temperature for 2018 was 1.12°C (2.02°F) above the 20th century average—the fourth highest annual temperature since global records began in 1880. The global ocean-only surface temperature was also the fourth highest on record at +0.66°C (+1.19°F). **(NOAA, 2018)**

The average global land and ocean surface temperature for January–November 2019 was 0.94°C (1.69°F) above the 20^{th} century average of 14.0°C (57.2°F) and the second warmest such period on record. **(NOAA, 2019)**

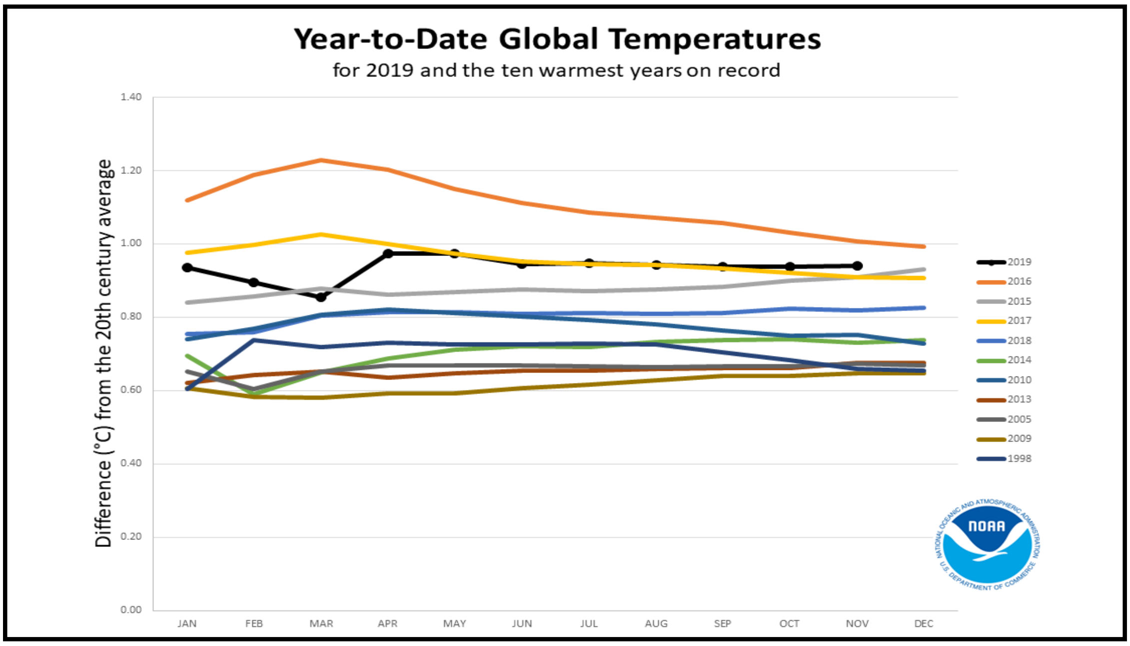

Figure 1: Year-to-Date Global Tempratures for 2019 and te ten warmest years on record **(NOAA, 2019)**

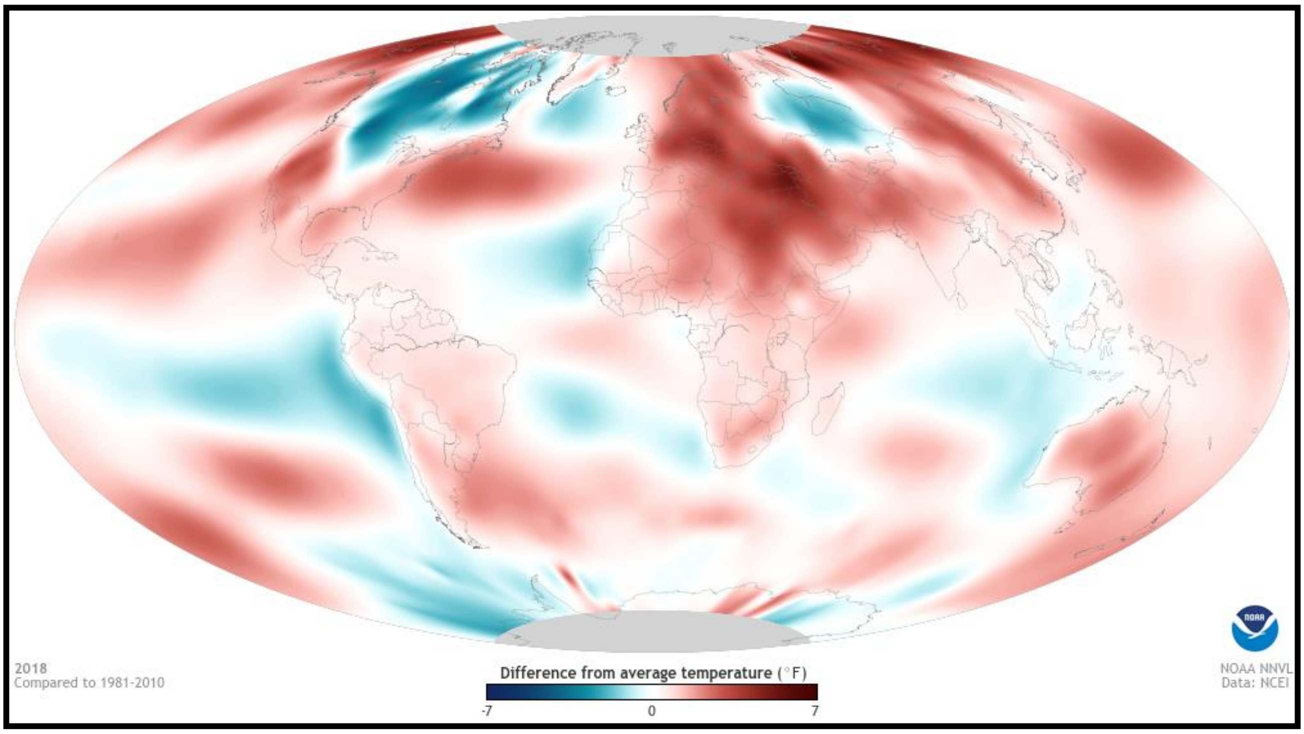

Figure 2: Temperatures in 2018 compared to the 1981-2010

Observations show that the African continent is warmer than 20 years ago, with an average rate of warming of about 0.05°C per decade. **(IPCC, 2001)**

II.1.1 Global warming drivers:

II.1.1.A. GreenHouse Gases emissions:

The main reason for this global warming issue is believed to be the increased emission of greenhouse gases (mostly CO_2). **(Berggren, 2017)**

The concept of global warming requires a fundamental understanding of the greenhouse effect. Solar radiation passes through the atmosphere and is absorbed at the Earth's surface. This heat is lost from the earth's surface as infra-red radiation. The infra-red radiation cannot escape the atmosphere as easily as the solar radiation enters. Some of it is trapped by a number of gases which act similar to the glass in a greenhouse—heat can enter but cannot exit—resulting in the Greenhouse Effect. **(Atul *et al*, 2005) .**

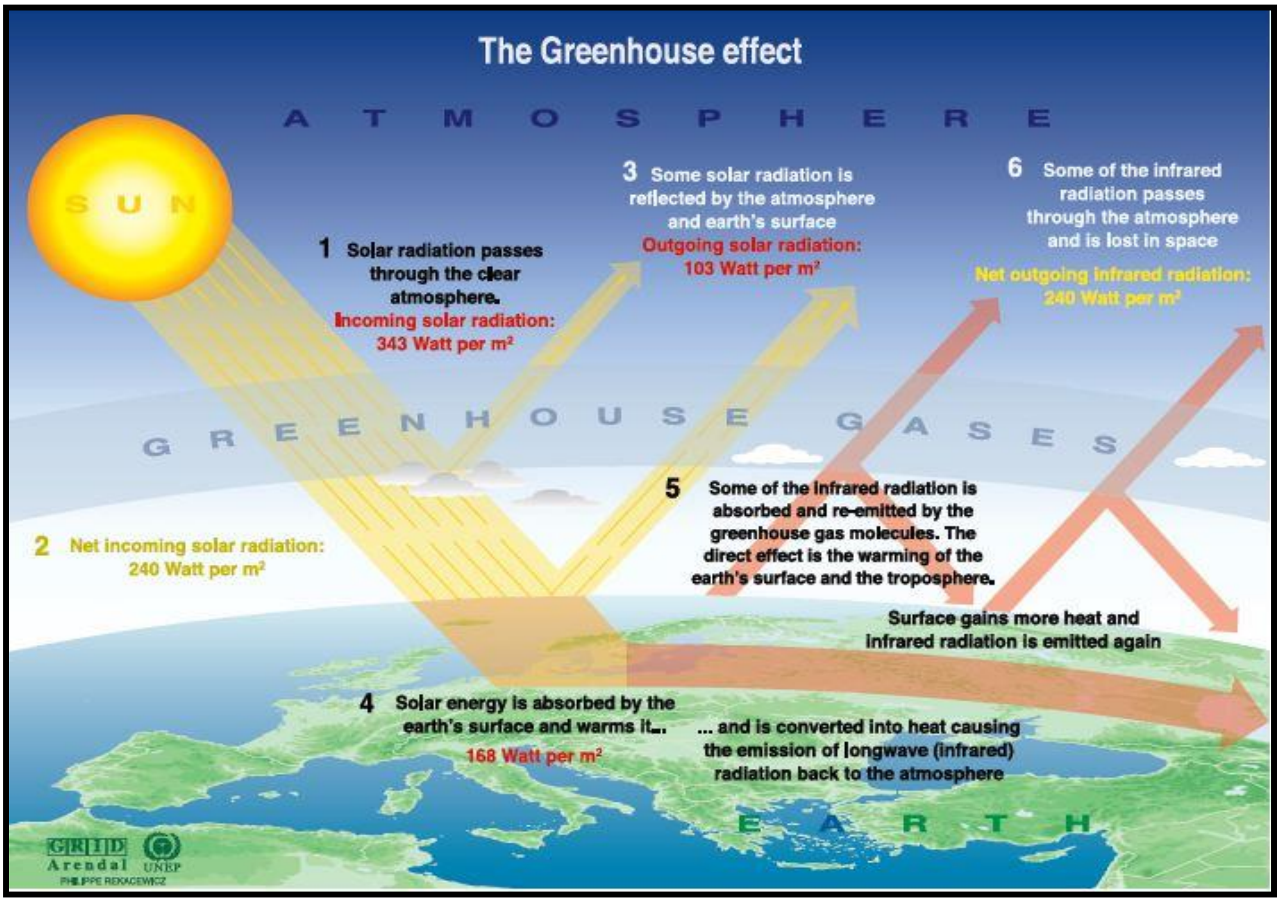

Figure 3: The Greenhouse effect **(SPREP, 2015)**

Gases that contribute to the greenhouse effect include:

- Carbon dioxide (CO_2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)
- Water vapor (H_2O) (feedback to the climate, increases as the Earth's atmosphere warms) **(UNFCCC, 2009)**

These gases are generated in city landfills, livestock farms, rice fields and through the use of nitrogenous fertilizers. Some greenhouse gases are produced by the the use of large quantities of fossil fuels (oil, coal, natural gas) (e.i, Carbon Dioxide), and some are manufactured artificially, such as the fluorinated gases used in refrigeration and air-conditioning systems. **(Oyhantçabal *et al*, 2010)**

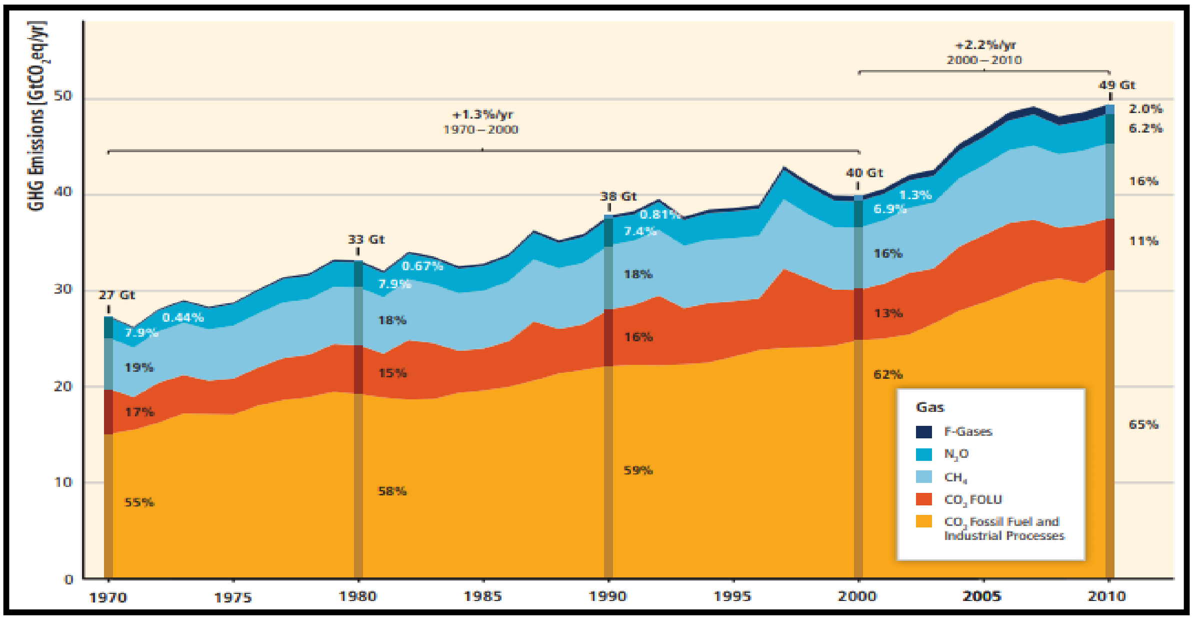

Figure 4: Total Annual Anthropogenic GHG Emissions by Groups of Gases 1970 - 2010 **(IPCC, 2014)**

Moreover, activities such as uncontrolled deforestation, destruction of marine ecosystems and population size growth enhance global warming because these activities increase production of greenhouse gases that could ultimately court global disasters.

Chapter II:

Vector-borne infectious diseases and climate change

I. Infectious diseases:

I.1. Definitions:

I.1.1 Emerging disease:

An emerging disease is defined as a new infection resulting from the evolution or a change of an existing pathogen or parasite resulting in a change of host range, vector, pathogenicity or strain; or the occurrence of a previously unrecognized infection or disease. **(OIE)**

I.1.2 Re-emerging disease:

A re-emerging disease is considered an already known disease that either shifts geographical setting or expands its host rang, or significantly increases its prevalence. **(OIE)**

I.1.3 Vector-borne disease:

Vector-borne diseases are infections transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, triatomine bugs, sandflies, and blackflies.. Arthropod vectors are cold-blooded (ectothermic) and thus especially sensitive to climatic factors. **(ECDC)**

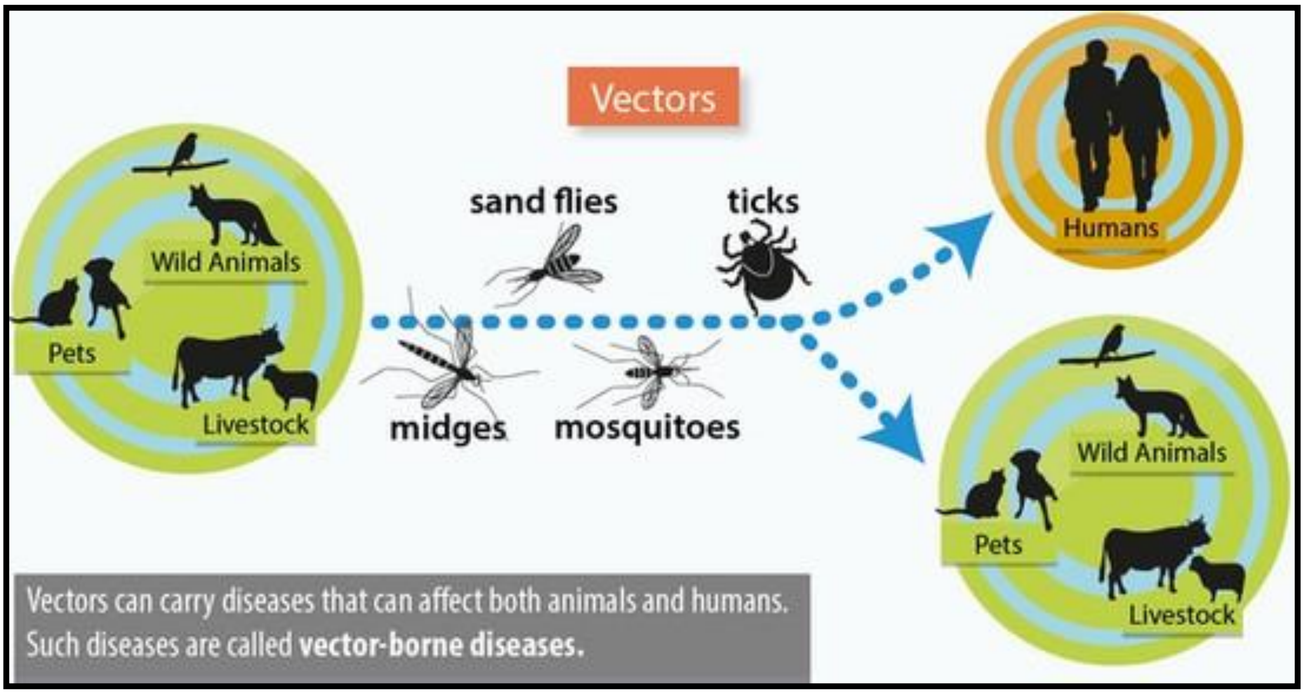

Figure 5: Vectors of infectious diseases

I.2. Categories of emerging and re-emerging infectious diseases:

Emerging and re-emerging infectious diseases can have many origins. They can be classified into the following categories:

Table 2: Categories of emerging and re-emerging infectious diseases

Viral diseases	**Bacterial diseases**	**Parasitic diseases**
- Avian influenza - Chikungunya - Crimean-Congo haemorrhagic fever - Dengue - Ebola virus disease - Hantavirus - Hand, foot and mouth disease Japanese encephalitis - Nipah virus - Rabies Rift Valley fever	- Anthrax - Botulism - Brucellosis - Leptospirosis - Listeriosis - Melioidosis - Plague - Salmonellosis - Scrub typhus - Tularaemia	- Taeniasis/cysticercosis - Toxoplasmosis - Trichinellosis

I.3. Impact of climate change on vector-borne emerging infectious diseases:

Climate is a major environmental driver influencing vector-borne diseases. Global warming will certainly affect the abundance and accelerate the distribution of the emerging and re-emerging vector-borne infectious diseases.

These Climatic variations create new ecological niches for vectors hence altering temporal and spatial distribution of disease **(Lafferty, 2009)**

I.3.1 General:

Arthropod vectors are the most sensitive to climatic temperature variability. Mosquitoes, ticks and sandflies are ectothermic and have life cycles that are dependent on ambient temperatures. Disease transmission is likely to occur if there are changes at the extremes of temperature (14-18°C at the lower end and 35-40°C at the upper end). Vector densities are expected to be their greatest at 30-32°C. **(Githeko *et al,* 2000)**

Warmer climates allow ticks to survive at higher latitudes and altitudes. Higher temperatures increase the developmental rate of ticks and the over-winter survival rate is also increased. However it has been postulated that earlier arrival of spring may not necessarily be advantageous to ticks as vertebrate numbers at that time may still be low. **(Randolph, 2008)**

The effect of precipitation on vectors is indirect; the precipitation patterns changes can have short- and long term effects on vector habitats. Increased precipitation has the potential to increase the number and quality of breeding sites for vectors such as mosquitoes, ticks and snails, and the density of vegetation (dense after rainfalls), affecting the availability of resting sites. **(Githeko *et al*, 2000)**

Table 2: Examples of effects of extreme climaticevents on the incidence of vector-borne diseases **(Robert W. Sutherst, 2004)**

Avg rainfall	Event
Low	Epidemic: Rift Valley fever affecting humans in arid northeastern Kenya after heavy rain (195) Epidemic: dengue fever with heavy rainfall in Malaysia (99) and the South Pacific, but introduction of virus is more important (129) Epidemic: Ross River virus outbreaks after summer floods if nonimmune native hosts are available (200) Epidemic: Murray Valley encephalitis in heavy-rainfall year in northern Australia (237) Epidemic: ponding of rivers during drought causing SLE and Japanese encephalitis in Papua New Guinea (200)
High	Epidemic: dengue in the Western Pacific in early 1998 during the latter part of an El Niño cycle (11), with higher than average sea surface temperatures in the central Pacific (http://iri.columbia.edu/climate/ENSO/background/monitoring.html) virus introductions also important.

[a] Note that in each case other factors such as fluctuating host immunity may be involved.

I.3.2 Mosquitoes study case:

Temperature has a direct effect on mosquitoes. It leads to increased activity, increased reproduction and therefore increased frequency of blood meals and faster digestion of blood. **(Martin V *et al*, 2008)**

Pathogens harboured by mosquitoes also mature faster. Increased water temperature cause mosquito larvae to develop faster also increasing overall vector capacity**. (Reiter, 2008)**

Temperature directly affects the distribution and nutritional requirements of mosquitoes. Extreme temperatures will kill mosquito populations – for example, *Culex annulirostris* larvae die at temperatures below 10ºC and above 40ºC **(Lee *et al*, 1989)**

Figure 6: Mosquitto *Culex annulirostris*

High temperatures (up to a limit) reduce the period needed for larval development, meaning that more generations can fit into a given time period. *C. annulirostris* has an egg-to-adult time of 12–13 days at 25ºC, and of only 9 days at 30ºC **(Kay *et al*, 1989)**

Mosquitoes are susceptible to lose body water because they have a high surface area to mass ratio; this scenario happens if a rise in ambient temperature is not accompanied by a rise in humidity which will influences the survival of mosquitoes if it reaches high degrees. **(Reeves *et al* , 1994)** Precipitation patterns are critical for mosquitoes' survival. A moderate increase in rainfall can be beneficial **(Lindsay *et al*, 1997)**. While excessive increases can wash away the mosquito larvae or dormant eggs and interrupt the transmission cycle. The length of a rainfall event, the number and duration of events, and the total amount of rain that falls are all factors that differently affect the breeding of mosquito vectors of Rift Valley fever in epizootic regions. **(Davies *et al*, 1985)**

Table 3: Selected influences of climate conditions on vectors of diseases **(W. J. Tabachnick, 2010)**

Climate condition	Influence on vectors
Increasing temperatures	
Higher transmission potential	
	Decreasing vector generation time
	Increasing vector population growth rate
	Decreasing pathogen extrinsic incubation period
	Increasing length of transmission period
Lower transmission potential	Decreasing vector longevity
	Decreasing life expectancy
Increasing abundance of water	
Higher transmission potential	Increase in vector larval habitats
	Increase in vector population sizes
	Increase in animal host populations over time
Lower transmission potential	Decrease vector host interactions with increase in water sources and dispersion of animal hosts
	Some vector-borne disease cycles require periods of drought for pathogen amplification
Both water and temperature will influence host and vector distributions in unknown complex ways.	

"Table1 lists several possible influences of climate on vectors and shows the potential influence on vector-borne disease cycles

II. Climate change and vector-borne infectious diseases in Africa:

Africa's climate changes became apparent starting in about 1975, and since then temperatures have increased at a rate of about 0.03 °C per year **(NOAA, 2018)** and the precipitation appears to be increasing in east Africa but decreasing in west and north Africa **(Carter TR *et al*, 1999)**

The tropical African climate is favourable to most major vector-borne diseases, including: malaria, schistosomiasis, trypanosomiasis, filariasis, leishmaniasis, plague, yellow fever and tick-borne haemorrhagic fevers**.,** Rift Valley fever, yellow fever and tick-borne haemorrhagic fevers. The continent has a high diversity of vector-species complexes that have the potential to redistribute themselves to new climate-driven habitats leading to new disease patterns. **(Andrew K *et al*, 2000)**

Vector species in Africa have adapted to ecosystems ranging from humid forests to dry savannas. As these ecosystems change so will the distribution of vectors species. For example, for trypanosomiasis vectors, although *Glossina morsitans* is mainly a savanna dweller, *G. palpalis* is a riverine species preferring to rest under dense vegetation. **(Andrew K *et al*, 2000)**

Climatic conditions and vegetation influence the ecosystem and largely determine the distribution of ticks and their density. Ticks spend a large time of their life living off their host(s) which makes them a subject to ambient temperature and humidity. Increasing temperature may shorten their life cycle but increase their reproductive rate. Very high temperatures are likely to reduce their survival and mortality will increase under drier conditions. **(Van den Bossche *et al*, 2008)**

A short-term increase in temperature and rainfall, as was seen in the 1997, caused *Plasmodium falciparum* malaria epidemics **(WHO, 1998)** and Rift Valley fever in Kenya **(Linthicum KJ *et al*, 1999) .**

III. Infectious diseases related to climate change:

(OIE, 2009) Conducted a study to find out the relationship between climate change and emerging and re-emerging infectious diseases, a questionnaire was addressed to the members.

Most Members identified at least one emerging or re-emerging animal disease that was believed to be associated with climate.

The most frequently mentioned diseases associated with climate change are listed in Table 4.

Table 4: Diseases that were believed to be associated with climate change or environmental change

Diseases mentioned more than twice as being believed to be associated with:	Climate change
Vector-borne	
Bluetongue	✓
Rift Valley fever	✓
West Nile fever	✓
African horse sickness	✓
Lumpy skin disease	✓
Leishmaniosis	✓
Epizootic haemorrhagic disease	✓
Tick-borne diseases	✓
Parasitic diseases (excluding tick-borne)	✓
Pasteurellosis	✓
Avian influenza	✓
Anthrax	✓
Blackleg	✓
Rabies	✓
Tuberculosis	×

Study cases

Chapter III:

Bluetongue disease

I. Introduction:

Bluetongue is a vector-borne viral disease of domestic and wild ruminants, transmitted by certain species of biting midges of the genera *Culicoides* **(Maan et *al., 2012*; Foxi *et al.*, 2016).** 120 years ago Bluetongue disease was first reported in South Africa **(Henning, 1956)** and since 1998, it has spread to North Africa and Europe **(Caporale, 2008).**

This disease is caused by BTV, a virus of Orbivirus genus within the family Reoviridae, which includes 30 genera divided into two subfamilies infecting a wide variety of plants, vertebrates, and invertebrates, including crustaceans, fish, insects, reptiles, and mammals. **(Mertens et al., 2005; Attoui *et al*., 2009)**

Bluetongue virus (BTV) is classified among category “A” diseases notifiable to the World Organization of Animal Health, twenty-six of bluetongue virus (BTV) serotypes have been recognized globally **(Zientara *et al*., 2014).**

Figure 7*: C. imicola* **(Wikipedia, 2020)**

II. Geographical distribution:

Globally the distribution of BTV is directly associated with the presence of competent vectors and their habitats. BTV activity can be found on all continents except Antarctica; though different serotypes and strains cause markedly variable diseases. **(OIE, 2013)**

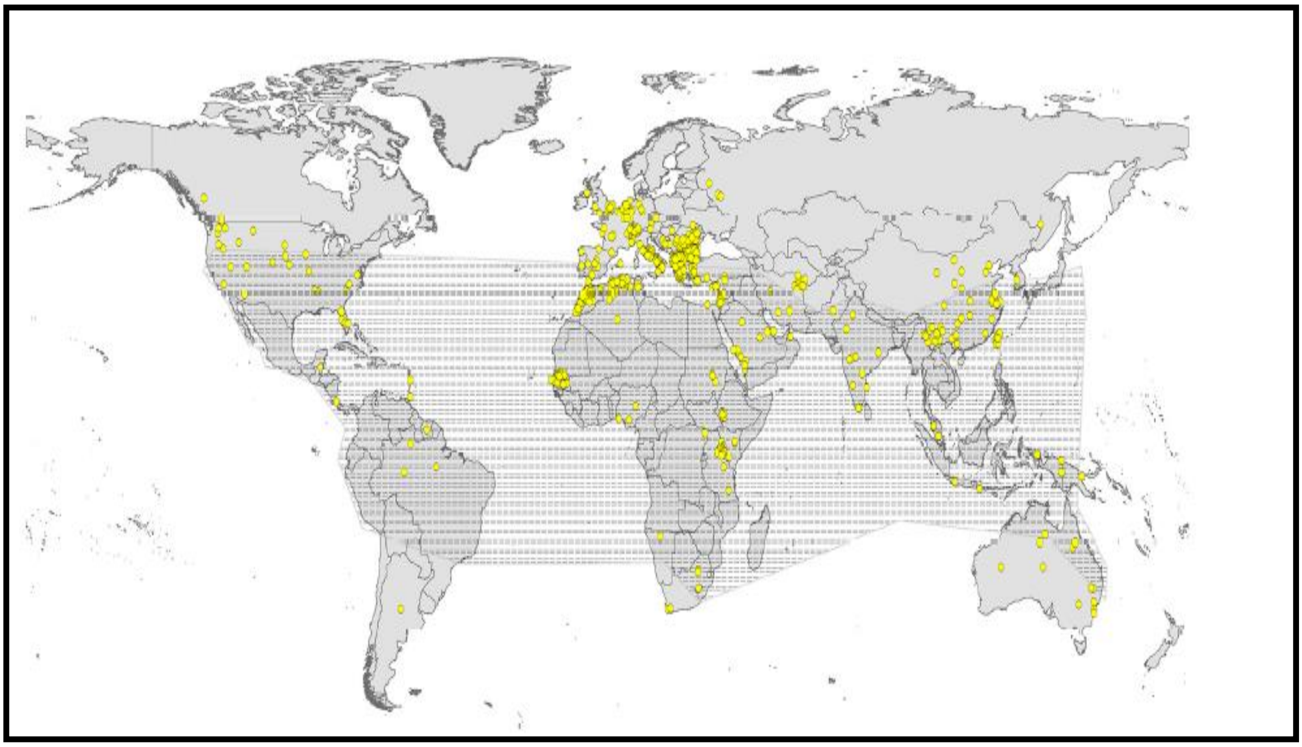

Figure 8: Summary of bluetongue virus occurrences **(Samy et al., 2016)**

Bluetongue vector, *Culicoides* is a highly diversified genus that contains at least 1,350 species within 34 subgenera **(Borkent, 2017)** .Several species are known to be potential or proven vectors of BTV in different regions. Examples include *C. imicola* and *C. bolitinos* in Africa, *C. imicola* and *C. fulvus* in Asia, *C. brevitarsis* and *C. fulvus* in Australia, *C. sonorensis* in North America, and *C. insignis* and *C. pusillus* in Central and South America **(Baldet *et al.*, 2005)**. The *C. obsoletus* complex and the *C. pulicaris* complex transmit BTV in Northern Europe **(Bessell *et al.*, 2016).**

Culicoides populations can build up to high abundances under suitable conditions, and adults can be transported by the wind for several kilometers within one night, leading to rapid spread of the diseases they carry **(Sellers, 2008)**

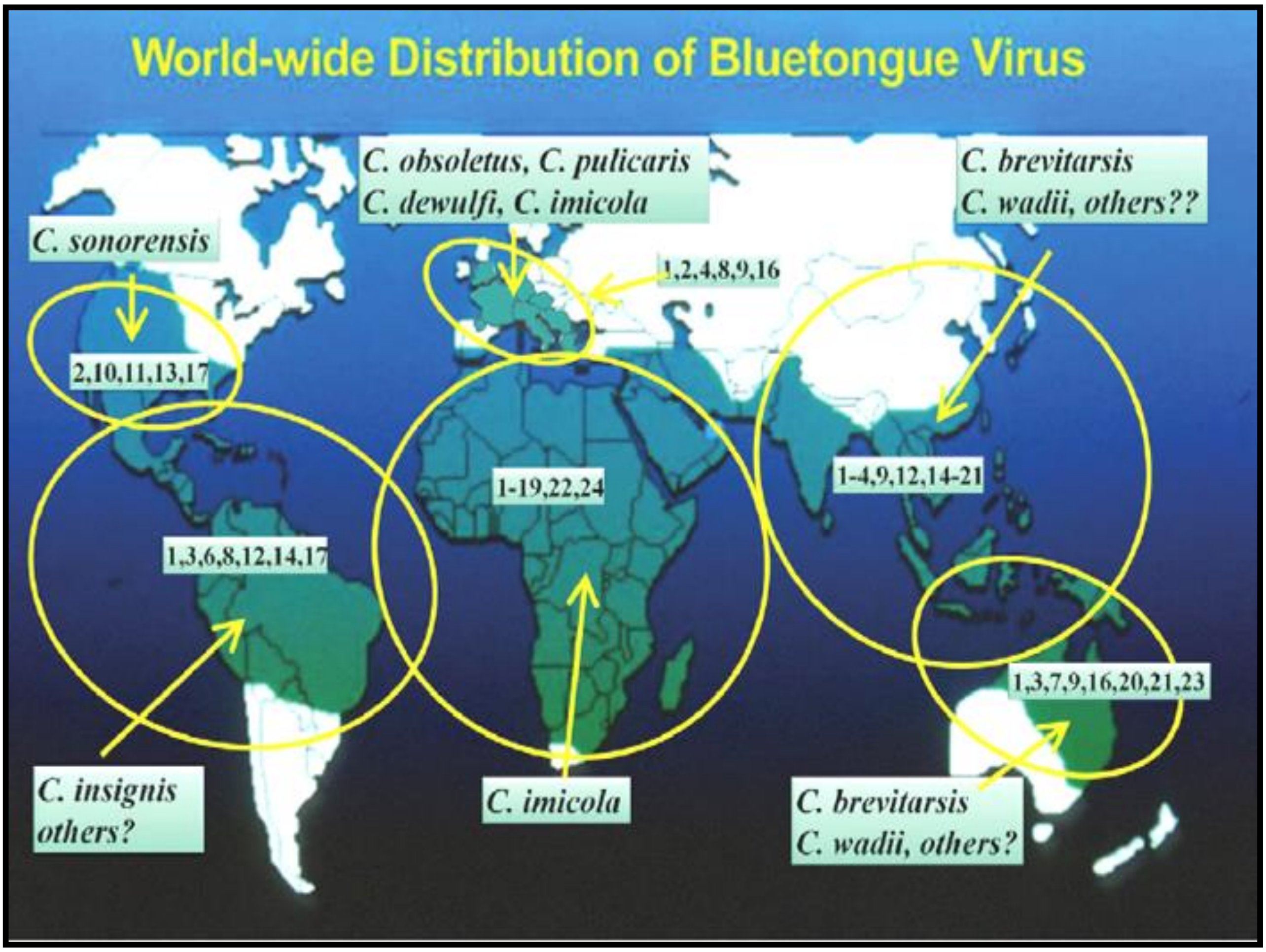

Figure 9: Worldwide distribution of BTV serotypes and the primary *Culicoides* vectors in different geographical regions **(Tabachnick, 2004)**

Bluetongue is historically an African disease, and although it has not been reported from all African countries, it is probably enzootic throughout the entire continent.

The potential distribution of BTV under present-day conditions showed high suitability across southern Europe, Australia, the Indian Subcontinent, and northern and southern Africa **(Samy *et al.*, 2016)**

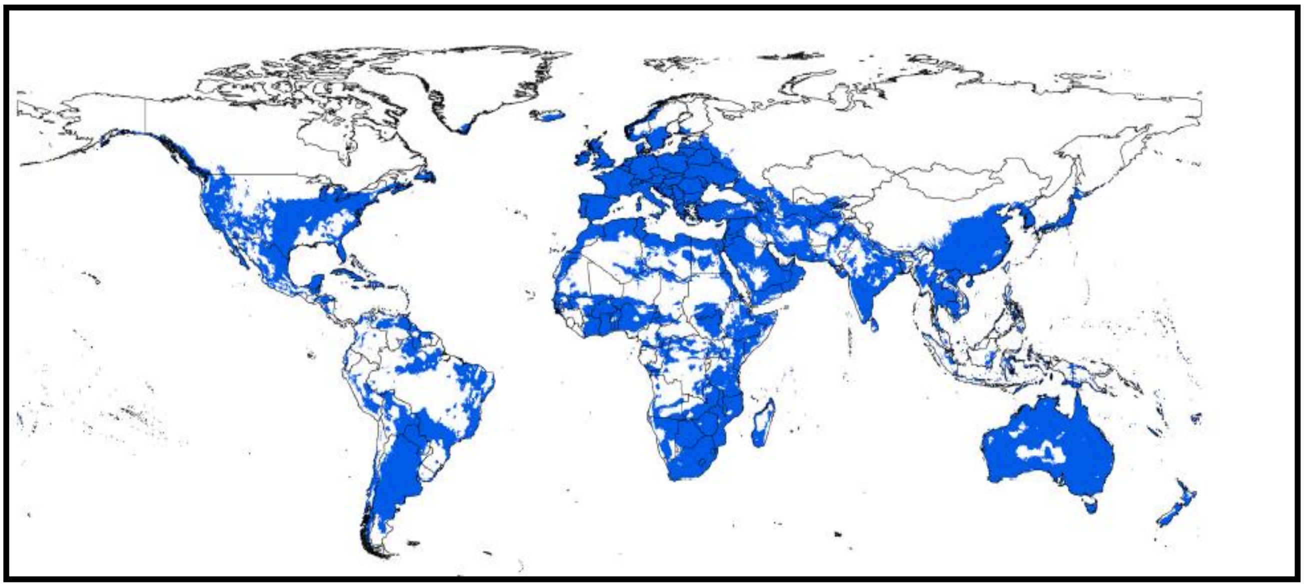

Figure 10: Current potential distribution map for bluetongue virus based on present-day climatic conditions
(Samy *et al.*, 2016)

III. Biological sensitivity of bluetongue virus and *Culicoides* to climate:

Bluetongue is a vector-borne disease that is modulated by temperature and moisture availability **(Mellor P.S *et al.*, 2000).** Generally, warm temperatures enhance the recruitment, development, activity and survival rates of *Culicoides* vectors **(Mellor P.S. *et al.*, 1998; Wittmann E.J. *et al.*, 2002).**
Significantly, the competence of *Culicoides* vectors is enhanced by warm temperatures **(Wittmann E.J. *et al.*, 2002; Paweska J.T *et al.*, 2002).**

Bluetongue virus can persist at low temperatures (<10°C) for up to 35 days inside adult vectors and later replicate and be transmitted when the temperature increases **(Mellor P.S. *et al.*, 1998)**

In a 'nonvector' species, *C. nubeculosus*, competence can be induced when larvae are reared at high temperatures, with 10% of emerging adults being infectable when reared at 33°C to 35°C, compared to 0% at 30ºC **(Wittmann E.J. *et al.*, 2002; Mellor P.S. *et al.*, 1998)**

This phenomenon has been attributed to the leakage of virus directly into the haemocoel, bypassing the midgut barriers, allowing virus replication and dissemination. Considering both vector and non-vector species together then, an increase in the cumulative frequency of either warm or hot periods in summer/autumn or whilst overwintering as larvae or adults will increase their transmission potential for BTV.

Moisture availability affects *Culicoides* vectors and, in turn, BTV transmission. Precipitation governs the size and persistence of semi-aquatic breeding sites for larvae and the availability and duration of humid microhabitats in summer/autumn where adults can carry out key activities and shelter from desiccation **(Mellor P.S *et al.*, 2000; Murray M.D., 1991)**

Whether changes in precipitation act as climatic drivers of transmission is likely to vary geographically according to the habitat preferences of the vectors in that region and the average suitability of breeding sites there. For example, *C. imicola* breeds in wet, organically enriched soil and mud, but the pupae cannot survive flooding of these sites **(Braverman Y, 1978; *Galun R. et al.*, 1974)**

Thus, precipitation increases might favor increased breeding in arid areas, but across the Mediterranean, the presence of this species can be matched statistically to areas that are relatively dry in summer **(Purse B.V. *et al.*, 2007)**

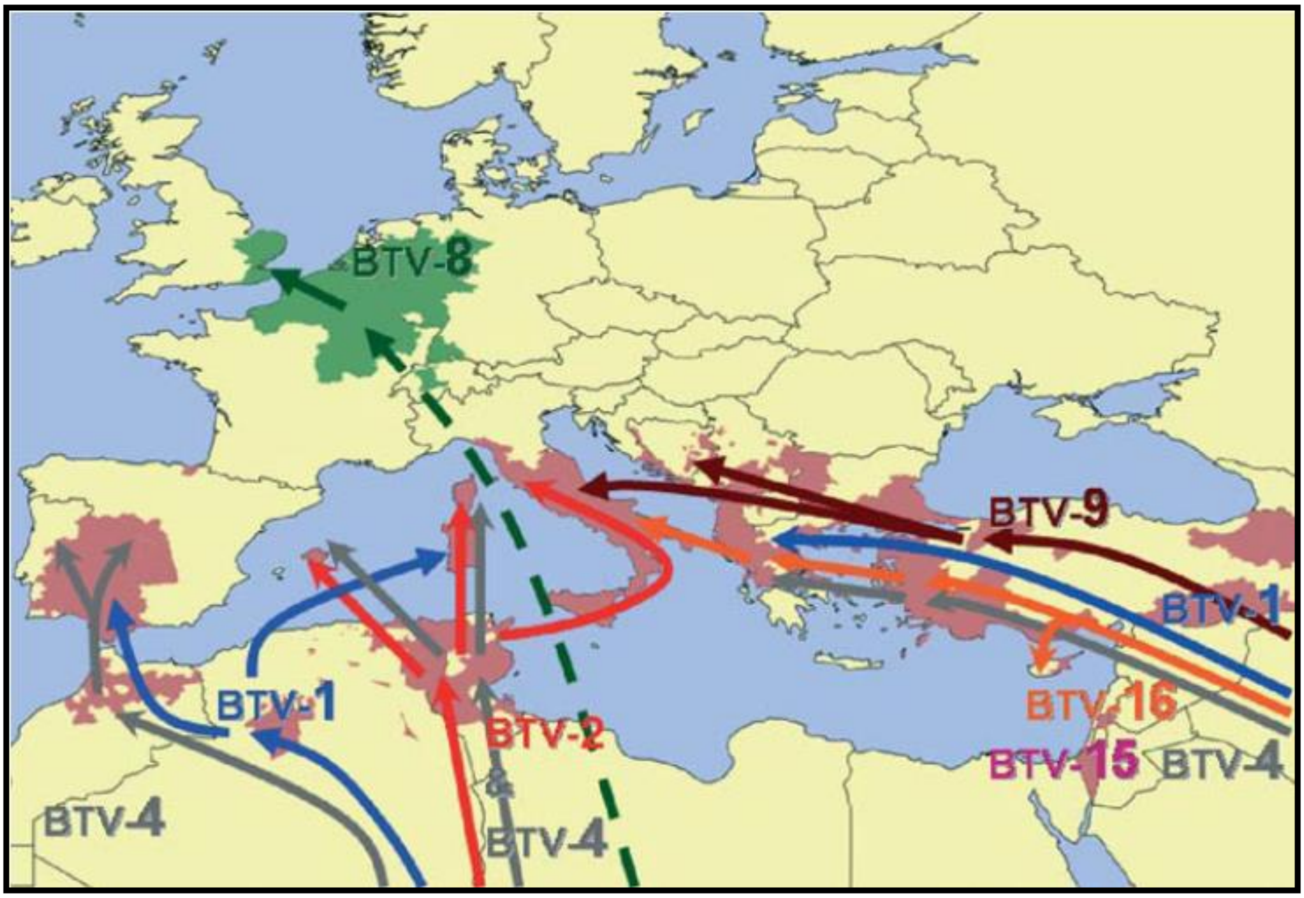

Figure 11: The molecular epidemiology of bluetongue virus in Europe
(B.V. Purse *et al.*, 2008)

IV. Recent BT geographical distribution:

According to **(OIE, 2019)** bluetongue disease geographical distribution patterns are changing and are continuing to spread worldwide.

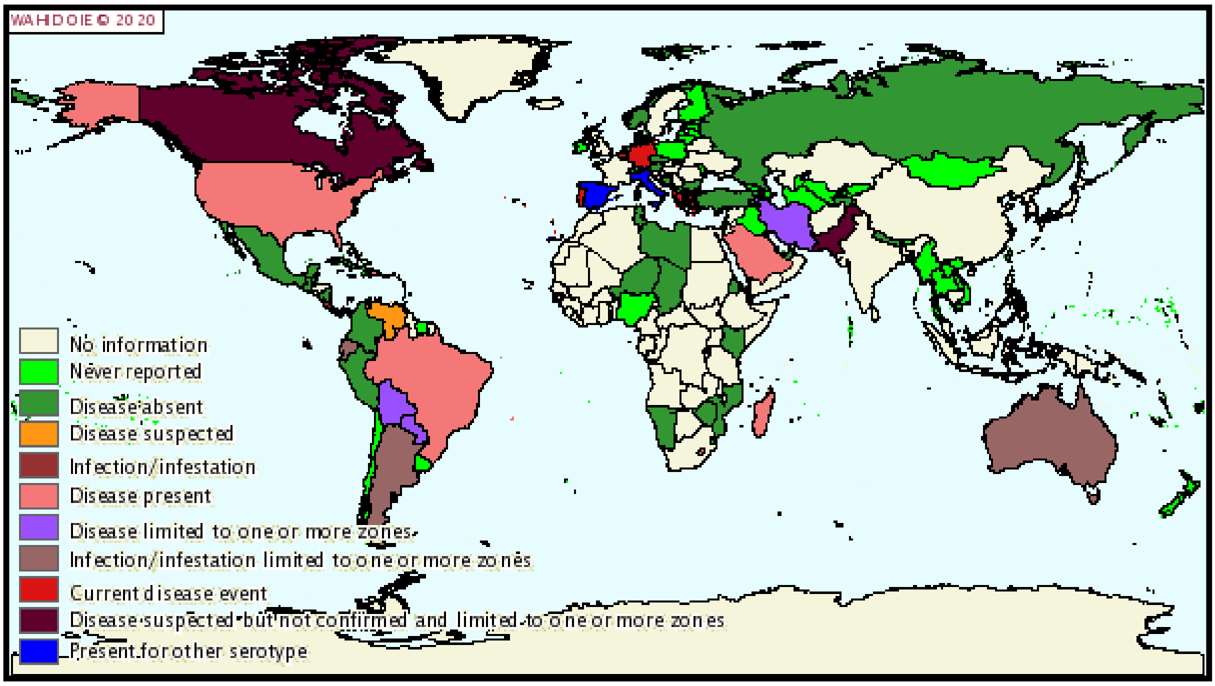

Figure 12: Recent BT geographical distribution "Jan- Jun 2019" **(OIE, 2019)**

The most recent outbreaks of BT: from July 2019 to January 2020 have been reported in Algeria and Europe.

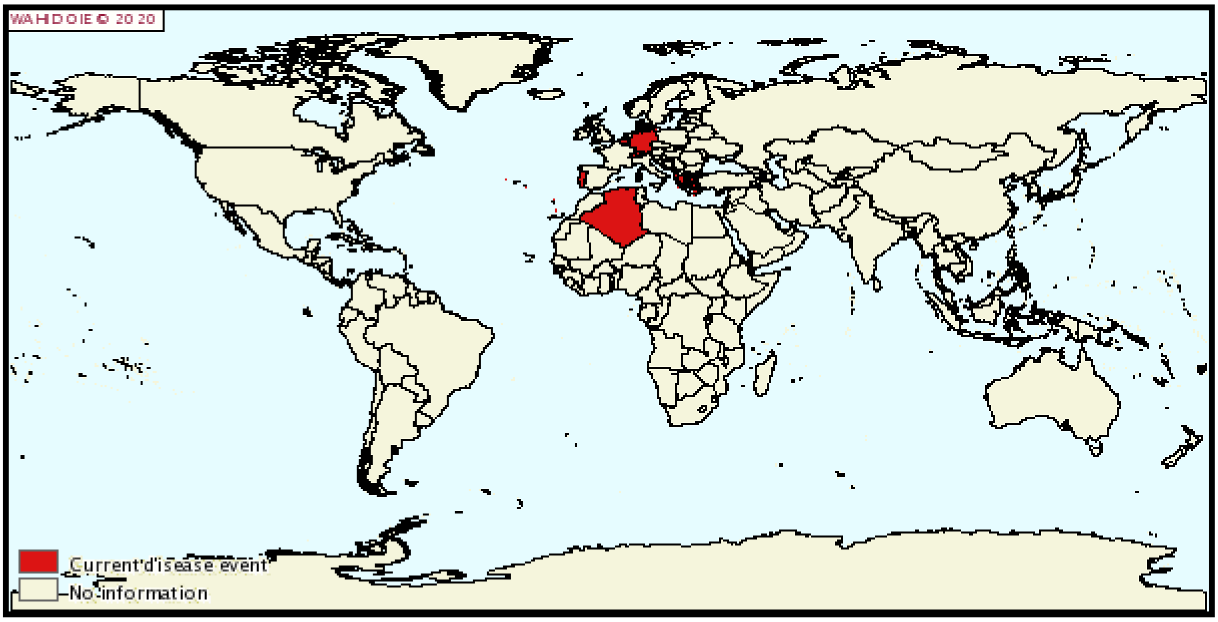

Figure 13: BT geographical distribution "Jul 2019- Jan 2020" **(OIE, 2020)**

Chapter IV:

Rift Valley Fever disease

I. Introduction:

Rift Valley fever is a mosquito-borne viral disease, it is considered as an acute fever that is most commonly observed in domesticated animals (such as goats, sheep, cattle, buffalo and camels) caused by a virus, a member of the genus Phlebovirus (family Bunyaviridae), with the ability to infect and cause illness in humans (zoonotic disease problem). The virus was first reported in livestock by veterinary officers in Kenya's Rift Valley in the early 1910s. **(Fenollar *et al.*, 2018)**

RVF V is transmitted by mosquitoes of twelve genera with over 30 different species shown to be competent vectors **(Swanepoel *et al.*, 2005)**. It is transmitted transovarially by some of the *Aedes neomelaniconium* species of mosquitoes **(Linthicum K.J *et al.*, 1985).** In particular, it can be transferred transovarially from females to eggs in some mosquito species of the *Aedes* genus.

Other potential vectors include *Culex tritaeniorhynchus* and *Aedes vexans*, **(Jupp *et al.*, 2002)** *Aedes caspius*, *Aedes mcintosh*, *Aedes ochraceus*, *Culex pipiens*, *Culex antennatus*, *Culex perexiguus*, *Culex zombaensis* and *Culex quinquefasciatus*. **(Turell *et al.*, 1996 ; Lee JS *et al.*, 2007; Fontenille *et al.*, 1998)**

RVF causes abortions in pregnant animals and high mortality in young animals, characterized by massive hepatic necrosis and pantropic hemorrhage. In humans, RVF causes a severe influenza-like disease, occasionally with more serious effects, such as haemorrhagic complications, hepatitis, encephalitis, blindness and sometimes death. **(Pietro Ceccato *et al.*, 2008)**

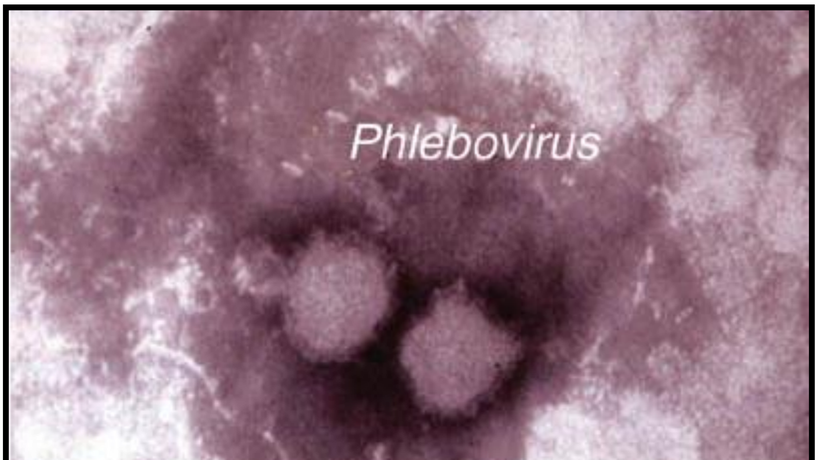

Figure 14: RVF virus **(Vincent M *et al.*, 2003)**

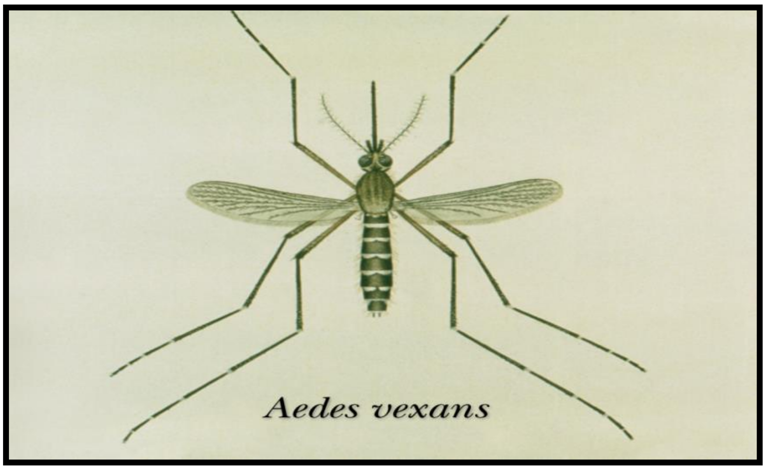

Figure 15: *Aedes vexans* **(CDC, 1976)**

II. Geographical distribution:

Rift Valley fever is endemic in several African countries. It's occasionally reported in Middle East countries. However, there is a potential risk of introduction of RVF in countries in the South-East Asia Region. **(WHO, 2014)**

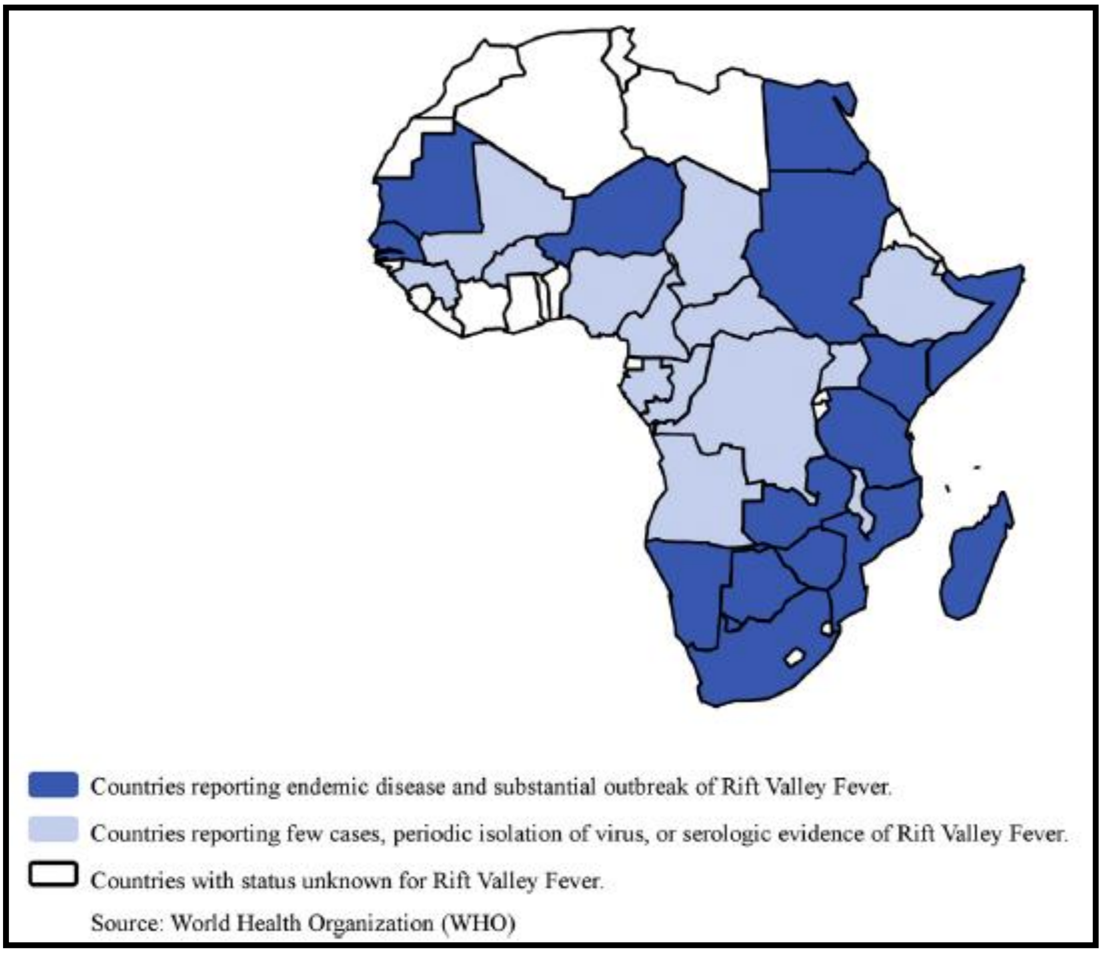

Figure 16: Rift Valley Fever risks in Africa

Table 5: Emerging and reemerging RVF in Africa in 21st century **(Hassan OA *et al.*, 2011)**

Country	Years : main outbreaks since 2000
Egypt	2003
Kenya and Somalia	2006–2007
Sudan and Tanzania	2007
Madagascar	2008–2009
Republic of South Africa	2010
Republic of Mauritania	2016
Republic of Niger	2016

II.1. Recent RVF geographical distribution:

According to **(WHO, 2010),** RVF distribution map shows that most of the infections, suspicions and disease presence are reported in Africa (Sahara Mauritania, South Africa, Botswana, Zimbabwe, Congo, Niger, Cameroon) and Saudi Arabia.

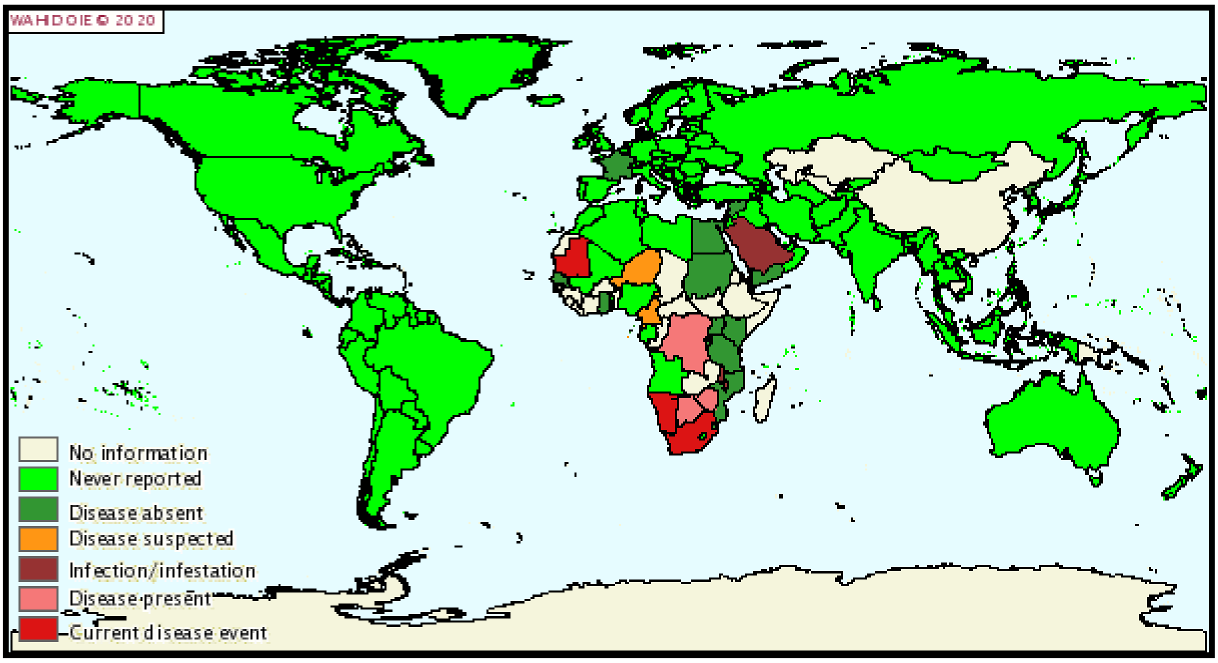

Figure 17: RVF worldwide distribution "Jul- Dec 2010" **(WHO, 2010)**

The new “January 2020” mapping of Rift valley fever shows that the recent disease event has occurred in South Sudan.

Figure 18: Recent RVF map distribution "Jan 2020" **(WHO, 2020)**

III. Impact of climate change of Rift Valley Fever:

Climate changes may affect the three fundamental components of the epidemiological cycle of RVF, namely: vectors, hosts and virus.

The hatching dynamic of *Aedes* mosquitoes, the main reservoir of RVF in Africa, strongly depends on the rainfall pattern **(Meegan J.M. et al., 1989)**. Excessive rainfall causes the flooding of sometimes dry areas and results in the hatching of dormant, drought-resistant, infected eggs of the mosquito (*Aedes*). The vector populations increase during times of flooding, because more eggs are immersed in water **(Patz *et al.*, 2002).** Between flooding periods, the eggs can survive desiccation for many years, and cause major epidemics at irregular intervals of 5 to 35 years. **(Martin V *et al*, 2008).**

Rift Valley Fever outbreaks are associated with El Niño events, triggered by large-scale changes in sea surface temperature in the Pacific Ocean and the western Equatorial Indian Ocean, leading to climate anomalies at the regional level (. **(Linthicum KJ *et al*, 1999)**.

III.1. El Niño–Southern Oscillation:

ENSO is an irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean, affecting the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as *El Niño* and the cooling phase as *La Niña*.

El Niño-Southern Oscillation events involve a large exchange of heat between the ocean and the atmosphere, and affect:
– global mean temperature – trade winds - tropical circulation – precipitation. **(Martin V *et al,* 2008)**

III.1.1 El Niño:

El Niño is a phase of the El Niño–Southern Oscillation, it refers to the warm and negative phase of the ENSO and is the warming of the ocean surface or above-average sea surface temperatures in either the central and eastern tropical Pacific Ocean. **(ABM, 2016; Michelle, 2014).**

In Africa, East Africa—including Kenya, Tanzania, and the White Nile basin—experiences, in the long rains from March to May, wetter-than-normal conditions. Conditions are also drier than normal from December to February in south-central Africa, mainly in Zambia, Zimbabwe, Mozambique and Botswana.

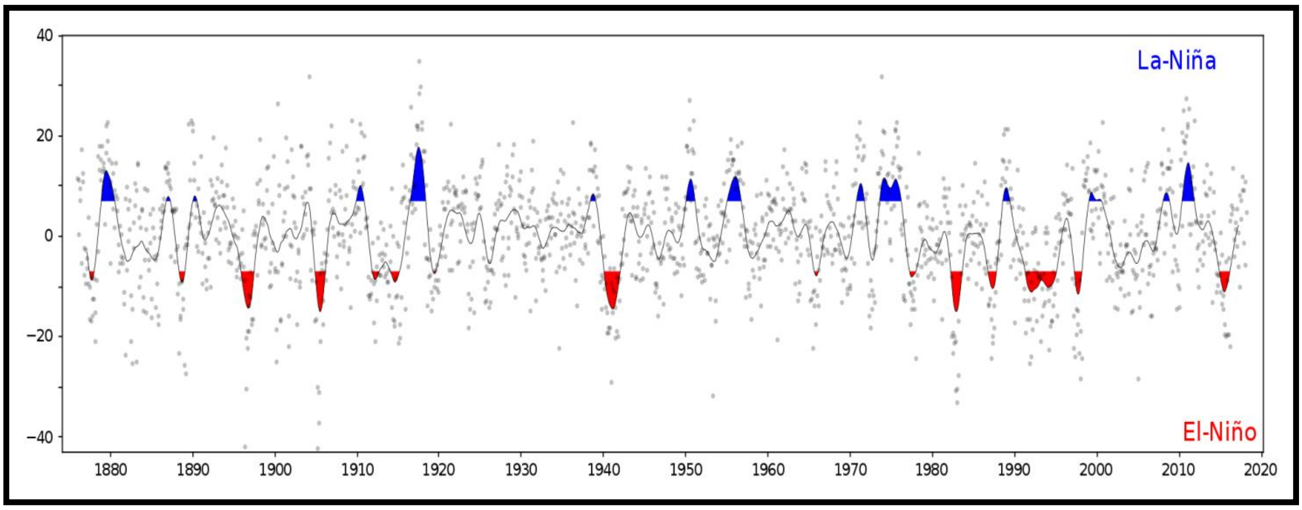

Figure 19: Southern Oscillation Index timeseries 1876-2017
(wikimedia, 2018)

III.2. The link between El Niño events and RVF:

In 1997- 1998 El Niño event has been linked to very heavy rainfall in north-eastern Kenya and southern Somalia, resulting in a severe outbreak of RVF. The outbreak killed more than 500 people and large numbers of, in particular, small ruminants, with some livestock owners losing up to 70% of their animals. A similar large outbreak of RVF occurred in 2007.

There have been a few incidences when an elevated RVF activity was not ENSO-driven. These outbreaks occurred in North and West Africa and they were not associated with excessive rainfall but with the presence of large rivers and dams that provide suitable breeding sites for the mosquito vectors. In such areas, increasing water storage capacity for agricultural development and irrigation is likely to provide new suitable breeding sites for mosquitoes transmitting the RVFV, and may make such areas more prone to RVF epidemics. **(Van den Bossche *et al,* 2008)**

Chapter V:

Preventive veterinary medicine

I. Preventive veterinary medicine:

National veterinary authorities are greatly concerned that climate change will result in the emergence or re-emergence of animal diseases within a 5- to 10-year timeframe.
It is currently accepted that 80% of all animal pathogens are zoonotic agents and that 75% of emerging animal pathogens are zoonotic. Because of the highly lethal nature of these zoonoses it is vital to ensure surveillance and early diagnosis, increasing interactions between the human health, animal health and environmental sectors in a more coordinated manner and on a larger scale than hitherto. **(Edgardo Vitale et al., 2010)**

.
Climate change-modulated vector-borne disease (VBD) complexes would appear to become more dynamic globally, especially in the temperate climate zones of the northern hemisphere. **(Juan Lubroth , 2012)**

The emergence and re-emergence of vector-borne diseases in many regions of the planet provides a clear example of the link between climate change and effects on the human/animal health interface. The urgency of the matter and its socioeconomic impact require updated surveillance strategies for the Veterinary Services in relation to the perceived and foreseeable risk of the occurrence of diseases associated with climate change. **(Edgardo Vitale *et al.*, 2010).**

In 1994 FAO created and Emergency Prevention System (EMPRES) that has shown that an early warning, early detection, and early response have been key to the prevention and control of both old and new pests and diseases in animal and crop production. Prevention and curtailing the spread of disease across country boundaries has become the credo of the FAO/World Organisation for Animal Health (OIE) initiative, Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TAD).
In many countries, the expertise in entomology and disease ecology within public veterinary services is inadequate to mount early warning and response mechanisms in the face of novel VBD emergencies. Improvements are required also in terms of a further integration of field veterinary work, laboratories and detection of critical control points further along the food chain. **(Juan Lubroth , 2012)**

The evolving ‘one world, one health’ framework has support from institutions such as OIE, FAO, WHO, the UNSIC, UNICEF and the World Bank, **(Peter Black *et al.*, 2009)** this approach brings together health professionals engaged as veterinary practitioners and food inspectors, working in fisheries health, forestry, plant protection, natural resource management and, of course, food safety and public health. **(Juan Lubroth , 2012).**

Conclusion

Conclusion

Climate change is emerging as one of the main challenges that humankind will have to face for many years to come. Human and animal health issues are only two of many concerns, albeit quite crucial.

Under global warming conditions, the climate tolerance limits of vectors are likely to expand northwards and southwards, creating favorable conditions for vectors to colonize new ecosystems and animal populations in temperate regions. These changes in the geographical distribution of vectors will also affect the distribution of vector-borne diseases, with a yet-unknown impact on animal and human health.

Bluetongue, Rift valley fever will continue to expand worldwide due to vectors transmissions under today's climatic conditions.

Veterinary Authorities responsible for disease preparedness and response need to develop systems and strategies that are adaptable, resilient and capable of dealing with the unexpected,
Through planning and research, we can mitigate the health effects of global warming. Through policy, politics, and global cooperation, we may reduce the environmental problems that cause global warming.

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Summary

The threat of climate changes is well known and its impact is being noted at many levels .Environmental changes has a huge impact on the emergence and re-emergence of certain vector-borne infectious diseases such as Bluetongue and Rift Valley Fever. These diseases are continuing to evolve in a changing world and so do their geographical distributions due to vectors transmission which is influenced by the temperature raise (between 1^{O}C- 3.5 ^{O}C), moisture availability, rainfall and drought periods.

Developing an effective and sustainable human/animal health services, associated surveillance and emergency preparedness systems and sustainable disease control and prevention programs is perhaps the most important strategy for dealing with climate change.

Résumé:

La menace des changements climatiques est bien connue et son impact est noté sur de nombreux niveaux. Ces maladies continuent à 'évoluer dans le monde, ainsi que leur répartition géographique en raison de la transmission des vecteurs qui sont influencés par l'augmentation de la température (entre1^{O}C- 3.5 ^{O}C), la disponibilité de l'humidité, les précipitations et les périodes de sécheresse.

Le développement des services de santé humaine / animale efficaces et durables, de systèmes de surveillance et de préparation aux situations d'urgence et de programmes durables de contrôle et de prévention des maladies peut-être la stratégie la plus importante pour lutter contre les changements climatiques.

ملخص

تهديد تغير المناخ معروف جيدًا ولوحظ تأثيره على العديد من المستويات. للتغيرات البيئية تأثير كبير على ظهور وإعادة ظهور بعض الأمراض المعدية المنقولة بالنواقل مثل Bluetongue و Rift Valley Fever. تستمر هذه الأمراض في التطور في عالم متغير وكذلك توزيعاتها الجغرافية بسبب انتقال النواقل التي تتأثر بارتفاع درجات الحرارة(بين1^{O}C- 3.5 ^{O}C) ، وتوافر الرطوبة ، وهطول الأمطار وفترات الجفاف.

إن وضع خدمات فعالة ومستدامة لصحة الإنسان / الحيوان ، وأنظمة المراقبة والتأهب لحالات الطوارئ المرتبطة بها ، وبرامج مكافحة الأمراض المستدامة والوقاية منها ، ربما تكون أهم استراتيجية للتعامل مع تغير المناخ.