Chapter

Vector-Borne Diseases and Climate Change in the Environmental Context in Haiti

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Abstract

Climate change is one of the main challenges facing many countries, particularly developing countries, because of its negative impact on their various ecosystems and their socio-economic development, which very often leads them down a slow descent into poverty. This is because climate change can manifest itself in different forms such as climate variability and extreme events (droughts, epidemics, floods, storms and hurricanes), which can affect biodiversity and cause many human and animal diseases and deaths. In fact, the evolution of ecosystems is dependent on climate and environmental change and appears to be closely associated with many emerging or re-emerging diseases. In general, the ecosystems considered to be most exposed to climate change are those located in and around the intertropical convergence zone in particular. They are believed to be closely linked to the occurrence of several emerging diseases, particularly vector-borne diseases. For years, the Republic of Haiti has been experiencing the adverse effects of these global changes with a marked disruption of its rainfall pattern and prolonged periods of drought as well as a pronounced increase in temperatures even in high altitude areas. Although there is evidence that climate change is increasing the frequency of vector-borne diseases and may contribute to increasing the virulence of their pathogens, there are very few studies conducted in Haiti on the relationship between climate change and vector-borne diseases. The purpose of this chapter is to define the interrelationships between climate change and vector-borne diseases in Haiti by identifying avenues of research to better understand the effects of climate change on public health and to make appropriate recommendations to decision-makers to ensure proper management.

Keywords: Climate change, Vector-Borne Diseases, Ecosystems, Environmental Factors, Public Health, Ecological Sanitation (Haiti)

1. Introduction

Global warming is a serious threat to humanity [1]. At the global level, warming trends have not ceased to manifest. As evidence of this, global annual air temperature increased by nearly 1°C between 1880 and 2017 [2] and the years 2015 to 2017 are considered to have been the warmest of all previous years within this period [3]. Moreover, the last three decades have been warmer than any previous decade since

1850 [4]. Long-term changes in temperature and precipitation are often accompanied by heat waves and intense rainfall, increasing the risk of flooding [5], mainly in countries in the Caribbean region such as Haiti.

Climate change is often described as one of the most pressing environmental challenges we face worldwide [6]. The latest report of the Intergovernmental Panel on Climate Change (IPCC) has confirmed that climate is being affected by human activities and has also highlighted that this has multiple impacts on human and animal health. Indeed, the work of the IPCC puts into perspective the weight of industrialization in climate disruption through significant greenhouse gas emissions. These actions are responsible for extreme hydrometeorological phenomena (droughts and floods), which can cause multiple cases of death and emergence of pathologies in living beings. Climatic disturbances are also at the origin of many infectious diseases, among which vector-borne diseases transmitted by hematophagous arthropods such as dengue fever, Zika, chikungunya and malaria.

Climate change is a major threat to Haiti, even though it contributes very little to the phenomenon. Like the countries of Latin America and the Caribbean, the Republic of Haiti has been suffering for years from the adverse effects of global changes with a marked disruption in the rainfall pattern, the occurrence of prolonged periods of drought and a pronounced warming of temperature and air. As agricultural productivity continues to decline, water resource management is becoming increasingly difficult. The upward trending emergence of vector-borne diseases such as dengue, Zika and chikungunya inoculated by invasive species of mosquitoes was observed in 2015. In the context of global climate change, dengue is considered one of the important diseases because of its high social impact recorded over the last three decades in the humid tropical world, with a risk of expansion into the temperate zone. According to the World Health Organization [7], dengue is the most important neglected disease today. Although it is reported that climate change is affecting the occurrence of infectious diseases, particularly vector-borne diseases, there have very few studies conducted in Haiti on the interrelationships between climate and vector-borne diseases. The purpose of this chapter is to define the interrelationships between climate change and vector-borne diseases in Haiti while conceptualizing the research in order to make the appropriate recommendations for their mitigation and the protection of public health. This chapter is divided into five sections:

- Climate Change and Environmental Degradation at a Glance: Global and Haitian Climate Change and Environmental Degradation;
- Impact of Climate Change and Environmental Change on Health;
- Elements of Epidemiology of Vector-Borne Diseases in Haiti
- Climate change and global health approach;
- Methods to combat climate change and vector-borne diseases

2. Climate change and environmental degradation

2.1 Main characteristics of climate change

According to the IPCC Third Assessment Report, the global average surface air temperature is projected to increase by 1.4 to 5.8°C by 2100 [8], with significant impacts on all elements of the global climate system. In addition, the fifth report published in 2014 also reveals that all physical and biological systems on all continents and in virtually all oceans will be affected by temperature increases due to climate change [9]. Therefore, changes in climatic conditions and induced effects such as rainfall variability, temperature, humidity affect the human and ecological systems of the planet. However, rising temperatures and increased drought periods generally lead to new challenges that are very difficult for a developing country to overcome.

The IPCC [10] predicts that climate change will affect coastal areas in a variety of ways and indicates that current changes in temperature and precipitation are likely to increase the frequency of life-threatening events. Changes in climate variability will also have consequences for human health. Climate variables such as temperature and precipitation have a major impact on the hydrological cycle and changes in these variables will alter runoff and evaporation patterns and the amount of water stored in soils and aquifers. They could also degrade groundwater quality. For example, a reduction in aquifer recharge rates and groundwater runoff could increase contaminant concentrations in groundwater and the incidence of infectious diseases. Work carried out in the cities of Cap-Haitian and Les Cayes (Haiti) has highlighted the presence of *Cryptosporidium* oocyst in surface water [11–13] and groundwater used by the population for domestic purposes [14]. These resources are contaminated by fecal pollution and are a source of potential biological risk to the health of the exposed population. Rainfall can promote the spread of infectious agents, while temperature promotes their proliferation and survival.

2.2 State of environmental degradation in Haiti

Developing countries (DCs) face the challenges of population growth, accelerated urbanization and poverty. On one hand, socio-economic inequalities and social polarization have increased, and on the other hand, the heterogeneity of poor households has grown, including the increase in socio-economic inequalities and social polarization [15]. According to the data in the literature, some developing countries are more subject to the impacts of climatic variations, especially those with an "extreme" climate and/or those whose climate is close to that of the sea. Haiti is one of these, mainly due to its high population growth juxtaposed with conditions of economic and social poverty.

Located on the border of two tectonic plates (the North American Plate and the Caribbean Plate located under the Caribbean Sea) [16], Haiti is not only placed on the direct trajectory of extreme weather events such as storms and hurricanes, but is also the site of strong seismic activity that seriously damages its socio-economic development process [17]. In addition, in recent decades, the process of degradation of Haiti's biophysical environment and its socio-economic decline has been exacerbated by climate change. Indeed, the second national communication on climate change and recent studies on the issue have revealed the high vulnerability of the country's main strategic sectors to this occurrence. Haiti is exposed to environmental threats such as sea level rise, the intensification of extreme weather events (hurricanes, floods, droughts, etc.), erosion and coastal pollution.

The demographic explosion currently characterizing the country is leading to deforestation, resulting in impoverishment and soil degradation. This deforestation makes the country particularly vulnerable to floods and erosion. Every year it loses about 1600 t/ha of land [18]. **Figure 1** shows the impact of deforestation on the Pine Forest Biological Reserve [18].

Haiti has a geophysical environment characterized primarily by particular climatic, hydrological and biogeographic phenomena. Environmental changes such as deforestation, desertification, soil erosion and extreme poverty linked to its geographical location make the country increasingly vulnerable to climate change. According to 2014'sGerman Watch long-term climate risk index, Haiti was,

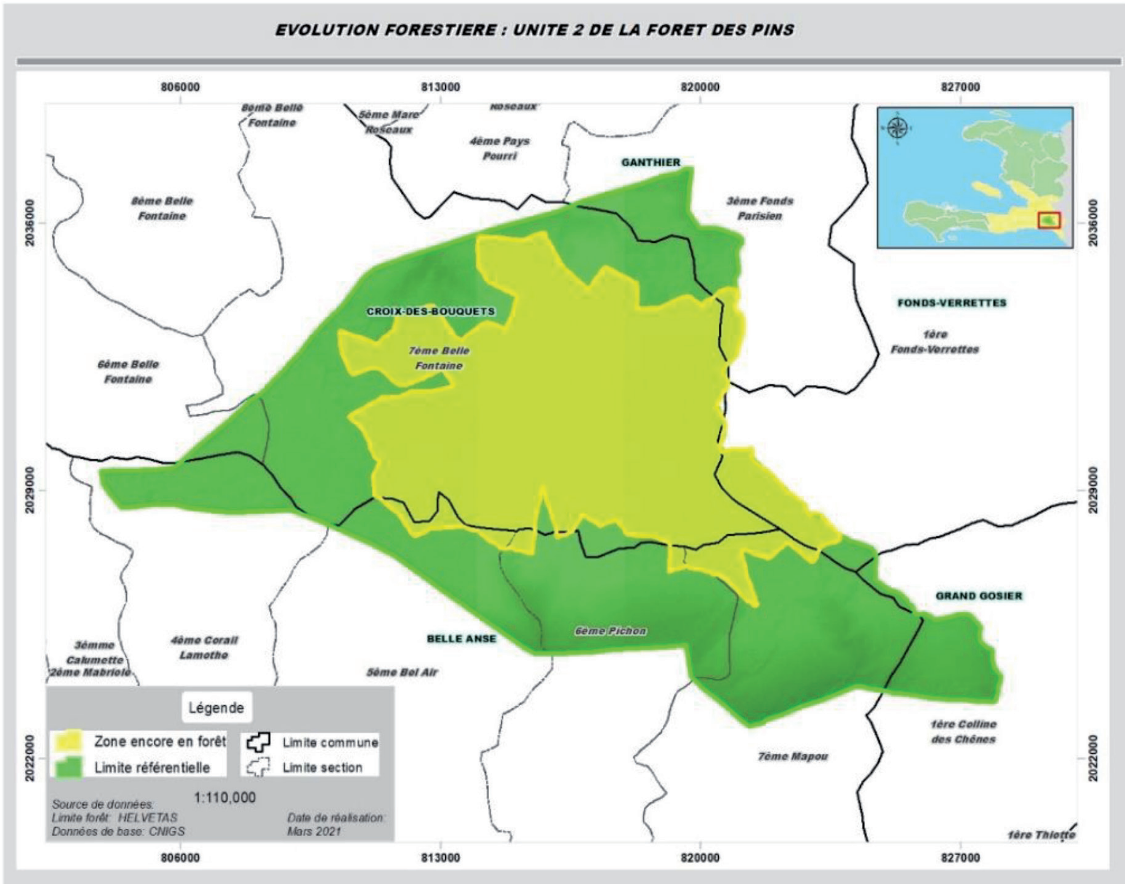

Figure 1.
Pine Forest Deforestation in Haiti [18].

between 1990 and 2008, the Caribbean country most affected by natural disasters (epidemics, floods, storms and hurricanes). These phenomena demonstrate the extent to which climate change contributes to environmental degradation, i.e. soil degradation, water scarcity, water pollution, loss of biodiversity and the occurrence of diseases. Haiti ranks third among the countries most affected by climate risks between 1993 and 2012 [19].

For developing countries, particularly Haiti, climate change represents a new threat that adds to existing risks, interacts with them and amplifies them. The negative consequences of climate change are exacerbated by the increased occurrence of extreme weather events, such as major hurricanes. These, which are increasingly intense, threaten to undermine the functioning of the various sectors associated with the country's socio-economic development, causing damage reaching alarming proportions of the national GDP. It is in this context and following the impetus provided by the Paris Agreement that the Haitian government, through the Ministry of the Environment (MDE) supported by the country's key sectors and actors, proceeded to develop the National Climate Change Policy (NCCP) following a highly participatory and inclusive process. This policy seeks to establish the major projects of the Haitian State in this area. As such, it should serve as a guide for all sectors and actors who want to contribute to the fight against climate change.

3. Impact of climate change and environmental modifications on health and vector-borne diseases

Climate change and environmental modifications are the main determinants of the changes observed in ecosystems that favor the occurrence of emerging and re-emerging animal and human diseases. More than ever, veterinary and health authorities around the world have realized the need to better understand the problem of climate loading and environmental change as it is posed in the 21st century in order to be able to prepare viable alert and response plans to these diseases, particularly vector-borne diseases whose proliferation appears to be closely linked to climatic parameters such as heat and humidity [20]. This situation is further complicated in countries such as Haiti, where significant environmental changes have been recorded in recent decades in terms of both forest cover and water resources.

Climate variability and change cause many cases of mortality and disease in humans and terrestrial and aquatic animals through the natural disasters they cause, such as heat waves, floods and droughts. The latest report of the Intergovernmental Panel on Climate Change (IPCC) has clearly shown that human activity is affecting the world's climate and has highlighted that this has multiple impacts on human and animal health.

3.1 Proliferation of vectors responsible for animal diseases and zoonosis

For about four decades, the scientific community and a large part of the civil society of developed countries have not failed to express their concern about the threat of a catastrophe looming over the planet if certain countries, major producers of greenhouse gases, persist in refusing to change their modes of industrial production which are largely responsible for the present situation. In the history of humanity, never before have there been so many massive emissions of such gases that have caused pronounced climatic disturbances that are reflected, among other things, in changes in rainfall patterns according to regions and the occurrence of extreme weather events. It is agreed that such climatic upheavals are at the root of many emerging or re-emerging infectious diseases. Indeed, it has long been known that there is a positive correlation between climate change and the occurrence of these diseases. Indeed, the temperature of arthropods/vectors generally varies according to that of the environment in which they live, hence their high sensitivity to ambient temperature variations. These temperature variations, by acting on the biology of these vectors, interact with the infectious agents that they often harbor [21].

In addition to temperature variations, other factors such as rainfall and humidity also contribute to the creation of favorable environments for vector development [3]. Changes in land use and socio-economic factors (human behavior, movement of people and goods, etc.) have also contributed to increasing ecological imbalances conducive to vector proliferation, resulting in the introduction and local transmission of new emerging pathogens in many countries [22]. However, the role of climate in the occurrence of infectious diseases, particularly vector-borne diseases, is not easily established.

This has led the IPCC to issue constant alerts about changes in the transmission of infectious diseases by vectors such as mosquitoes and ticks [23]. The sudden appearance and spread in 2007 and 2014 in many countries, tropical and temperate, of a vector-borne disease such as Chikungunya, which was facilitated by the extension of the distribution area of Aedes mosquitoes and the greater mobility of human populations. A similar scenario probably occurred in other temperate countries with other vector-borne diseases such as dengue and Zika as new areas of mosquito vector proliferation were established. Mosquito-borne diseases are climate-sensitive because the risk of epidemic disease increases or decreases in part with temperature, rainfall and humidity, which affect the life and reproductive cycle of insects [5].

3.2 Increasing prevalence and incidence rates of emerging or re-emerging diseases

Epidemic peaks are generally linked to climatic disturbances, as was the case in 2015 with the El Niño phenomenon, which led to the resurgence of malaria, chikungunya, Zika, plague and dengue fever. Since 1950, 2015 was the most important year in South America for Zika virus infection. Researchers have identified four school cases worldwide: plague and hantavirus in the United States, cholera in Tanzania, and dengue fever in Brazil, Thailand and Indonesia [3, 24]. **Figure 2** shows the emergence of several epidemic diseases around the world during the El Niño phenomenon of 2015-2016 [24].

Researchers have been interested in the high prevalence and especially the high incidence rate of Buruli ulcer observed in French Guyana since 1969. They compared the changes in rainfall in the region with the evolution of the number of Buruli ulcer cases over the past 40 years and showed that the reduction in rainfall and its runoff has led to the multiplication of areas of stagnant residual water serving as a breeding ground for the bacterium Mycobacterium ulcerans responsible for Buruli ulcer. This observation is not consistent with the generally accepted idea that reduced rainfall leads to a decrease in the prevalence of infectious diseases. On the contrary, it has been observed that swampy habitats, with the reduction of rainfall, have become more accessible and usable, thus increasing the level of human exposure to the bacteria still present in the aquatic environment.

3.3 Highlighting the interrelationships between health, biodiversity and ecosystems

Ecosystem change includes climate change, environmental change and related relationships and is believed to be closely associated with many emerging diseases [25]. The interrelationships between health, agriculture and ecosystems open a fairly broad door to the "One health" approach. They highlight how:

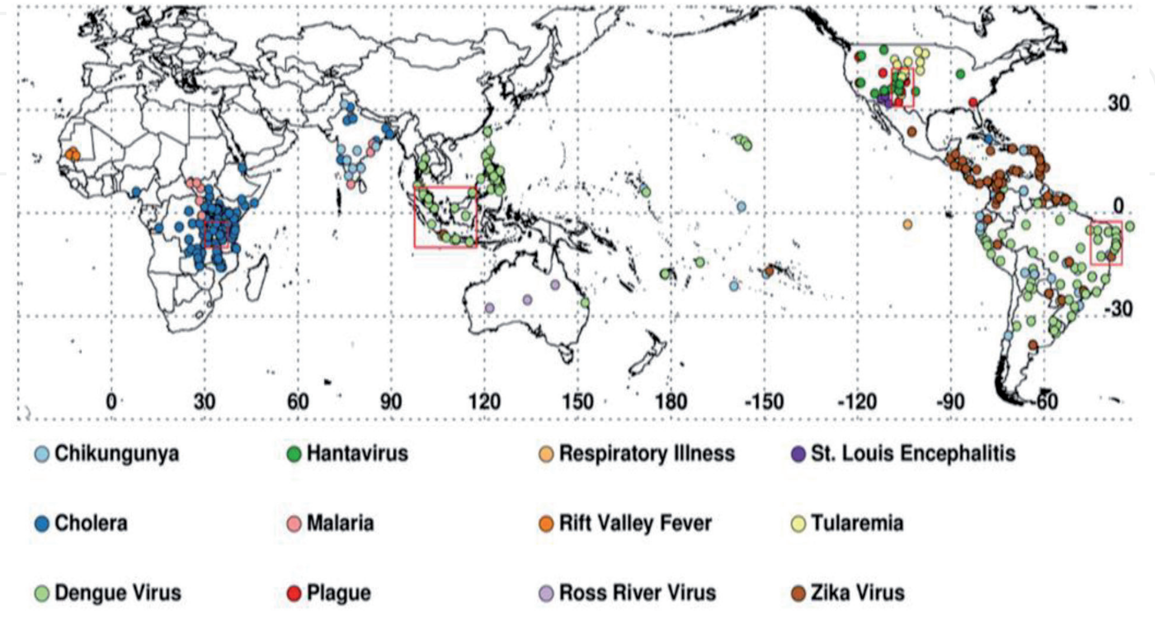

Figure 2.
Emergence of several epidemical diseases across the globe during the El Niño phenomenon of 2015–2016. The four cases studied in detail (United States, East Africa, Brazil and Southeast Asia) are boxed in red [24].

- the precarious nature of agriculture in poor regions, the strong dependence of the economy on agriculture and its vulnerability to pests/predators and pathogens can contribute to the loss of food resources, thus creating food insecurity with risks of deforestation as is the case in Haiti, and a great fragility of the population and the various livestock in terms of health due to the increased risk of infection;

- the increase in the use of the cheapest, and therefore most toxic, pesticides can have negative repercussions on the health of the population;

- Transboundary animal diseases can have a highly negative impact on international markets for animals and animal products. Indeed, diseases such as foot-and-mouth disease, bovine spongiform encephalopathy, swine fever, and avian influenza have caused economic losses in the tens of billions of dollars;

- Every hour, the oceans absorb one million tons of CO_2, creating an increase in the acidification of the environment unsuitable for marine life.

It is currently recognized that infectious and parasitic diseases have medical, social and environmental dimensions and that public health actors must strive for a holistic, comprehensive approach to better understand the dynamics of their development, particularly those that are zoonotic. To this end, a strategy should be adopted that integrates data or advances from public health, animal health, agriculture and environmental sciences in order to identify the determinants and risk factors associated with the various health states at the Human/Animal/Environment interface. Such an approach is related to the "One Health, One Health" approach and requires, to ensure its success, a new form of collaboration that requires the formation of multidisciplinary teams of scientists and the establishment of a platform for intersectoral cooperation at the institutional level.

In order to better manage the emergence or spread of zoonosis effectively, the ecological requirements of zoonotic pathogens and also the importance of anthropogenic factors must be taken into account. The unprecedented anthropogenic pressure on ecosystems in the context of global environmental change, which is constantly increasing, will continue to promote the occurrence of zoonotic diseases [26]. Thus, deforestation is a frequent source of emergence of zoonosis from wild animals. This is the case for diseases caused by West Nile virus and Nipah virus [27]. It is therefore important to consider the conditions of their emergence in relation to the environment and/or the organization of animal production chains, with particular emphasis on social factors (organization and functioning of animal husbandry and marketing structures). The governance of territories or geographical areas is another aspect that needs to be taken into consideration when organizing health management [28].

The CDC has presented a very good illustration of the impact of climate change on Human Health in the following **Figure 3** [4].

CIRAD has developed an integrated approach to health that is a little broader than the conventional concept of "One Health", which seems to us to be quite interesting, and which is based around the following major axes:

- incorporating knowledge from the human and social sciences, agronomy and environmental sciences into the approach;

- broaden the panel of conventional actors (doctors, veterinarians, public health practitioners) to include new institutional and social actors such as, on the one hand, government agents in the environmental (forestry, wildlife, water

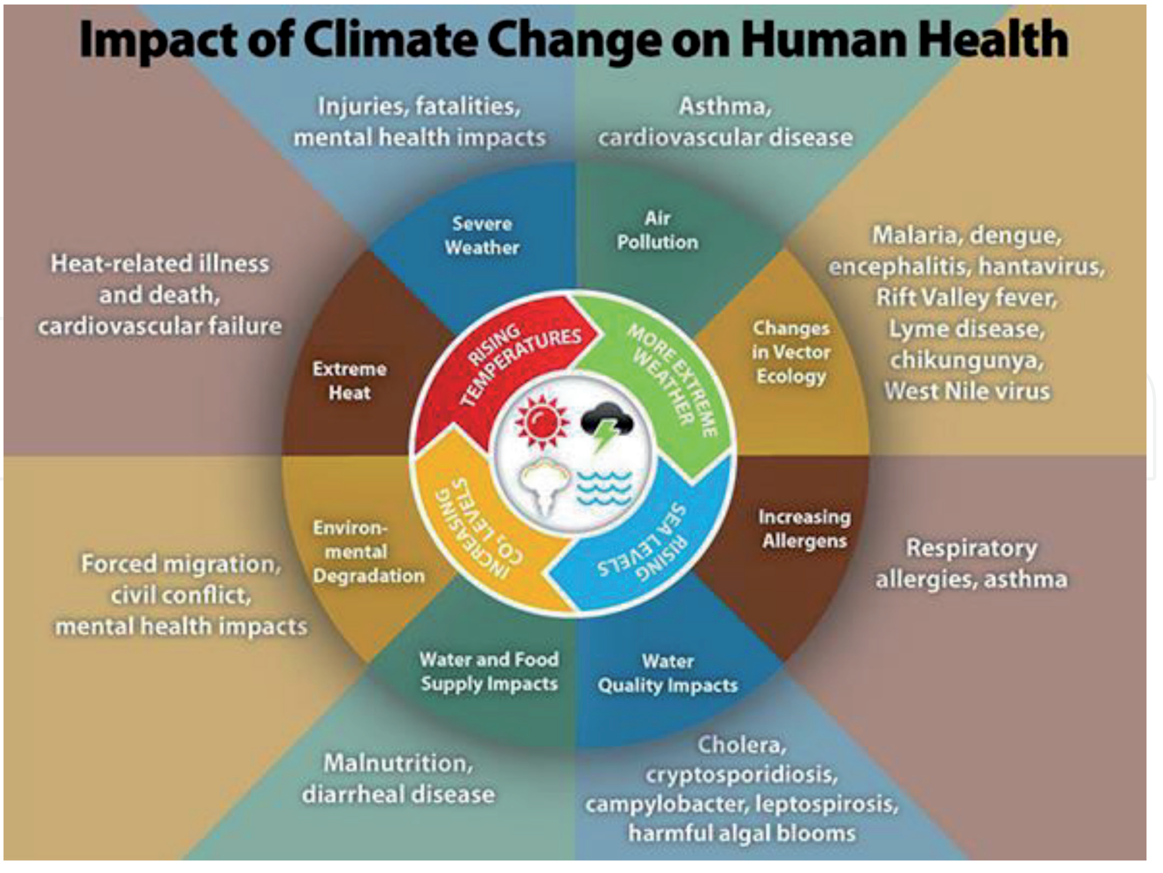

Figure 3.
Impact of Climate change on public Health [4].

management), agricultural or rural development sectors, and on the other hand, categories of social actors such as stockbreeders and farmers, peasant leaders, buyers and sellers of animal products as well as religious authorities.

The environment is continually changing. Therefore, this permanent change must be accompanied by adaptive and participatory methods to facilitate decision-making, which is quite complex for public health actors. The more complex the health problem is, the more the actors must learn to manage this uncertainty related to decision making. This is why some experts propose a participatory modeling and simulation approach to guide consultation and decision-making. This approach is largely inspired by companion modelling [28].

The tools used lead the actors concerned by health in a given territory to cooperate, even though they do not necessarily know each other or work together. These tools enable them to work together to build a shared representation of a complex situation and to simulate actions and their effects in order to build consensual solutions. This approach also offers the possibility of integrating health control and surveillance actions into the territorial context. It can therefore accompany health management interventions, such as vaccination, drug distribution or surveillance and the emergence of new clinical cases in human or animal populations.

4. Elements of Epidemiology of Vector-Borne Diseases in Haiti

In recent decades, climate change has been the central theme of several international environmental congresses. Climatologist Katharine Hayhoe has even stated that "all human beings aspire to the same thing: to live safely on our planet. So, while our work must remain objective and impartial, we are increasingly raising our voices and supporting the clear message that climate change is real, that humans are responsible for it, that its consequences are serious and that we must act immediately". It is that climate change is a multidimensional and interdisciplinary field that should be of interest to all human beings living on this planet. Its manifestations are indeed multiple, such as heat waves, warming and ocean acidification, which have important consequences on the life cycle of the main vectors responsible for animal diseases and zoonosis. It also favors the emergence of certain vector-borne diseases and the geographical extension of vector-borne diseases in temperate zones [5].

According to the World Health Organization, vector-borne diseases are responsible for more than 17% of infectious diseases and cause more than one million deaths each year [29, 30].

4.1 Scope of action of vector-borne disease epidemiology

To fight vector-borne infectious diseases in humans and animals, it is important to know their epidemiology, i.e. to have relevant information on the pathogens, vectors and manifestations of these diseases. In other words, it is important to know, for example:

- whether or not the pathogenic agent is cultivable or not;
- the sources of the pathogenic agent, i.e. animal, environment, human;
- possible reservoirs and intermediate hosts;
- how the disease is transmitted;
- the length of the incubation period;
- the duration of the transmissibility period;
- the action of physical and infectious agents;
- the susceptibility of the pathogen to available anti-infective drugs.

The epidemiology of vector-borne diseases is directly related to: the distribution, competence and capacity of vectors (the competence of a vector is its ability to infect a vertebrate host, to ensure the development of an infectious agent and to transmit this agent to another host, while capacity is associated with environmental conditions and also depends on: (i) the competence of the vector and the rate of vector-host contact; (ii) vector density and longevity; (iii) the level of infectivity of the infectious agents, their host specificity and their resistance to anti-infective; (iv) human activities, environmental and climatic conditions that may influence vector distribution and activity, and vector-human interactions and animal reservoirs [21].

In the case of Haiti, epidemiology should enable the collection of more data on the impact of climate change on the clinical and epidemiological manifestations of vector-borne diseases, and determine the consequences of climate change on ecosystems in Haiti in terms of biodiversity, vector habitats and the transmission period of certain vector-borne diseases, as well as social parameters. It would also be interesting to identify the main changes observed in Haiti in the evolution of vector-borne diseases following repeated natural disasters (cyclones) and large variations in rainfall recorded in recent years.

4.2 Vectors and infectious diseases in Haiti

As everywhere in the tropical world, mosquitoes are the most widespread vector in Haiti. But there are others such as ticks, flies, sandflies, fleas, triatomines and some freshwater gastropods such as limnea.

4.2.1 Infectious and parasitic diseases transmitted by insects in Haiti

The main insect vectors of infectious diseases in Haiti are:

- Aedes mosquitoes, vectors of Chikungunya, Dengue, Yellow Fever, Zika.
- Anopheles (Malaria)
- Culex (West Nile Virus Fever, Lymphatic Filariasis)
- Phlebotomas (Leishmaniasis)

In this chapter, we will be restricted to considering only the most important vector-borne infectious diseases such as: a. malaria, b. dengue fever, c. Chikungunya, d. Zika.

a. Malaria

Malaria is caused by Anopheles, which are responsible for approximately 219 million cases worldwide and more than 400,000 deaths each year. In Haiti, malaria is considered a major public health problem with a fairly large spatial and temporal distribution in the West departments and that of Grand-Anse.

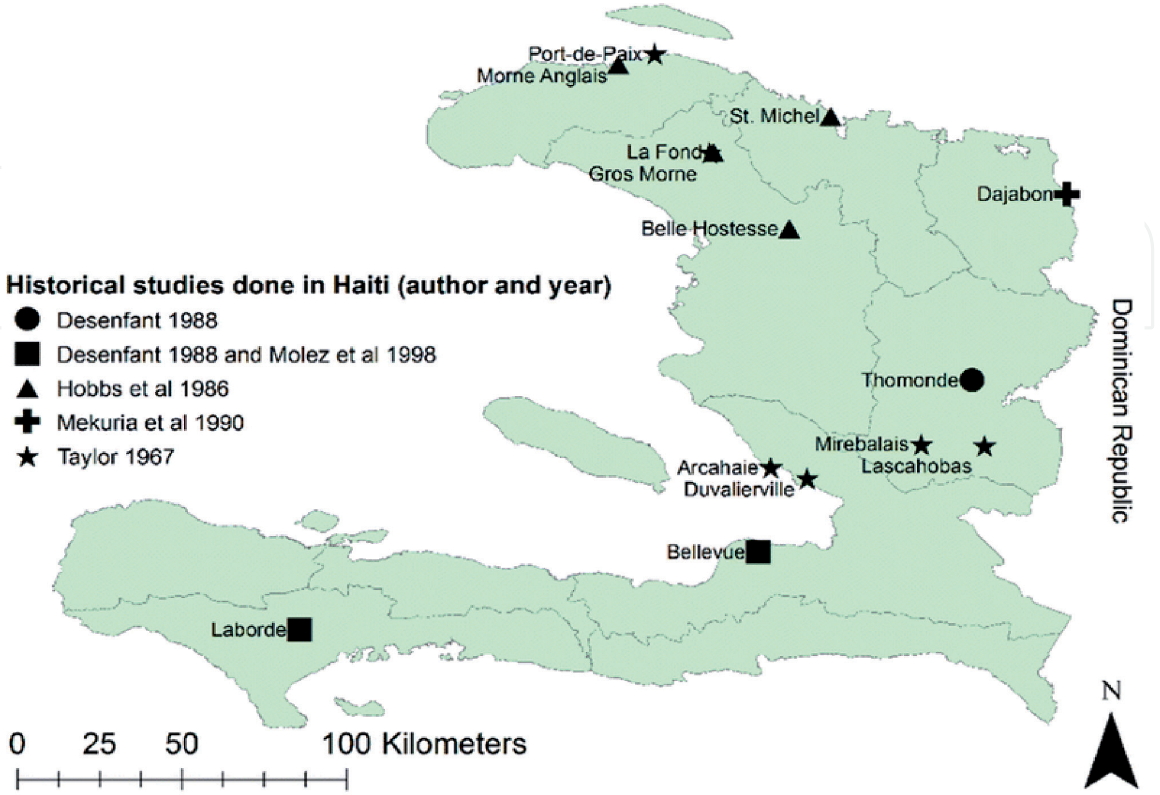

Figure 4.
Map of the sites of the mosquito behavior studies in Haiti [31].

The following **Figure 4** is an illustration of the main sites of mosquito behaviour studies.

The country has not been able to reach its goal of eliminating malaria by the year 2020 as planned. Additional information should be generated by epidemiological studies on vector ecology in order to develop strategies to facilitate the eradication of this disease [31, 32]. In order to understand the direct and indirect impacts of climate change on malaria, the variability of malaria transmission as well as climatic and anthropogenic factors need to be analyzed. The sporogonic cycle of Plasmodium is related to the increase in air temperature and the life cycle of Anopheles is related to changes in their natural breeding habitat resulting from changes in humidity following acclimatization reactions of vegetation under climate change.

The indirect impacts of temperature change on soil moisture dynamics are important and should be balanced against the direct effects of temperature change on mosquito and parasite life cycles for the prediction and future control of malaria [29, 30].

b. Dengue fever

Dengue fever is the most common infectious disease transmitted by mosquitoes of the genus Aedes, which carry the virus responsible for the disease. Although it is a tropical viral disease, it should be noted that a dengue epidemic occurred in Madeira, Portugal in 2012. This highlighted the potential for re-emergence of dengue in Europe due to global warming and the extension of vector distribution areas due to climate change. The dengue virus is circulating in Haiti, but it is not yet recognized as a major disease in the population. In 2011, to assess the prevalence of antibodies against dengue virus (DENV), serum samples were collected from infants and young children aged 7 to 36 months (n = 166) and tested by seroneutralization tests. Serotype 1 of the dengue virus infected 40% of this study population, followed by serotype 2 (12%), serotype 3 (11%) and serotype 4 (2%).It was found that 53% of infants and young children under 12 months of age had already been infected with DENV. The seroprevalence rate against DENV increased to 65% at 36 months of age. Heterotypic antibody responses were an important component of the total dengue immunity profile [33].

In October 2012, 25 cases of dengue fever, confirmed by rapid diagnostic tests (RDTs), were detected among workers of non-governmental organizations (NGOs) in Haiti based in Leogane and Port-au-Prince to determine the extent and risk factors for dengue virus infection. Of the 776 staff members of the targeted NGOs, 173 (22 percent; 52 expatriates and 121 Haitians) participated. Dengue IgM antibodies to dengue virus (DENV) were detected in 8 expatriates (15%) and 9 Haitians (7%), and the non-structural protein DENV 1 in one expatriate. Anti-DENV IgG antibodies were detected in 162 (94%) participants (79% expatriates; 100% Haitians), and confirmed by micro-neutralization tests as specific for DENV in 17/34 (50%) expatriates and 42/42 (100%) Haitians. Of 254 nymphs collected in 68 containers, 65% were AedesAegypti; 27% were Aedesalbopictus. Few NGO workers reported taking action to avoid mosquitoes (**Table 1**) [34].

A cross-sectional study of dengue virus (DENV) and West Nile virus (WNV) transmission was conducted using standard seroepidemiological methods. Blood samples (N = 673) were collected from 278 males and 395 females from three localities in the western and southeastern departments of Haiti. Serum was tested for the presence of anti-DENV and anti-WNV immunoglobulin G (IgG) antibodies using an indirect enzyme-linked immunosorbent assay (ELISA). Anti-DENV IgG antibodies were detected in 72.1% (95% confidence interval [CI] = 68.7, 75.5) of the

Variable	NGO workers with recent infection†		NGO workers without recent infection		Crude OR* (95% CI)‡	p-value
	n = 17		n = 156		n = 181	
	n	%	n	%		
Sex (male)	11	65%	120	77%	0.6 (0.19–1.59)	0.37
Expatriates	8	47%	44	28%	2.3 (0.82–6.24)	0.16
Occupation						
Indoor setting (ex. Office/admin)	1	6%	32	21%	0.2 (0.03–1.9)	0.20
Outdoor setting (ex. Construction)	8	47%	68	44%	1.2 (0.43–3.38)	0.80
Mixed setting (both indoor and outdoor)	7	41%	50	32%	1.6 (0.55–4.42)	0.42
Vaccination History (YF or JPE)	7	41%	43	28%	1.8 (0.66–5.14)	0.27
Previously lived in or traveled to Other Dengue Endemic Regions	9	53%	70	45%	1.4 (0.51–3.8)	0.61
Lived in or Travel to Dengue Endemic Regions (incl. Haiti)	15	88%	155	99%	0.48 (0.004–0.57)	0.03
Environmental factors at work place						
Screens on doors/ windows	8	47%	59	38%	1.5 (0.53–4.00)	0.60
Air-conditioning	6	35%	47	30%	1.3 (0.44–3.62)	0.78
Open water source nearby	9	53%	37	24%	3.6 (1.30–10.05)	0.02
Standing water source nearby	7	41%	45	29%	1.7 (0.62–4.82)	0.30
Reported knowledge of						
Infectious disease in Haiti (very good)	6	35%	23	15%	3.6 (1.16–10.98)	0.03
Mosquito bite prevention	9	53%	31	20%	6.2 (1.92–19.72)	0.002
Mosquito avoidance strategies employed						
Long sleeves	5	29%	50	32%	0.9 (0.30–2.64)	1.00
Long pants	5	29%	61	39%	0.7 (0.22–1.93)	0.60
Bed net	11	65%	101	65%	1.0 (0.35–2.85)	1.00
Mosquito repellent use						
multiple times a day	7	41%	26	17%	3.5 (1.22–10.04)	0.02

**OR, odds ratio.*
†Recent infection is any participant with a positive anti-DENV IgM or non-structural protein 1 (NS1) result.
‡Significance level, $p < 0.05$. Univariate analysis using Fisher's exact test was used to assess risk factors for recent infection, and 95% confidence intervals (CI) were based on the modeling accounted for the sampling design. Only significant variables with a cell size of 5 or greater were retained.

Table 1.
Risk factors for current and/or recent dengue virus (DENV) infection in non-governmental [34].

Dengue virus serotype	Derivation and height of antibody	Age groups in months (no. in sample)					
		7–12 (49)	13–18 (48)	19–24 (31)	25–30 (22)	31–36 (16)	All age groups (166)
1	Dominant	32% (15)	54% (26)	39% (12)	36% (8)	31% (5)	40% (66)
	GMT	357	448	591	615	452	465
	(95% CI)	(209–608)	(290–691)	(364–960)	(289–1,310)	(113–1,803)	(366–591)
	Cross-reactive	12% (6)	8% (4)	19% (6)	32% (7)	19% (3)	16% (26)
2	Dominant	15% (7)	6% (3)	10% (3)	18% (4)	19% (3)	12% (20)
	GMT	257	607	1286	308	389	411
	(95% CI)	(46–1,428)	(41–9,009)	(250–6,616)	(12–8,043)	(141–1,077)	(203–831)
	Cross-reactive	20% (10)	38% (18)	35% (11)	46% (10)	43% (7)	34% (56)
3	Dominant	6% (3)	10% (5)	13% (4)	18% (4)	19% (3)	11% (19)
	GMT	467	467	815	909	1807	678
	(95% CI)	(218–1,002)	(218–1,002)	(105–6,316)	(200–4,129)	(751–4,351)	(391–1,176)
	Cross-reactive	31% (15)	40% (19)	42% (13)	46% (10)	25% (4)	37% (61)
4	Dominant	2% (1)	0	3% (1)	0	5% (1)	2% (3)
	GMT	33		125		280	133
	(95% CI)	NA		NA		NA	(4–4785)
	Cross-reactive	12% (6)	15% (7)	23% (7)	22% (5)	12% (2)	16% (27)

**GMT = geometric mean titer; CI = confidence interval; NA = not available.*

Table 2.
Serotype-specific antibody to dengue virus as a function of age, Haiti [35].*

sample population; without significant differences in seroprevalence by study site, gender or age group (see **Table 2**) [35].

There was a high prevalence of anti-DENV IgG antibodies in all age groups, including the youngest age group (2–5 years), suggesting hyperendemic transmission of DENV in the western and southeastern departments of Haiti. These results undoubtedly demonstrate the endemic nature of dengue fever in the country (**Table 2**).

c. Chikungunya

Chikungunya is an infectious disease caused by an Arbovirus belonging to the Togaviridae family, which is transmitted to humans through the bite of a mosquito of the genus Aedes, mainly AedesAegypti better known as the tiger mosquito. The chikungunya virus has been known since the 1950s when it caused major epidemics in Southeast Asia and India. The wide geographical distribution of vectors has made it possible for the virus to emerge in many regions, as has been seen with other arboviruses, such as West Nile virus, which has been introduced and established on the North American continent since 1999. The first cases of chikungunya were detected in Haiti during April 2014, but the disease was detected in the Caribbean in St Martin as early as December 2013. Indeed, in a longitudinal cohort epidemiological study of 153 serum samples collected between 2011 and 2013 and another 61 collected in 2014, of those collected in 2014, none of the 153 samples were positive for IgG responses to chikungunya virus antigen, while 78.7% or 48 out of 61 were positive. In the cross-sectional sample, such responses were detected in 96 (75.6%) of the children and occurred at similar prevalence in all age groups [36].

Serological tests indicate that there has been a rapid and intense spread of the chikungunya virus in Haiti. The Ministry of Public Health and Population had reported a cumulative total of 39,343 cases between May 31 and June 16, 2014 in the 10 departments with an infection rate of 67% for the West Department. By mid-August 2014, more than 68,000 cases had been reported. However, after the peak at the beginning of June, the number of new cases per week had continued to decrease from over 12.000 to 315.

The disease left bad memories in the population because of the intense pain it caused through its clinical manifestations (signs and symptoms) including arthralgia, intense myalgia with sequelae that persisted for several months or even years. Although the clinical presentations of the diseases caused by these mosquitoes are similar, the arthralgia strongly suggests a Chikungunya virus infection [37].

d. Zika

Zika is an infectious disease caused by a flavivirus with a wide geographical distribution that is most often transmitted by the bite of an infected mosquito. The disease was first identified in the Americas in 2015 and was characterized by the occurrence of an abnormally high number of cases of congenital microcephaly in Brazil. It rapidly spread to the rest of the region and to the Caribbean including Haiti. Zika virus infection is associated with adverse fetal outcomes and rare neurological complications in adults [38]. The magnitude of the public health problems associated with Zika virus led the World Health Organization to declare the Zika virus epidemic a public health emergency of international concern on February 1, 2016 [38].

Because Zika was often an asymptomatic infection that did not necessarily require care, it was difficult to estimate the true incidence of Zika infection. However, during the period from October 12, 2015 to September 10, 2016, the Haitian Ministry of Public Health and Population (MSPP) had detected 3,036 suspected cases of infection in the general population, 22 suspected cases of Zika virus disease in pregnant women, 13 suspected cases of Guillain-Barré syndrome (GBS), and 29 suspected cases of Zika virus-associated congenital microcephaly. Nineteen patients with suspected Zika virus disease were detected, including 10 in the Western geographical department, 6 in Artibonite and 3 in the Central geographical department. These cases were confirmed by laboratory tests and included 2 pregnant women and 17 in the general population [39]. The surveillance program needs to be strengthened and supported by a functional laboratory in order to better monitor the evolution of the disease in Haiti.

5. Climate Change and The Global Health Approach

For the past fifty years or so, the world has been confronted with an unbridled population growth, a large part of which is forced to migrate to other shores to ensure its survival. At the same time, never before in history have the adverse effects of climate change and the risk of ecological disasters been so evident. These changes are accompanied by other profound alterations to the environment, such as the loss of biodiversity, deforestation, soil erosion, acid rain and ocean acidification. At the same time, the increase in life expectancy of the population and the unbridled process of urbanization have contributed to increased vulnerability to various environmental and health risks, particularly with regard to the occurrence of emerging and re-emerging vector-borne diseases for humans and animals. This has led to a holistic approach to human, animal and environmental health known as "One Health".

5.1 Nature of the "One Health, One Health" concept or approach

This concept emphasizes that public health problems that generally involve human/animal/environment interaction are so complex that they cannot be solved by a single discipline but by a multiple, transdisciplinary and multisector approach. Indeed, it is generally accepted that the environment in which human and animal populations live together has changed considerably over the years, greatly influencing the occurrence of many infectious and even non-infectious diseases.

According to the American Veterinary Medical Association, the "One Health" approach can be defined as "the joint effort of several disciplines working locally, nationally and globally to optimize the health of people, animals and the environment. In other words, it is an integrated approach that recognizes that there is a close interdependence between the well-being of humans, animals and their ecosystem health [40]. Thus, this approach promotes the principles of harmonization of human, animal and ecosystem health to better prevent and/or mitigate emerging diseases while noting that it can be applied to areas other than zoonosis, such as food safety, food security, antimicrobial resistance and response to the consequences of climate change.

Health problems are, in general, strongly linked to global environmental and socio-economic changes and to changes in production systems at the territorial level. This is what makes health management so complex as it mobilizes knowledge from both veterinary public health and agriculture and environment. Because of the emergence of new health uncertainties, unconventional actors are entering alongside the decision-makers traditionally in charge of public health [28]. In the context of climate change and outbreaks of vector-borne diseases throughout the world, including in the Caribbean including Haiti, the public health, animal health and environment sectors have three major challenges to address:

- The establishment of a platform for inter-organizational collaboration and communication to strengthen cooperation between the fields of human health, animal health and ecosystem health;

- Minimizing the impact of new emerging or re-emerging diseases by combining disease surveillance and emergency preparedness at the local, national and international levels;

- creating new methods and tools so that all of these actors can address health issues at the territorial level, the territory being understood here as a socially and politically constructed space and the seat of interactions between actors.

The real innovation of the "One Health" approach is the incorporation of the environmental component in the field of human and animal health. By using such an approach, climate change adaptation methods are more likely to contribute to solving food security problems, particularly in developing countries through the promotion of extensive livestock production systems in areas with large land areas, the increase in animal feeds, environmental sanitation and the establishment of regional integrated surveillance systems for certain vector-borne infectious diseases. It is undeniable that integrated community-based surveillance of zoonosis can be a very promising avenue for reducing the health effects of climate change [41].

5.2 Positioning of the One Health concept in relation to human and animal health

Climate change and environmental change are part of the set of changes that affect ecosystems and promote the emergence and re-emergence of animal diseases. In recent years, more than 70% of these emerging infectious zoonosis have their source in wildlife [Black and Nunn, 2009] and about 60% of emerging infectious diseases are classified as zoonotic, i.e. transmitted from animals to humans [20].

Global warming contributes to the emergence of infectious diseases in the animal and plant world by exerting a marked effect on arthropod insects (mosquitoes, aphids, sandflies, fleas), on ticks that can harbor and transport viruses, bacteria and protozoa. In addition, it causes a thermal increase that increases the risk of extending the current geographical range of these species with the risk of transmission to animals and humans of diseases against which there is no natural immunity [28]. There are a number of meteorological and climatic parameters that can affect human and animal health. In addition to heat, cold, water, ozone, air, allergens and ultraviolet rays, these include heat, cold, water, ozone, air, allergens and ultraviolet rays.

5.2.1 In men

Some authors argue that climate change is the most significant threat to human health in the 21st century, associated with an increase in chronic diseases, health problems caused by extreme heat and floods, food shortages caused by drought or floods, and various diseases including respiratory problems. The effects of climate change on human health can be both direct and indirect. They are considered direct when they are related to the physiological effects of heat and cold and indirect when they result, for example, from changes in human behavior following forced migration, major natural disasters such as floods and earthquakes, or major outbreaks of food-borne or vector-borne diseases. Not all climate-induced changes are necessarily negative for human health, especially those leading to a decrease in extreme temperatures [42].

a. Impact of heat and cold

In temperate countries, periods of high heat are sometimes accompanied by relatively high morbidity and mortality. It is estimated, for example, that in Europe, for a one-degree increase in temperature, heat-related mortality would increase by 1–4%. Heat is an immediate health risk to be considered because it has been shown that nearly three-quarters of the hot days observed since 1850 are attributable to climate change [43]. On the other hand, cold can also cause illness and death among the most vulnerable, especially the elderly and homeless. Variations in temperature, especially those that are upwardly oriented, can be the cause of some foodborne and vector-borne zoonotic diseases.

Food-borne bacterial infectious diseases such as salmonellosis and colibacillosis are generally sensitive to temperature and are becoming increasingly important every day even in developed countries such as Europe and the United States.

b. Impact of vectors

Vector-borne diseases result from the indirect impacts of climate change on biodiversity – arthropod vectors, pathogen reservoirs [44]. They are mainly transmitted by arthropods, in particular insects and ticks. They are generally responsible for animal diseases.

c. Water-related problems of climate change

Climate change induces profound changes in the volume of water available in a given area, which can materialize either through heavy rainfall and flooding or through drought leading to a scarcity of water in this area for the domestic use of the population and for animals. Floods generally carry certain infectious and parasitic diseases, including vector-borne diseases that are closely linked to the proliferation of mosquitoes and other vectors. Many outbreaks of waterborne diseases are due to the mobilization of pathogens or extensive contamination of water by fecal bacteria such as salmonella and coliforms. Thus, it is not uncommon to observe in Haiti outbreaks of anthrax or anthrax following cyclones and also an abnormally high number of gastrointestinal-dominated pathologies dominated by gastrointestinal disorders. Such contamination has generally had unfortunate consequences on the health of the population by rendering catchment waters that were intended for human consumption completely undrinkable.

Water-borne diseases are not necessarily related to floods since the lack of water can prevent daily hygiene practices, especially at the time of the new coronavirus pandemic or in countries where cholera is still prevalent. This lack of water, in some areas, can be extremely serious for the health of the population because it is important to wash your hands with soap and water several times a day to protect yourself against these two diseases.

d. Air Quality

In many industrialized countries, there is a serious air quality problem resulting from environmental degradation caused by uncontrolled industrial activities. In these countries, various pathologies of the respiratory type appear, mainly linked to the presence of ozone and particles in the air.

e. Impact of ozone on climate change

Ozone is a major pollutant in the majority of industrialized countries and its increasing concentration is dependent on climate variability and change. The Republic of Haiti, like many other poor, undeveloped countries, is experiencing the consequences of the impact of ozone on climate change, which are more attributable to the actions of neighboring industrialized countries than to its own agricultural and industrial production activities. Rising temperatures could result in local increases in peak ozone and fine particulate matter levels [45].

f. Allergens in the air

Allergens such as pollen or molds can be dangerous at certain times of the year for children and the elderly, as well as for anyone already suffering from chronic respiratory diseases such as asthma, severe allergies or chronic obstructive pulmonary disease. In a country like Haiti, the diagnosis of these disorders may not be established due to the lack of specialists in allergology.

g. The global effects of climate change on human health

It has been found that in some countries, major natural disasters have often caused severe psychological consequences for children who face such trauma. Global changes are increasing and diversifying the sources of soil and water contamination and are creating new interfaces of contact between humans, animals and their pathogens [28]. Their effects on health are generally unevenly distributed across people because the health and well-being of the population is also correlated with socio-economic factors such as income, housing, employment, education, gender and lifestyle. In addition to children, vulnerable groups include people with outdoor workplaces, the elderly, women, and those already suffering from disease or severe social inequalities [46]. Climate change also has direct impacts on the migration of people, which can be internal or national, intra-regional or international. It can have a negative impact on national economies, as the availability of food and water leads to an increasing need for humanitarian assistance and health protection for vulnerable groups [46].

5.2.2 In animals

Like humans, animals are very sensitive to the effects of climate change, which can be very negative for the health and well-being of livestock. Climate change plays a role in the establishment and geographic expansion of zoonosis [42]. However, according to several studies, the effect may, in some cases, be positive because the increase in air temperature could reduce the risk of death and improve the health and well-being of humans and livestock living in regions with very cold winters. However, extreme variations in climatic parameters such as heat, cold, humidity, and precipitation have an overall negative impact on the health and welfare of animals, resulting in a marked increase in morbidity and mortality. The negative effects of climate change are, as in humans, the consequence of combined changes in air temperature, precipitation, frequency and magnitude of extreme weather events and can also be both direct and indirect.

Heat stress can, depending on its intensity and duration, directly affect the health of animals by causing metabolic disturbances, oxidative stress and a drastic decrease in immune capacity leading to infections and death. Indirect effects are associated with the quantity and quality of feed and drinking water available to animals and the survival and distribution of pathogens and/or their vectors [47]. Indeed, animals are also highly susceptible to certain vector-borne diseases such as those transmitted by ticks like bovine anaplasmosis, piroplasmosis in dogs and cattle, cowdriosis or heartwater, equine encephalitis, African swine fever as well as by insects like Nile Valley fever or by mollusks like liver fluke. Populations of these different vectors tend to increase with climate change.

The issue of climate change, and its impacts on living beings, has become so important and relevant for life on the planet that the World Organization for Animal Health (OIE) has introduced it in recent decades into its strategies. [48, 49]. According to Vallat [48], the impact of climate change on health has often been mentioned, mainly for human health. As regards animal diseases, their relationship with climate change is more rarely mentioned, no doubt because the recent epizootics were mainly linked to highly contagious viral diseases (foot-and-mouth disease, classical and African swine fever, Newcastle disease, influenza avian, etc.) and for which the movements of animals and foodstuffs of animal origin, in particular through trade, have played a preponderant role [48].

Oyhantçaba et *al.* [49] note thet the links between animal production and climate change are complex and multi-directional. On the one hand, animal production has an influence on climate change, with mainly ruminants generating emissions of greenhouse gases. In particular, animal production is a very important source of methane and nitrous oxide released into the atmosphere. On the other hand, climate change influences livestock production by affecting the conditions governing animal production, fodder crop production and animal health. The impacts on animal health are increasingly being recognised, and this theme occupies a special section of this document, as we shall see below [49].

With the introduction and very rapid expansion of West Nile fever virus in North America, the role of wildlife has become clear. This episode highlighted the gaps in our knowledge about the ecology of this type of infection, particularly when they emerge in new settings [48].

It is a fact that the environment in which animals live plays an increasingly important role in the manifestation of diseases, particularly vector-borne diseases. Global warming has led to changes in the ecology of vectors, resulting in the disappearance of certain habitats, the appearance of new ones and, more generally, the displacement of the geographical area that hosts the habitats required by a given vector as a result of environmental changes. Such upheavals in ecosystems have had fairly serious consequences for livestock farming. Thus, we have witnessed the migration of vectors of tropical origin, often carriers of pathogenic germs, to milder and even temperate climates. But still, the causes of vector-borne diseases are multifactorial as they are generally associated not only with climate change but also with trade globalization, urbanization and deforestation [47].

In addition to vector-borne diseases, a dynamic of non-vector-borne diseases is developing, which are also subject to the influence of climate change. One example is avian influenza infections that can be influenced by the migration routes of wild waterfowl. It has been observed that some species of wild birds have reduced their migration distance as a result of global warming, which has sometimes contributed to the spread of some infectious fish diseases to areas that were previously free of them. The persistence of viruses in the environment, including in water, is also influenced by changes in temperature [44].

In general, wildlife plays a significant role in the transmission of some major animal diseases such as avian influenza, rabies, swine fever and tuberculosis. As a consequence of climate change, countries with forests or savannahs with important wildlife often face the problem of water scarcity for watering these animals. As a consequence, they are obliged to gather at the same water point, thus favoring the continuous circulation of pathogens, first among themselves and then in domestic herds due to encounters which are becoming less and less fortuitous in some countries as a result of wild deforestation and anarchic urbanization programs.

6. Methods for Combating Climate Change and Vector-Borne Diseases

Maintaining the earth's ecological system and other biophysical systems in good working order is an imperative that is part of the sustainable development option of countries to ensure the persistence or maintenance of life. It is now widely recognized that these systems are in a state of disrepair and that the resulting climate change represents one of the greatest threats to humanity in the 21st century by disrupting the well-being and health of animal and human populations. We must therefore face reality and strive to live within the norms that govern the normal functioning of our planet. Faced with climate change, which induces a whole range of diseases including vector-borne diseases and zoonosis, it is necessary to make a number of recommendations to mitigate its effects on extreme weather events and on the health of animals and humans. Special attention will be given to the major vector-borne infectious diseases that occur in the Caribbean and particularly in Haiti.

6.1 Main measures to combat climate change

It is important to restore as quickly as possible the health of ecosystems damaged by human action, through a good understanding of the relationship between climate and health, capacity building, information exchange and the promotion of research. Mitigation and adaptation measures should therefore be taken.

6.1.1 Commitment of each country to respect the recommendations of the Paris Agreement on Climate and Global Warming signed in 2016

Predictions suggest that the average global surface temperature of the earth will experience, during this century, a sharp increase of up to more than 5°C and significant changes in rainfall patterns and climate variability [50]. Each country should strive to follow the guidelines of the Paris Agreement and promote research, either at the national or regional level. Research will benefit from finding innovative methods to analyze weather and climate in relation to animal and human health. To this end, it is important to establish data series over long periods of time to better understand the mechanisms of climate change and its interaction with animal and human health or disease occurrence, and to be able to develop early warning systems to predict outbreaks and extreme weather events such as intense heat waves and rainfall, the increased risk of drought, the increase in the strength and speed of winds and tropical cyclones in certain areas such as the Caribbean, including Haiti, and the accentuation of the El Niño phenomenon.

Such work requires a firm commitment not only from the main international organizations concerned such as WMO, IPCC, WHO, OIE, UNEP but also from each country to work towards the reduction of greenhouse gases and other pollutants and to follow the principles of sustainable development required for the survival of the planet and the recommendations of the various international meetings resulting from the Paris Agreement on Climate and Global Warming.

6.1.2 An analytical approach to the impact of climate change on diseases

Evidence suggests that diseases that occur following major weather events are also conditioned by factors other than climate. This requires the collection of a baseline data set and the use of appropriate analytical methods to quantify the climate's contribution to the expression of these diseases. This requires the establishment of functional and reliable climate and disease monitoring and surveillance systems.

6.1.3 Climate change adaptation measures

The effects of climate change are objective data on which we must act quickly to complement climate change mitigation measures in order to significantly reduce their level of impact on animal and human health. These measures could address the various factors that condition the vulnerability of human populations such as population density, economic development, local ecological conditions, health status and access to health care.

6.1.4 Fight against infectious diseases

Infectious diseases, especially those of vector or waterborne origin, are very sensitive to climatic conditions. Therefore, there is a constant need to collect data on the prevalence and especially the incidence of infectious diseases to better address epidemiological studies. Only in this way will it be possible to establish any relationship between observed morbidity or mortality with a given climatic event. Multidisciplinary research teams should be formed and operate within a regional or international framework, as climate problems generally extend beyond the geographical boundaries of a single country [29].

6.2 Main vector control methods

6.2.1 Vector control guidelines

The World Health Assembly approved in 2017 "Global Action for Vector Control 2017-2030" [51]. This document provides strategic guidance to assist countries and development partners to strengthen vector control in their disease prevention and outbreak response strategies. It calls for a reorientation of vector control programs with technical capacity building, improved infrastructure, strengthened monitoring and surveillance systems and strong community mobilization. Changing the behavior of the population is considered one of the essential elements in the fight against vector-borne diseases. WHO has recognized the importance of working with partners to educate and sensitize the public and to build understanding of the need and ways to protect themselves and their communities from the various vectors. In addition, access to water and sanitation services is a very important factor in disease control and elimination.

6.2.2 Main vector control methods

Vector control methods are multiple because they change with the nature of the vectors, which present a great biological diversity. The most commonly used are: a) Biological methods which consist of using, for example, larvivorous fish at the level of water bodies and large aquaculture basins; b) Physical methods that refer to the protection of the environment, either by physical barriers (e.g., mosquito nets, window screens, etc.) or by changes in the environment (e.g., decrease in the density of copses) to cause a reduction in the vector population; c) Chemical methods which are diverse. They may use larvicides, parietal intra-household spraying, insecticide-treated nets, and space spraying; d) Sanitation which is a set of methods and techniques aimed at improving the overall health of the environment by removing the causes of unhealthy conditions.

7. Conclusion

The situation of planet earth is becoming more and more critical every day, especially in countries that care little about the problems caused by global warming and the various forms of pollution of ecosystems. The future of mankind looks very threatened and bleak due to the multifaceted impact of climate change on biodiversity, agriculture, environment and human and animal health. Indeed, the consequences of climate change on public health are today almost indisputable; they are particularly noticeable in vector-borne diseases. Slight variations in the average temperature, in the rainfall regime, in humidity, can have serious health implications, mainly in tropical developing countries because they are likely to affect the physiology of vectors.

The Republic of Haiti has suffered for years the adverse effects of climate change with a marked disturbance in the rainfall regime, the occurrence of prolonged periods of drought and an increase in air temperature. Descriptive epidemiological studies reveal significant prevalence rates of many vector-borne diseases in the country: malaria, dengue fever, chikungunya, Zika, yellow fever, Nile Valley fever, lymphatic filariasis, diseases linked to tick bites, etc. While the causal relationship between health and climate and environmental changes has not yet been clearly defined in Haiti for lack of in-depth epidemiological studies, there is no doubt that there is a positive correlation between these variables.

It is therefore high time to conduct studies on climate change at national and regional levels in order to better understand their impact on terrestrial and aquatic ecosystems and to better understand, in particular, their impact on human and animal health through analytical epidemiological research. It is therefore urgent to take the necessary steps to define a coherent framework of action and intervention strategies likely to facilitate the reversal of the accelerated trend of degradation of the environment and the health of the population, at least in areas of the country identified as high risk. This framework will include in its approach the "One health" approach, taking into account the environmental component in the field of action of human and animal health with a view to reducing the effects of climate change on human health in Haiti.

The variations observed in the epidemiology of vector-borne diseases, in particular arboviruses (dengue fever, yellow fever, Zika for example), result from social, economic and environmental changes that are largely dependent on climate change. It is important to understand the dynamics of this evolution in the country which is faced with a great lack of local meteorological and climatic data, due to the lack of stations or centers assigned to the collection of this data on a regular and systematic basis. In addition, there is also no reliable information on the biotopes of arthropod vectors, any changes that have occurred in their way of life in recent decades, the distribution of vectors at the country level, the contributing factors and/or limiting their proliferation in the Haitian context, estimates of their population according to periods of rain and drought, etc.

The country benefits from considering the opportunity to revitalize the inter-sectoral cooperation platform with a strong involvement of national and foreign universities to make it functional and capable of properly addressing the various problems related to climate change and its impact on public health by general and vector-borne diseases in particular It is in this perspective that the next actions of Quisqueya University will be oriented.

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