Climate Change and Potential Health Effect in Benin, West Africa

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Abstract- Climate change-related risks, such as health, resources disparities, vulnerability, and food insecurity are increasing in Benin, West Africa (WA). Morbidity and mortality based of vectors borne diseases (malaria, meningitis, dengue, cholera, etc.), air pollution-related respiratory diseases, and climate extremes events (floods, droughts, etc.) and heatwaves are most likely risks. Several studies have been carried out on climate change in Benin. But none showed methodologically consistent and detailed and giving any certitude on the analysis of temporal-spatial trends and the future climate of the country. As a result, the climate remains uncertain and no studies have been carried out to assess the impact of climate change on health over Benin. While, the risks of the appearance of vector-borne diseases (VBD) that are sensitive to climatic variations and changes, such as malaria, meningitis, dengue fever, cholera, etc. remain and magnifying day to day.

Keywords: Climate change, Risk, Health, Vector-borne diseases, Morbidity, and Mortality.

I. INTRODUCTION

Climate change defines as any changes directly or indirectly attributable to human activities that affect the composition of atmospheric air and add to the natural variability of climate (UNFCCC 1992). According to Ongoma and Chen (2017), climate change is a global phenomenon, with varying indicators and impacts from one region to another. The effects of climate change are significant in developing countries that depend mainly on climate-related humans activities (IPCC 2014; Mora et al. 2013), then with incidences of endemic epidemics (malaria, meningitis, cholera, etc.) related to temperature and rainfall trends (De Longueville et al. 2013). The fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC 2014) has affirmed high confidence in the link between climate change and human health (IPCC 2014; Smith et al. 2014). The report emphasized that, despite the advances in understanding the influence of climate change on health, uncertainties and knowledge gaps must be addressed to improve decision support systems. In addition, the World Health Organization attributes to climate change the defining issue for health systems in the 21st century (WHO 2016).

There are three essential components for most human's diseases: an agent (or pathogen), a host (or vector) and a transmission environment (Epstein 2001). For most climate-sensitive diseases, climate change may impact the whole process of a disease's development (WHO 2005) including the survival, reproduction, either distribution of disease pathogens and their hosts, as well as the availability and means of such pathogens transmission environments. For example, temperature increases impact the spread of malaria. Leeson (1939), and Patz and Olson (2006) revealed the influence of increasing temperature on the pathogen. Warmer ambient temperatures (between 25°C and 30°C) affect the *Anopheles mosquitoes* biological cycle by shortening its duration of mosquito larvae to 10 days instead to 20 to 30 days so increasing the transmission rate of malaria (Huang et al. 2011; Patz and Olson 2006) Likewise, decrease in rainfall will not only lead to competition among water resources management, but thus it will affect water quality and thereby increase the risk of water-borne pathogens. Heavy extremes rainfall on the other hand will increase incidence of water borne diseases (Smith et al. 2014; Stewart et al. 2004). It has been concluded that, many of the major killer diseases such as cholera, diarrhea, malaria, dengue and other infections carried by vectors are highly climate sensitive (Thomson et al. 2018; WHO 2018), and that if left unchecked, climate change may indeed swell the population at risk of malaria in Africa by 90 million by 2030 (Fouque and Reeder 2019; Franklinos et al. 2019).

In Benin, the wealth of literature deals with climate change in its current and future state and the impacts of its alteration on the various sectors. In fact, the report of Scientific Support Project to the National Adaptation Plans (Climate Analytics 2018) on the status quo of scientific knowledge highlights that the country's climate has changed dramatically with the onset of extreme climate events. The climate trend is marked by an upsurge and a temporal-spatial variation of the rains over the country. The average temperature increases. The country's future climate literally presents uncertainty with high risks of occurrence of extreme climate events (Climate Analytics 2018). The notable impacts studied by the researchers are based on the sectors of agriculture (Fadina and Barjolle 2018; Yegbemey et al. 2014); biodiversity (Fandohan et al. 2013) water resources (Biao 2017; Hounkpè et al. 2016). Natural resources are under threat and people's incomes are becoming low. As indicated in the climate analytics report, the literature is poor with regard to studies related to climate change and human health in Benin. While at the global and sub-regional level the problem is addressed and the risks of evidence of the impact of climate change on certain diseases (malaria, meningitis, cholera, etc.) are very significant.

This paper aims to assess the current climate situation of Benin, its variability, trends, and potential predictability, and establish the relevance of this knowledge with climate-related diseases. The remaining part of this study outline is as follows: Section 2 briefly describes the area of study, data and methods used. Section 3 presents results and discusses, while the conclusion and recommendations of the study are given in Section 4.

II. STUDY AREA AND METHODOLOGY

2.1. Area of Study

Figure 1 shows Benin in West Africa (WA) region where the study domain is located along longitude 2–36°E and latitude 6°S–29°N. It borders the Atlantic Ocean to the south and Togo to the West. Other neighboring countries include Nigeria to the east and Niger to the east north and Burkina Faso to the West North. The study area is located in North equator.

The country has massive and diverse geographical features. The north of the country is shaped stretched between the Niger River. A range of mountains extends along the northwest border and into Togo; these are the Atacora. Benin climate is hot and humid. Annual rainfall in the coastal area averages 1300 mm. The country receives bimodal rainfall patterns per year. The long rainy season is from April to late July (AMJJ), with a shorter less intense rainy period from mid-September to November (SON). The main dry season is from December to April (DJFMA), with a short cooler dry season from mid-July to September (JAS).

These seasons are associated with maximum solar heating driven by the oscillating migration of the rain belt along the Inter-Tropical Convergence Zone (ITCZ). The ITCZ drives a remarkable influence in the distribution and patterns of rainfall and temperature fluctuations over the study area. Temperatures and humidity are high along the tropical coast. In Cotonou (Capital City, South Benin), the average maximum temperature is 31 C and the minimum is 24°C. The monsoon, oceanic and charged with humidity, blows from April to November, from the southwest. The harmattan continental and dry, blows in the opposite direction of the monsoon (it comes from the north, from the Sahel), from November to May, bringing orange ocher dust. The humidity level, always important, is between 65 % and 95%. The average temperature is between 22 °C and 34 °C, April and May being the hottest months, just after the harmattan blew for six months before the monsoon brings its rains. The northern part of the country is located in the African belt or predominates meningitis with high incidence rate (Diallo et al. 2017).

The majority of these areas are ASALs (arid and semi-arid). In the case of malaria, Benin is classified in countries where malaria is endemic (WHO 2018).

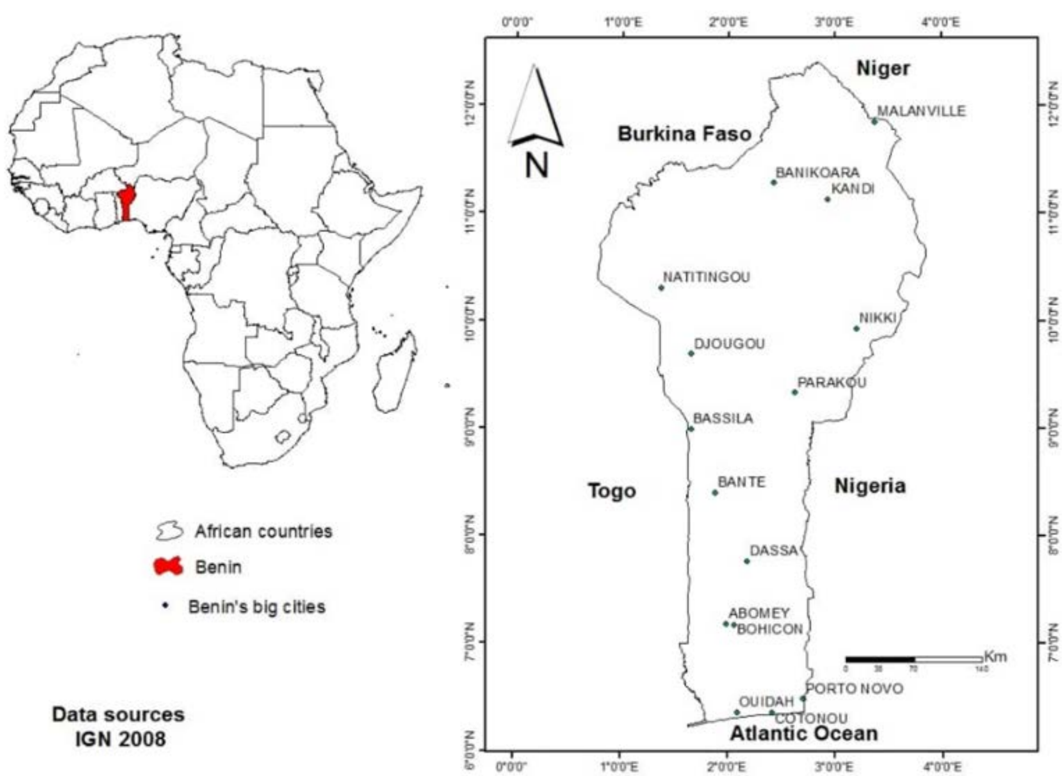


Fig. 1: Topographical elevation (m) of Benin, WA.

Every year children, pregnant women, and adults die after being infected Anopheles mosquitoes (WHO, 2017). Climate representations are significant in increasing the vectors of these two infectious diseases of poverty (Thomson et al. 2018).

2.2. Methodology

This paper is based on an extensive literature review related to climate change and health issues in the context of Benin, West Africa. In addition, relevant policy and program documents published by various key stakeholders were reviewed. We searched PubMed, Google Scholar, Research gate and Web of Science, for all papers published relative to the topic. Search terms were related to climate change and variation in Benin, vector-borne diseases, models of human health and climate change, climate change impact on human health. We included treatment papers, reviews, case studies, and surveillance reports and we focused also on modelling studies that evaluated the effect of climate change on vector-borne diseases in West Africa.

III. RESULTS AND DISCUSSION

3.1. Climate change over Benin

Fourth Assessment Report (AR4) of Intergovernmental Panel on Climate Change (IPCC), during 1931-1960 and 1968-1990, the region of West Africa (WA) where Benin is located recorded drastic weather, such as a drop of 20 to 40% of the rainfall and a fall in the flow of the main rivers of Benin 40 to 60% since 1970 (IPCC 2007).

According to Akponikpè et al. (2010) and Mora et al. (2013), rainfall and temperature are the main parameters of the analysis of climate change and variability in Benin, since they represent the most critical parameters in the intertropical zone. However, a number of studies have been focused on rainfall the all trends and variability, since it has shown more inter-annual variability than temperature trends.

Indeed, studies of Boko et al. (2012), have shown that since in 1970, there was a steady decline in the number of rainy days with the shortening of the duration of the small rainy season ending with heavy rains (Climate Analytics 2018). Among 1971 and 2000, the northern region of the country recorded an average of 80 rain days/year and the southern region recorded an average of 140 rain days/year, while between 1951 and 2010 there was a decrease of 11 to 28% of the annual precipitation and an increase of the average temperature of 1 °C (McSweeney et al. 2010). Hountondji et al. (2011) have shown that between 1960 and 2000, the annual rainfall amount, the total number of wet days and the total amount of rain recorded in 30 days decreased significantly. An analysis established over the last 60 years on the interannual variability, carried out that the years 1977 and 1983 were particularly marked by a climatic drought while the years 1962, 1968, 1988, 1997, 1998 and 2010 recorded strong cases floods (Climate Analytics 2018) with a high impact on health, agricultural, etc.

Otherwise, the climate evolution over Benin marks up by a wide variation rainfall and the precocity of the seasons. The rainfall analysis from annual totals at synoptic stations shows a downward trend with extreme rainfall and storm events. Based on the analysis of annual rainfall data from 1922 to 2005; has been shown that there was a high incidence of excess rainfall in the 1950 and 1960, particularly in the southern part of the country, while the 1970 and 1980 experienced severe droughts (Yabi and Afouda 2012). Further, N'Tcha et al. (2017) showed that the number of days of heavy rains and storms, the consecutive days of rains and the total annual rainfall between 1950 and 2014 in the Ouémé catchment decreased significantly.

3.2. Future Climate and extremes climate events over Benin

In Africa, climate projections show that whatever the scenarios considered (the moderate scenario: RCP 4.5 or the most pessimistic: RCP 8.5), a trend of temperature increase of the order of 2 ºC to 4 ºC with, however, large uncertainties on precipitation (IPCC 2014). Further, Mouhamed et al. (2013) and Taylor et al. (2012) have shown in their studies that the region will experience more extreme events such as extreme rains, heatwaves, floods and droughts with disparities across sub-regions. According to Baudoin (2010) and Yegbemey et al. (2014), the climate of Benin is characterized by extremes events such as the floods during the rainy season and the small dry season; pockets of drought, the strong winds, heat waves and sea-level rise with a 75% to 80% risk for flood and droughts events.

The information extracted for Benin from climate models (regional or global), which are based on IPCC scenarios (RCP 4.5 and RCP 8.5), allows for an analysis of the future state of weather over Benin (Climate Analytics 2018). Jalloh et al. (2013) using different models of climate simulations have shown, by 2050, it would have an increase in average temperature across the country, although the magnitude varies spatially and from one model to another. However, there are many uncertainties with respect to precipitation projections according to the models and the temporal projection considered (N'Tcha et al. 2017; Obada et al. 2017). Some models indicate an increase in precipitation (Climate Analytics 2018), while others predict a decrease in precipitation (Alamou et al. 2017), especially in the south of the country. Thus, the results of N'Tcha et al. (2017) and Alamou et al. (2017) showed uncertainties in the projection of rainfall extremes in the Ouémé and Mékrou Catchment respectively. Similarly, Obada et al. (2017) under an analysis with a series of climate models, predict that whatever the scenario of pessimistic emission (RCP 8.5) either moderate (RCP4.5), the uncertainty of the rains will vary from -10% to + 10% on the Mekrou basin, while the basin will record a 10% decrease in the number of wet days.

Under these unfavorable weather conditions with an uncertainty future prediction, can be of extreme events future such as flooding and drought as in the past with huge threat to socio-economic development (health, agriculture, etc.).

3.3 Link between climate change and human health

Note there is no scientific study based, which addresses the impact of climate change on human health in Benin. Nevertheless, the results of the research have been found on the issue at the global and continental level.
According to Thomson et al. 2018, the health and wellbeing of African populations are closely tied to their environment which is itself closely linked to the regional and local climate. It is now abundantly clear that climate change is occurring globally (IPCC 2014), and having impacts on human health systems worldwide. It has therefore been suggested that attention should be given to studies that consider the link between climate change and infectious (e.g.: Meningitis) and vector-borne (e.g.: Malaria) diseases, so as to have a better understanding of the nature of the relationship (Ceccato et al. 2018; Chaves and Koenraadt 2010; Haines et al. 2006).
Regarding how climate change can affect human health, there are three ways (Figure 2): (1) directly impacts, such as the mortality and morbidity (including "heat exhaustion") due to extreme heat events, floods, and other extreme weather events in which climate change may play a role; (2) indirect impacts from environmental and ecosystem changes, such as shifts in patterns of disease-carrying mosquitoes and ticks, or increases in waterborne diseases due to warmer conditions and increased precipitation and runoff (vector-borne diseases, VBDs); and (3) indirect impacts mediated through societal systems, such as undernutrition and mental illness from altered agricultural production and food insecurity, stress, and violent conflict caused by population displacement; economic losses due to widespread "heat exhaustion" impacts on the workforce; or other environmental stressors, and damage to health care systems by extreme weather events.

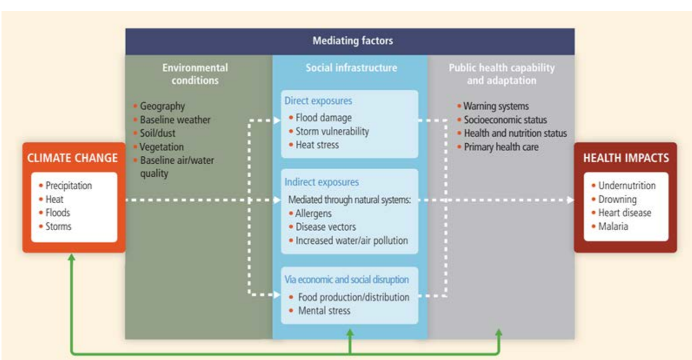


Fig. 2: Conceptual diagram showing three primary exposure pathways by which climate change affects health.
Source: Adapted from Smith et al. 2014 in Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the AR5 of the IPCC. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, pp. 709-754.

3.3.1. Direct impacts Climate on Health

It is difficult to estimate the net direct impact of climate change, as it relates to climate events, such as extreme temperature (heat waves, heat stress, heat exhaustion, heat exposure, etc.), on annual mortality and morbidity, which, moreover, will vary from one population to another (McMichael et al. 2003). The number of vulnerable people exposed to heatwaves increased by 125 million between 2000 and 2016 (Smith et al. 2014). Over 70,000 additional deaths occurred over Europe as a result of the heatwave (Fouillet et al. 2006). Worldwide, more than half of all non-household labor-hours occur outdoors, mainly in agriculture and construction (Heinemann 2010; ILO 2013). Consequently, workers in agriculture and construction in tropical developing countries such as Benin are among the most exposed, but heat stress is also a problem for those who work on the inside in environments not controlled by the temperature, and even for some workers in high-income countries (see Figure 3) such as the United States (Luginbuhl et al. 2008). Impact on mortality of events such as a heatwave can not be determined with certainty because an undetermined number of these deaths have occurred in vulnerable people who would have died in the near future and most of the additional deaths during periods of heat stress occur in people already suffering from a disease, primarily cardiovascular or respiratory (McMichael et al. 2003). There are international standards of maximum recommended workplace heat exposure and hourly rest time (Parsons 2014). The insert shows (Figure 3) the International Organization for Standardization standard (ISO 1989) for heat stress in the workplace that leads to recommendations for increased rest time per hour to avoid heat exhaustion at different work levels.

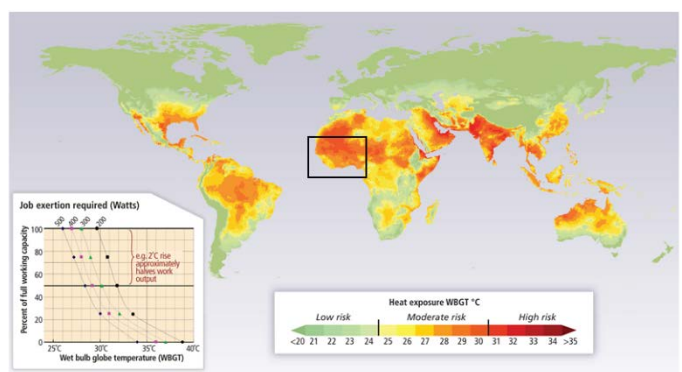
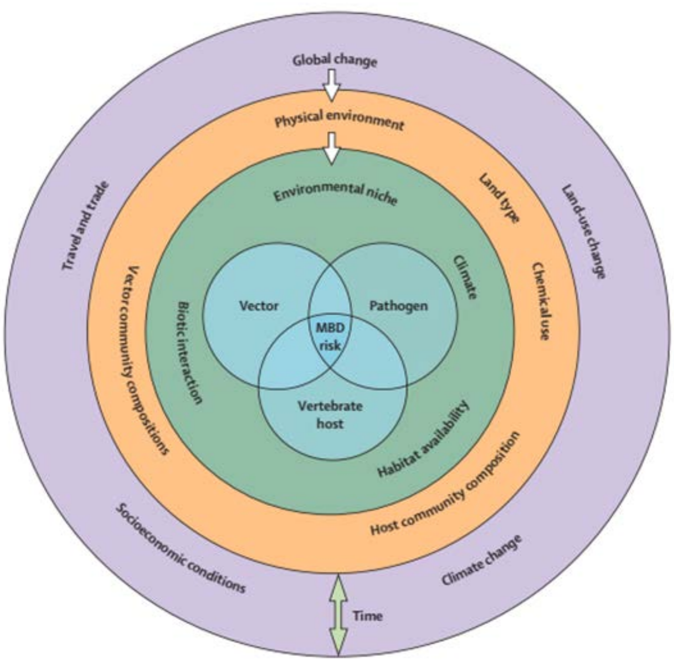


Fig. 3: The 1980–2009 average of the hottest months globally, measured in web bulb globe temperature (WBGT), which combines temperature, humidity, and other factors into a single index of the impact on work capacity and the threat of heat exhaustion.
Source: Adapted from Smith et al. 2014: Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the AR5 of the IPCC. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, pp. 709-754.

This is based on studies of healthy young workers and includes a margin of safety. Note that some parts of the world already exceed the level for safe work activity during the hottest month. In general, with climate change, for every 1°C that Tmax (Temperature maximum) goes up, the Wet Bulb Globe Temperature (WBGT) goes up by about 0.9°C, leading to more parts of the world being restricted for more of the year, with consequent impacts on productivity, heat exhaustion, and need for air conditioning to protect health (Lemke and Kjellstrom 2012). However, Benin is located in West Africa where exposure to heat WBGT is with moderate risk and almost within the higher risk range.
The insert shows the International Organization for Standardization standard (ISO 1989) for heat stress in the workplace that leads to recommendations for increased rest time per hour to avoid heat exhaustion at different work levels. This is based on studies of healthy young workers and includes a margin of safety.

3.3.2 Indirect Impacts of Weather and Climate on Health

Weather and climate conditions, as well as the availability of surface water, can positively or negatively affect the transmission of vector-borne diseases (VBDs). For those VBDs air surface temperature(SAT), precipitation, moisture, surface water, and wind are most climate parameters which increase or decrease the development of transmission vectors, such as Malaria, Dengue Fever, Meningitis, Cholera, etc. These are some of the best-studied diseases associated with climate change, due to their widespread occurrence and sensitivity to climatic factors (McMichael et al. 2003).
Malaria is considered endemic in over a hundred countries across the globe and many cases of malaria and deaths due to malaria occur in Sub-Saharan Africa, where is located Benin.



It is mainly caused by five distinct species of plasmodium parasite *(Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae, Plasmodium ovale, Plasmodium knowlesi)*, transmitted by *Anopheles mosquitoes* between individuals. In 2010 there were an estimated 216 million episodes of malaria worldwide, mostly among children younger than 5 years in the African Region (WHO 2010). The number of global malaria deaths was estimated to be 1,238,000 in 2010 (Murray et al. 2012). The influence of temperature on malaria development appears to be nonlinear and is vector-specific (Alonso et al. 2010).
Haines et al. (2006) indicated that observations of short-term variations in climate or weather show that even small temperature increases and precipitation changes can result in measurable impacts on malaria. Warmer ambient temperatures affect the extrinsic cycle by shortening its duration, so enhancing the transmission potential of malaria (Krämer et al. 2010). Temperature was associated with malaria cases in Korea, Southwestern China and India (Kim et al. 2012).
Also, rainwater creates pools that can become a breeding site for *Anopheles mosquitoes*. High rainfall also increases humidity and prolongs the life of adult mosquitoes. According to Suwito et al. (2015), the increases of precipitation and humidity are directly proportional to the density of *Anopheles mosquitoes.*

3.4. Evidence of the impact of climate change on VBDs transmission in Benin

3.4.1. Malaria

Few recent works have been done since AR4 to elucidate the role of local warming on malaria transmission in Benin, but time-series studies have been out in West Africa region, such as in Ghana (Ankamah et al. 2018; Darkoh et al. 2017), Senegal (Diokhane et al. 2016), Burkina Faso (Tourre et al. 2017), Niger (García-Pando et al. 2014) using the modelling, mapping to assess the impact of climate change on malaria transmission and prevalence.

Fi. 4: A system dynamics approach to understanding mosquito-borne disease risk. *A conceptual model to show a systematic approach to understanding mosquito-borne (MBD) disease risk whereby public health outcomes are influenced by complex interactions between environmental and socio-economic systems.*
Source: Adapted from Franklinos et al. 2019 in “The effect of global change on mosquito-borne disease.”

In 2018, the application of the *"Climate Proofing"* method by the Scientific Support Project to the processes of National Adaptation Plans in the process of integrating climate change adaptation into the National Health Development Plan, allowed to clarify the link that could be established between climate change and malaria in Benin (GIZ 2018).

The results of the approach stipulate that between 1970 and 2010, the average temperatures observed in the municipality of Kandi (North Benin) varied between 27 °C and 29.5 °C with maxima located between 33.5 °C and 36 °C. Knowing that in the case of malaria, the increase in temperature leads to a reduction of the larval development cycle of *Anopheles mosquitoes* and increasing their sting frequency. Concretely, when the temperature is below 20 °C, the development cycle of mosquito larvae is 25 to 30 days and when it is between 25 °C and 30°C, this cycle is shortened to about 10 days. The direct consequence of this thermal alteration is the rapid proliferation of the mosquito population, the increase in the frequency of human infection, which increases from 2-3 times per day (in periods of low temperature) to 43 times a day when the temperature is high. While the evolution of the temperature at the level of most municipalities of Benin is similar. The result is an increase in the number of malaria prevalence in the population.

As a result of temperature, factors such as the influence of sea-level rise, heavy rainfall, relative humidity, and extreme weather events are also climatic parameters that affect the prevalence of malaria. The erosion of the coast of the Gulf of Guinea, where the coast of Benin is located, was attributed to climate change, with the cause of the sea-level rise, and was estimated at 200 m/year in 2008 by Heinrich Boll Stiftung-NGO (Heinrich 2017). Sea level rise can be followed by an overflow that results in salinization of the surface water often used by the population. This promotes the development of the second vector of malaria, *Plasmodium malariae*. Consequently, there is an increase in the transmission vectors and the prevalence rate of malaria.

As for extreme weather events such as heavy rains and floods, they promote the multiplication of breeding grounds for mosquito larvae, the result is also the increase in the mosquito population and in turn the rate of prevalence of malaria and other mosquito-borne diseases (dengue, filariasis, etc.). Knowing that each year the coast (south of the country) of Benin, has experienced floods since 1997, with the most catastrophic flood recorded in 2010 (Climate Analytics 2018). The flood of 2010 was unprecedented. The two rainy seasons usually observed in the south of the country have been combined in a single continuous rainy season for nearly months; with the storm, have been observed in almost the entire country in August 2010 (Climate Analytics 2018). This led to a quick and massive rise in the level of the main rivers and their tributaries throughout the country, with the result that mosquito colonies multiplied. There would be a continuous health impact in the next years if nothing is done in engineering design to fight future flooding else.

3.4.2. Meningitis

Meningitis is an inflammation of the meninges, most often of infectious origin. The meningitis belt in sub-Saharan Africa is the region where most epidemics of meningococcal meningitis occur and which suffers the greatest burden of endemic disease (Molesworth et al. 2003). Meningitis is an infection of the thin lining that surrounds the brain and spinal cord. Although there are many causes of meningitis, the epidemic form of the disease is caused by the bacterium Neisseria meningitides. Meningitis epidemics are believed to result from a combination of favorable environmental, host and micro-organism (*Neisseria meningitides*) conditions. These conditions include immunologic susceptibility of the population, climatic conditions, socio-economic status and transmission of a virulent strain (WHO 1998). The Center and North of the country are affected by meningitis (Djohy et al. 2015). The results of the qualitative study carried out by Djohy et al. (2015) on the popular perception of epidemic meningitis in a context of climate change in the north of Benin showed that the population associate the etiology of the disease with various factors: heat waves, various winds, aerosols, dust, etc., said to be dependent on uncertain climatic events. They conclude that the populations concerned are caught between the risks of a changing environment and the hegemony of a multi-dynamic disease. Besides, the results of the basic modelling study in Senegal, WA (Diokhane et al. 2016) and Niger, WA (García-Pando et al. 2014) showed that there is a correlation between the prevalence of meningitis: the Sahara dust loading and meningitis and Soil Dust Aerosols and Wind Predictors, respectively. While it was literally stated that 14 to 34.5% of the total variability of meningitis in the northern part of Benin is explained by climatic conditions (Oke 1994). Knowing that the northern and central parts of the country experience wind waves and dust during the dry season, it would have a link between these climatic events and the prevalence of meningitis. Modelling oriented scientific studies could elucidate this assumption.

3.4.3. Other climate-sensitive diseases in Benin

WHO has inscribed cholera and yellow fever as communicable diseases and vector-borne diseases (WHO 2013) in Benin. Cholera is a sudden and serious intestinal infection that is caused by the bacterium. In 2012, Benin reported 625 cases including 3 deaths of cholera (WHO 2013). *Vibrio cholera*, the bacterium responsible for cholera grow in water (surface water, coastal waters, etc.) and in food contaminated with the feces of an infected person. From 2005 to 2012, the provinces of Atlantique and Ouémé were the most affected by cholera in Benin. Knowing, that theses provinces are both affected by floods every year. Cholera epidemic cases can be explained by the heavy rains, and therefore the duration of the flooding that favors the development of the pathogen (De Magny et al. 2007; De Magny et al. 2008).

Like malaria, yellow fever has a mosquito as its pathogen. *Aedes aegypti*, the yellow fever mosquito, like any other mosquito, is sensitive to temperature and rainfall variation. Climate change and the repetition of extreme weather events (heavy rains, flooding, heat waves) can enhance vector development and increase transmission.

IV. CONCLUSION AND RECOMMENDATION

Climate change currently represents one of the greatest sustainable economic development challenges, particularly in low-income countries like Benin. As other major man-made environmental changes, threatens ecosystems and their function of sustaining life and, consequently, human health. The assessment of the current status of knowledge reveals that there is a great gap in the future projection of the climate in Benin. Therefore the risks of extreme weather events are very high since the indices are very little developed in the literature. Under these conditions, the health of the population of Benin is exposed either first to the direct effect of climate change and to the indirect effects related to extreme climates events that result.
Enhanced funding for interdisciplinary research and new opportunities in data availability and analyses related to climate change impact on human health will enable a better understanding of the interacting mechanisms that drive disease transmission, which will help to guide decision and policy making for safeguard population health. Raise the application of a model for integrating science-based approaches and decision-making processes that take into account the participatory relationships between different science disciplines related to climate change and public health in preventive health policies at the global level (Figure 5).

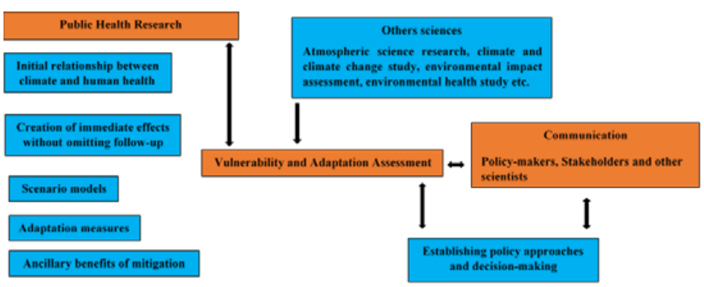


Fig. 5: A dynamic framework of public health science tasks.

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