International Journal of Environmental Research and Development.
ISSN 2249-3131 Volume 6, Number 1 (2016), pp. 65-86

http://www.ripublication.com

A Risk-Level Model for Different Climate Change-Related Diseases in Different Countries

Rezvan Mohammadiziazi
Graduate Research Assistant, Department of Civil and Environmental Engineering, University of Delaware, USA.

Arshia J. Faghri
University of Pennsylvania, Undergraduate Studies, USA.

1. ABSTRACT

The environmental consequences of climate change directly affect the physical and psychological health of humans all around the world. This paper describes the developmental process and the results of a risk level model for different types of climate change-related diseases for different countries. In other words, the question of what diseases will be most prevalent due to climate change in different countries has been addressed. A comprehensive review of the existing literature dealing with the issue of climate change and human health is first presented. Next, the diseases that are most likely getting exacerbated by climate change are introduced and how climate change will have negative impact on their outbreaks are discussed. In the last section of this paper, top twenty vulnerable countries against the effects of climate change are identified and recent outbreaks of mentioned diseases in these countries are studied.

The rank based risk analysis model that is developed allocates a rank between A to F to each country. Although this ranking is done on only the most vulnerable countries against climate change and countries which obtained lowest (worst) rank, this methodology can be used to evaluate the risk of any country against climate change induced diseases in the world.

The results obtained from this research work will be of utmost importance for the ministries of health in different countries. It’s imperative that these nations be pro-active in preparing for what is to come. In addition, further researches can be done to identify the relationship between economic, financial, and educational condition of different countries as well as technological improvements such access to the World Wide Web and social networks and the vulnerability degree of each country against disease outbreaks due to climate change.

2. CLIMATE CHANGE

Scientists define climate as a long process of change in weather patterns over decades or even centuries. On the other hand, weather is defined as daily changes of climate. Although the truth is that climate is the mean of weather events during a long period of time, it is the impacts of weather (e.g., Hurricane Katrina in 2005, Super storm Sandy in 2012, California drought of 2013–2014) that is more vividly remembered (Marchi 2015). During the past few decades, the term global warming was used frequently to address changes in climatic pattern. However, the fact is that global warming is one of the derivatives of the climate change. Other derivatives are changes in precipitation, sea level rise, temperature fluctuations, etc. (Division of Energy and Climate, DNREC 2014). Based on several climatic models, the climate variability in the future is beyond what was experienced in the past. This proves that historical data may not be sufficient to project future changes (US EPA 2012).

Humans are contributing to changes in the atmosphere by adding greenhouse gases including carbon dioxide mostly by burning fossil fuels. These greenhouse gases trap outgoing infrared radiation and make the planet warmer. Other activities like converting forests to cultivated lands and changing the vegetation would add CO2 to the atmosphere, modify the land reflectivity (surface albedo), and change the rate of evapotranspiration (Stocker 2014). Also, water vapor is considered a greenhouse gas since it is involved in the warming of the earth, because of the increasing temperature's feedbacks (Division of Energy and Climate, DNREC 2014). Between 1990 to 2013, the total warming effect induced by human activity to the Earth's atmosphere increased by 34 percent. The contribution of carbon dioxide alone increased by 27 percent (United States Environmental Protection Agency 2014).

Greenhouse gas emissions have several different sources. For example, in the United States electricity generation is at top of the list, followed by transportation. However, since 2005, there is 10 percent decrease in total amount of greenhouse gas emissions in United States (United States Environmental Protection Agency 2014). More solar radiation is reflected to space by ice and snow, and less is absorbed by the surface, so the temperatures decrease. Decreased temperature causes more ice growth, more reflection of solar radiation, and even cooler temperatures (Division of Energy and Climate, DNREC 2014). In addition, clouds play a significant role in climate because they not only can increase the reflectivity phenomenon, but also because they warm the earth and atmosphere through infrared radiative transfer (Stocker 2014). There are many climate change indicators that can be counted as changes in the surface temperature, atmospheric water vapor, precipitation, severe events, glaciers, ocean and land ice, and sea level (Stocker 2014) . The key point is that a single climate stressor can result in a range of impacts. It is also important to note that the same type of change (e.g., warming air temperatures) can result in opposite effects depending on the local topography, the season, urbanization, and other factors. For instance, a region that typically experiences snowy winters will benefit from warmer winters by less need for snow and ice removal for many transportation facilities such as airports and highways.

2.1. Sea Level Rise and Flooding

Changes in ocean levels is consistent with changes in global temperatures. During the ice ages when the temperature was 5°C (9°F) below what it is today, much of the ocean's water was in the shape of glaciers and sea level was approximately than 100 meters (300 feet) less than the present level ((Kennett 1982); (Oldale 1985, 192-200)). However, during the last interglacial period, the average temperature was about 1°C (2°F) warmer than today which resulted in sea level 20 feet higher than today (Mercer 1968).

Based on many studies there has been 10 to 15 centimeters (4 to 6 inches) rise in the sea level during the previous century, worldwide ((Barnett 1984, 7980-7988); (Fairbridge and Krebs 1962, 532-545)). Hughes and Bentley estimated that disintegration of West Antarctica because of the global warming would take between 200- to 500-year and the consequence would be 20 feet of rise in sea level (Smith 1990).

It is estimated that global warming could raise sea level approximately 1 meter because of thermal expansion of the upper ocean layers, melting mountain glaciers and ice sheets in Greenland. The cryosphere or frozen parts of the planet, are affected by temperature changes. The amount of ice contained in glaciers globally has been declining every year for more than 20 years, and the lost mass causes sea level to rise. In addition, there has been considerable losses in Arctic sea ice particularly at the time of the minimum extent, September at the end of the annual melt season. However, there has been a slight increase in Antarctic sea ice (Stocker 2014). Changing ocean currents, winds, and atmospheric pressure due to climate change can also increase sea level (Smith 1990). Also, changes in the hydrologic cycle induced by human activities could affect sea level rise. Although several studies have addressed the impact of global warming on sea level rise, the greenhouse gas effect would not result in the same amount of sea level rise everywhere. This is due to the fact that ice sheets loss would move the earth's center of gravity and move the oceans' water toward the new center of gravity (Smith 1990).

The uncertainty around temperature increase, rate of thermal expansion, and predicted melting of land-bound ice will result in uncertainty in the amount of rise in the sea level. Because of these uncertainties, scenario analysis is the common method of studying the future sea level conditions (Marchi 2015). In all of the climate and sea level rise projections, there are two or more scenarios which represent high, medium or low predictions. The lower scenarios represent a future in which mitigation strategies are taken into consideration seriously and the rate of greenhouse gases emissions decrease drastically. The higher scenarios represent a future in which there is no change in the trend of fuel and energy consumption, and greenhouse gases emissions (Division of Energy and Climate, DNREC 2014).

The slope of the land is the crucial factor that determines the amount of inundation, Bruun and others have shown that the total shoreline retreat from a sea level rise depends only on the average slope of the entire beach profile. The shoreline ability to survive depends on the possibility of moving landward or construction of levees, bulkheads, and other inhibiting structures. A rise in sea level would cause the saltwater attack to rivers, bays, wetlands, and aquifers which threats animals, vegetation and human that are using the water (Smith 1990).

Sea level rise has direct and indirect effects in coastal regions. It amplifies high tides, resulting in increase of frequency, duration, and extent of coastal flooding. History shows that even a small increase in sea level over the past decades have caused higher storm surge and wind waves (Dettinger et al. 2004, 283-317).

If sea level rises, flooding would increase along the coast for four reasons: (1) Storm surges will be built on higher base because of sea level that has been raised. A 1-meter sea level rise would enable a 15-year storm to flood many areas that today are flooded only by a 100-year storm ((Kana et al. 1984, 105-150); (Leatherman 1984)). (2) The properties that are close to beach areas are more vulnerable to storm waves. (3) Coastal drainage will be affected adversely and will become less effective because of higher water level so the system could not drain the rainstorm properly. (4) Finally, the water table would rise due to the rise in sea level and in some places that ground water is below the surface, it will make it rise above the surface.

2.2. Intense Precipitation and droughts

Extreme weather events such as tornadoes, severe thunderstorms, hurricanes, derechos, droughts, extreme heat waves, coastal flooding, storm surge, and extreme snowfall and rainfall (Marchi 2015), are classified as rare spatially and temporally. A rare event can be described as one that would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. An extreme climate event is an extreme weather event that remains for longer period of time than usual (e.g., drought or heavy rainfall over a season) (Stocker 2014). Intensity, duration and frequency are three factors that convert a normal weather pattern into extreme event (Seneviratne et al. 2012, 12566). Changes of these three factors have already been experienced in some locations in the world (Division of Energy and Climate, DNREC 2014).

Floods and droughts are considered as the hydrological extreme events. Increased evaporation and more cloud formation due to the warmer temperature, would increase the amount of precipitation in some regions. Extremes in rainfall would result in flooding (from tropical storms, thunderstorms, orographic rainfall, widespread extra-tropical cyclones, etc.), whereas drought is caused by lack of precipitation and high temperatures that contribute to drying (Trenberth 2005). Understanding of the patterns of drought and flooding are complex. Although average or total amounts of precipitation have decreased in some regions, heavy rain events have increased and the amount of heavy rainfall has increased 20 percent in the past century (Vrac et al. 2007).

Precipitation has generally increased at high northern latitudes over the twentieth century and decreased in the tropics and subtropics (see Figure 1; (Jones et al. 2007, 235-336)). The eastern parts of North and South America, northern Europe, and northern and central Asia, are experiencing a more humid weather than before because warmer air can hold more water which return back to the water cycle as precipitation

(Trenberth and Shea 2005). On the other hand, Sahel, the Mediterranean, southern Africa, and parts of southern Asia are drier than before. To summarize this section, there is a vast distinction in the pattern of precipitation meaning that a wetter climate has become more common in the higher latitude and tropical regions are drier than before (Trenberth 2005).

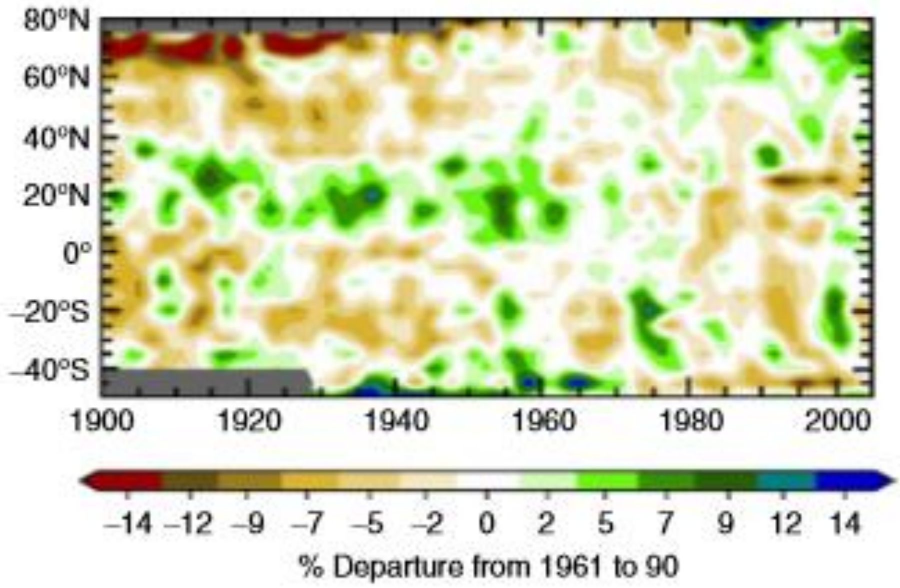

Figure1. Latitude–time section of zonal average annual anomalies for precipitation (%) over land from 1900 to 2005, relative to their 1961–1990 means. (From (Jones et al.) and reproduced by permission of IPCC)

2.3. Temperature Change

As it was mentioned previously in this study, greenhouse gases are the main reason of increasing the Earth's atmosphere temperature. Climate change also contributes to the shift in the wind patterns and ocean currents which results in inconsistency of temperature rise around the world meaning that some place experience higher temperature than before and some places are getting cooler (United States Environmental Protection Agency 2014).

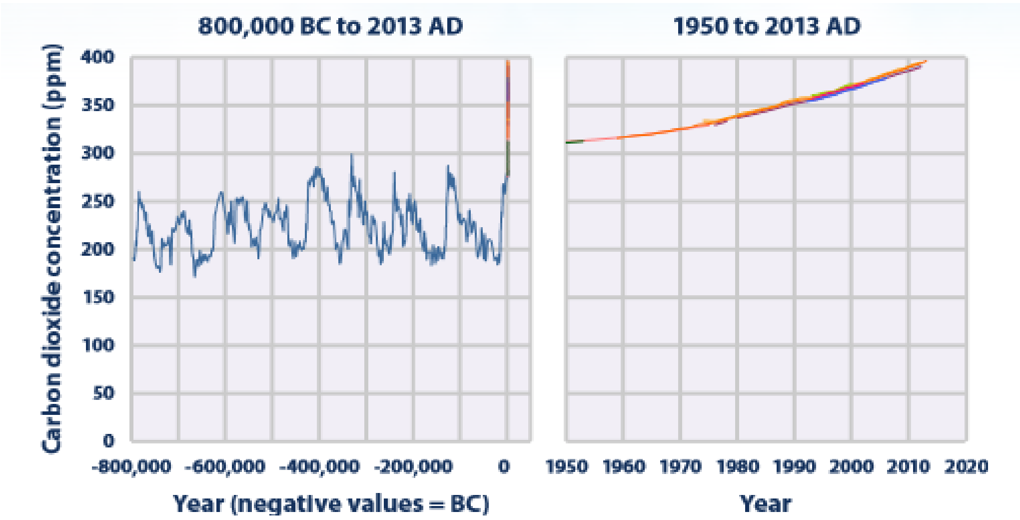

Figure2. This figure shows concentrations of carbon dioxide in the atmosphere from hundreds of thousands of years ago through 2013 (ppm), (Lins 2012).

Because of the climate change surface air temperature and surface absolute humidity have increased which result in higher heat index (a measure of the combined effects of temperature and moisture). It is important to note that warming pattern has not been uniform all around the globe. Between 40°N and 70°N latitude, have cooled in recent decades (IPCC Forth Assessment Report 2007).

3. CLIMATE CHANGE AND HUMAN HEALTH

Recognition that climate change can affect human health in numerous ways is a recent development that represents the depth of scientific knowledge. Since centuries ago climatic disasters distort communities and populations causing famine, infectious diseases, floods, social collapse and disappearance of whole populations. In some case, it causes new health threats and in other cases it exacerbates existing health threats. Age, economic resources and location indicate the level of risk for different people. Climate change is also likely to affect biodiversity and the ecosystem and services that we rely on for human health. Direct impacts of climate change are exposure to weather extremes such as heatwaves and winter cold, increase in extreme weather events like floods, cyclones, storm surge and drought, increased air pollution and production of aeroallergens. Indirect impacts include economic and political disruption such as effect on regional food yields and water resources. Modeling of climate change demonstrates that there will be an increase of 5-10% in future underfed people (McMichael, Woodruff, and Hales 2006, 859-869). In the longer term and with considerable variation between populations as a function of geography and vulnerability, these indirect impacts are likely to have greater magnitude than the more direct ones (Campbell-Lendrum et al. 2003) .

Temperature rise

The IPCC, intergovernmental panel for climate change, estimates about two degree Celsius rise in global average warming by the end of the century (Patz and Hatch 2014). The unusually rapid temperature rise since the mid- 1970s is substantially attributable to this anthropogenic increase in greenhouse gases (McMichael, Woodruff, and Hales 2006, 859-869). There are numerous adverse climate events associated with increase in temperature. High temperature expedites evaporation of moisture from soil causing droughts. On the other hand, warm air preserves humidity resulting in intense precipitation and flooding (Patz and Hatch 2014) . Both rising temperature and increase in rainfall will decline the air quality of indoor areas by rising the probability of growing indoor fungi and molds which lead to increase in respiratory illnesses such asthma-related conditions (John Balbus 2014)

Heat wave

From 1999 through 2009, 7800 deaths are recorded in United States caused by exposure to extreme heat (White House 2014). As temperature continues to rise due to climate change, heat waves are expected to become more frequent, intense and longer lasting in coming decades. Extreme heat increases cardiovascular, cerebrovascular, respiratory and kidney diseases and deaths from heat stroke and other related conditions. Recently, variability in climate change in future has been studied. Small changes in temperature variability, along with a shift in mean temperature can greatly increase the frequency of extreme heat (McMichael, Woodruff, and Hales 2006, 859-869).

Urban and non-urban population act differently towards heat waves. People living in urban environment are at greater risk than those who live in non-urban regions. Two major factor cause this discrepancy, first inefficient housing and second, urban heat island effect. Inner urban environment, with high thermal mass and low ventilation, absorb and retain heat which results in higher temperature than surrounding sub-urban and rural areas.

Flood

Increase in both extreme precipitation and total precipitation result in increase of severe flooding events in certain regions. The most frequent natural weather disaster was flooding (43%), killing almost 100,000 people and affecting over 1·2 billion people (McMichael, Woodruff, and Hales 2006). In 2010, Flood has been reported the deadliest among other natural disasters by having 175 million victims. Immediate effects of flooding are physical injury, morbidity and mortality. In some cases, flooding may lead to mobilization of dangerous chemicals from storage or remobilization of chemicals already in the environment, e.g. pesticides. In addition to immediate health hazards associated with extreme precipitation events when flooding occurs, other hazards can often appear once a storm event has passed. Following flood, food-borne illnesses, diarrheal diseases, respiratory diseases and vector-borne disease transmitted by mosquitos and mice like Malaria, and Dengue fever have been reported. As a result of overflowing water excessive rainfall also facilitate entry of human swage, animal wastes and agricultural field pollution in to waterways and drinking water supplies, increasing the risk of water-borne diseases.

Drought

Droughts associated with climate change may lead to population displacement and more environmental refugees (Haines et al. 2006). Famine and malnutrition are the results of droughts and crop failure. Nelson found that by 2050 yields of staple crops would decline in developing countries and that child underweight would be approximately 20 percent higher, equivalent to approximately 25 million children being affected (Nelson and others 2009). Long periods of high temperature are associated with occurrence of wildfires in some areas. Wildfires contain particulate matter, carbon monoxide, nitrogen oxides and volatile organic compounds that can significantly reduce air quality.

Aeroallergens:

As frost-free days and air temperature increase due to climate change, the production of plant-based allergens would be greater. For example, in some communities in northern states the length of ragweed seasons has increased (White House 2014). Experimental research has demonstrated that doubling CO_2 levels from 300 to 600 ppm causes a four-fold increase in the production of ragweed pollen. Pollen-related allergies have been increased because of longer pollen season and greater pollen concentration. In addition, asthma episodes that lead to diminish productivity and loss of school days will increase.

Based on the studies and available knowledge in the field, climate change has various impacts on different diseases. It could either minimize the adversity around certain diseases or aggravate the negative consequences of other diseases. Ten diseases have been identified to become exacerbated by the effects of climate change. These climate change-related diseases are described in the following paragraphs.

Avian Influenza

AI (avian influenza), commonly called “bird flu”, is a contagious animal disease that infects birds and some mammals (Mu et al. 2011). The strain of AI is divided into two sub-group based on their contagiousness and symptoms severity: high pathogenic avian influenza (HPAI) and low pathogenic avian influenza (LPAI).

Climate has been found to alter disease survival and disease vector behavior. In particular, experimental evidence shows low temperature and high relative humidity conditions increase the persistence and stability of the AI virus (World Health Organization 2005). One study shows that climate change would almost certainly influence the AI virus transmission cycle, and directly affect virus survival outside the host (Gilbert et al.; World Health Organization 2005). Since the probability of AI outbreaks is affected by temperature and precipitation, it seems that past climate change may enhance the severity of current AI outbreaks. Climate change has significantly increased the probability of AI outbreaks by 8% to 1160%. These results suggest that climate change is one of the forces driving the recent increase in outbreaks observed. For most countries, future climate change is found to increase the risk of AI outbreaks. This occurs partly because these countries produce a high proportion of poultry meat or products and would be easily impacted by AI outbreaks (Mu et al. 2011). Overall, the outbreak risk is increased in areas with lower temperature and heavier humidity.

Heart Disease

The effects of high or low temperatures are well known on cardio vascular conditions (Parsons 2014). Thus climate change can therefore affect local patterns of heart disease in several ways. The impact of climate conditions, in particular ambient temperature, both now and in the future, will vary according to local vulnerabilities, geographical and sociopolitical situations and the promotion of protective measures (London 2008).

With more intense heat waves of longer duration, mortality due to myocardial infarction (heart attack) is expected to increase in frequency.

Lyme disease

Lyme Borreliosis is transmitted to humans during the blood feeding of hard ticks of the genus Ixodes. Current knowledge of the impact of different climatic factors on vector abundance and disease transmission is rather extensive. Daily climatic conditions during several seasons (as ticks may live for more than three years) influence tick population density both directly and indirectly. The pathogen is not in itself sensitive to ambient climatic conditions, except for unusually high temperatures, but human exposures to the pathogen – through tick bites – may be influenced by weather conditions. Both the length of each season as well as daily temperatures and humidity are important factors for the survival, development and activity of ticks ((Balashov 1967); (Duffy and Campbell 1994)).

Global climate change has been implicated in having a potentially serious impact on the future spatial and temporal distribution of vector-borne diseases. While local abundance of vectors may be guided by density dependent factors such as competition, predation and parasitism, the geographic range of arthropod species' habitat are controlled by large scale density independent factors (Brownstein, Holford, and Fish 2005, 38-46).

Malaria

Malaria causes a significant burden of disease at the global and regional level (Murray et al. 2012). Malaria is a mosquito-borne infectious disease caused by parasitic protozoans of the genus Plasmodium and is transmitted by female mosquito vectors of the Anopheles species.

A potential consequence of anthropogenic climate change, foreseen for the coming century, is a change in the distribution and incidence of malaria. Approximately 110 million clinical cases occur annually, and more than 1 million people, mostly children, die from malaria in tropical Africa (Martens et al. 1995a). Anthropogenic climate change may directly affect the behavior and geographical distribution of the malaria mosquitoes and the life cycle of the parasite, and thus change the incidence of the disease. Indirectly, climate change could also have an effect by influencing environmental factors such as vegetation and the availability of breeding sites (Martens et al. 1995b).

Plague

Plague is primarily a disease of rodents and their fleas, which can infect humans. It is transmitted between rodents by rodent fleas, and can be transmitted to people when infected rodent fleas bite them. Humans are extremely susceptible to plague and may be infected either directly or indirectly. The fatality rates of 50-60% if left untreated (World Health Organization 2000a).

While many climate experts and environmentalists explore the negative effects of global warming, a new study reveals a positive outcome of the warming of the planet: the potential elimination of the plague. Global warming affects temperatures and precipitation regimes that play a pivotal role in the lives of rodents and fleas. The study analysis suggested that snow may play a key role in the relationship between climate and plague. Snow affects the summer soil moisture, which is known to be instrumental for flea survival and the development and sustained growth of vegetation for rodents.

Rift Valley Fever

Rift Valley fever is an acute, mosquito-borne viral disease, mainly affecting ruminants and humans. In humans, RVF causes a severe influenza-like disease, occasionally with more serious effects, such as hepatitis, encephalitis, blindness and sometimes death (Martin et al. 2008).

Climate changes may affect the three fundamental components of the epidemiological cycle of RVF, namely: vectors, hosts and virus. The consequences of global warming on vectors, in particular, may be many. Increased temperature may have an impact on vector capacity ((Cornel, Jupp, and Blackburn 1993); (Kay and Jennings 2002)). It is thus considered possible that arthropod species within EU countries could also become competent vectors for RVF, if initial infection occurs (Pfeiffer et al. 2005). As far as hosts are concerned, climate changes may induce modifications in their distribution and density, as well as their migratory pathways. Historically, the dissemination of RVF has been attributed in part to nomadic herds: the modification of migratory pathways could introduce the virus into previously virus-free areas. Climate modification may also result in the selection of a strain that is either more or less virulent (Martin et al. 2008).

Sleeping Sickness

Two sub-species of the parasitic protozoan are the causative agents of human African trypanosomiasis (HAT), commonly known as sleeping sickness. Trypanosomes are transmitted by the bite of the bloodsucking tsetse fly and the ensuing infection is lethal if untreated (Cecchi et al. 2009). It is a chronic and ultimately lethal disease with a long asymptomatic stage that may last several years following the onset of the infection. Rhodesian sleeping sickness is an acute form that is found in Southern and Eastern Africa, with death usually occurring within six months of the onset of overt clinical symptoms (Apted 1970). It is believed that the ongoing environmental modifications will have drastic repercussions on the epidemiology and the spatial distribution of sleeping sickness in the region (Courtin et al. 2009).

Tuberculosis

It is well known that the incidence of many respiratory infections shows seasonal variation, and it is much less well documented for tuberculosis (TB) (Thorpe et al. 2004). In the pre-antibiotic era, the TB mortality rate was higher in late winter and early spring than that any other time of the year (Nagayama and Ohmori 2006). There are several possible reasons of the seasonality of tuberculosis, serum vitamin D level variability, indoor activities, seasonal changes in immune function and patient or health care system delays in the diagnosis and treatment of tuberculosis. Climate change effects are similar to seasonality in some way for example changing temperature and changes in rainfall and humidity. It can be concluded that tuberculosis spread in different regions of the world is under influence of climate change as it is affected by seasonality.

Yellow Fever

Yellow fever (YF) is one of the greatest infectious scourges of humankind. Approximately 200,000 cases of YF occur annually, resulting in about 30,000 deaths; 90% of cases occur in Africa. Large epidemics, with over 100,000 cases, have been recorded repeatedly in Sub-Saharan Africa, and multiple outbreaks have occurred in the Americas. The virus has never appeared in Asia or in the Indian subcontinent (Barnett 2007). Global warming and increased rainfall contribute to the abundance and distribution of vectors like mosquitoes. Current evidence suggests that inter-annual and inter-decadal climate variability have a direct influence on the epidemiology of vector-borne diseases (World Health Organization 2000b). It is estimated that average global temperatures will have risen by $1 - 3.5$℃ by 2100 (Watson, Zinyowera, and Moss 1996), increasing the likelihood of many vector-borne diseases (World Health Organization 2000b). If the water temperature rises, the larvae take a shorter time to mature (Rueda et al. 1990, 892-898) and consequently there is a greater capacity to produce more offspring during the transmission period. The extrinsic incubation period of dengue and yellow fever viruses is also dependent on temperature.

Cholera

Cholera is an acute intestinal infection caused by ingestion of food or water contaminated with the bacterium Vibrio cholera. It has a short incubation period, from less than one day to five days, and produces an enterotoxin that causes a copious, painless, watery diarrhea that can quickly lead to severe dehydration and death if treatment is not promptly given.

There is a growing evidence that the population of bacteria and Protoctistas are being altered by climatic change, and it is now known that these marine microflora, lying at the heart of the food web, provide a reservoir for Vibrio Cholera and other enteric pathogens. Climate is controlled by the interaction of the atmosphere, oceans, land systems and ice cover. A change in any of these aspects will affect the entire system (Paul R. Epstein).

4. METHODOLOGY

There are several factors affecting the vulnerability of a country or a region against climate change. The vulnerability of a specific country can be evaluated from different points of view, for example economic vulnerability addresses either positive or negative financial and economic effects of climate change that result in drastic change of a country's GDP (gross domestic product). The rate and characteristics of vulnerability is different for each climate change stressors and evaluation of overall vulnerability for a single country or area is a complex process due to various factors that are involved such as population, education, access to medical care, income, etc. The uncertainty around climate change exacerbate the complexity of this process.

In order to measure the effect of climate change on hazardous diseases dispersion for each country in the world and allocate a specific rank for that country, three climate change stressors have been studied; extreme weather, sea level rise, and agricultural productivity loss. Based on these climate change derivatives, each country obtains a rank which represents its position in the global ranking. It is worthwhile mentioning that the direct risk of climate change for a region is different from its vulnerability against the climate change because of the fact that existing infrastructures, economic and financial situation have crucial role in strength of a country to adapt to climate change and its further results. As it was mentioned earlier the purpose of this study is to identify countries which are at most risk of climate change from health and medical point of view. Table 1 shows twenty countries which are most exposed to the risk of climate change and most vulnerable to its effects.

As it was mentioned earlier elaborate and complex calculation has been done in order to decide the overall vulnerability rank of a country. In order to go further in this study, we use the result of comprehensive research done by David Wheeler in deciding each country's position in global ranking (Wheeler 2011).

Table 1. Ranking of different countries against different derivatives of climate change

	Extreme Weather		**Sea Level Rise**		**Agricultural Productivity Loss**		**Overall**	
	Direct Risk	**Overall Vulnerability**	**Direct Risk**	**Overall Vulnerability**	**Direct Risk**	**Overall Vulnerability**	**Direct Risk**	**Overall Vulnerability**
1	China	Somalia	Djibouti	Liberia	Central African Republic	Somalia	China	Somalia
2	India	Bangladesh	Monaco	Myanmar	Congo	Myanmar	India	Burundi
3	Bangladesh	China	Greenland	Guinea-Bissau	Equatorial Guinea	Burundi	Central African Republic	Myanmar
4	Philippines	India	Suriname	Somalia	Gabon	Liberia	Equatorial Guinea	Central African Republic
5	Vietnam	Myanmar	Guyana	Djibouti	Sudan	Central African Republic	Burundi	Eritrea
6	Hong Kong SAR, China	Ethiopia	Japan	Bangladesh	Senegal	Zimbabwe	Sudan	Guinea-Bissau
7	Somalia	Vietnam	Liberia	Korea, Dem. Rep.	Botswana	Eritrea	Bangladesh	Zimbabwe
8	Macao SAR, China	Malawi	Vietnam	Togo	Namibia	Guinea-Bissau	Rwanda	Liberia
9	Sudan	Sudan	Gabon	Cote d'Ivoire	Bolivia	Congo, Dem. Rep.	Senegal	Ethiopia
10	Ethiopia	Philippines	Latvia	Cuba	Paraguay	Afghanistan	Namibia	Congo, Dem. Rep.
11	Malawi	Madagascar	Belize	Vietnam	Iraq	Sudan	Ethiopia	Afghanistan
12	Honduras	Burundi	Svalbard and Jan Mayen	Benin	Burundi	Sierra Leone	Myanmar	Niger
13	Kenya	Mozambique	Bangladesh	Solomon Islands	Rwanda	Ethiopia	Malawi	Rwanda
14	Madagascar	Uganda	Cote d'Ivoire	Sierra Leone	Zambia	Togo	Niger	Sudan
15	Bolivia	Kenya	Gibraltar	Mauritania	Cuba	Cuba	Swaziland	Malawi
16	Sri Lanka	Bolivia	Egypt, Arab Rep.	Mozambique	Dominican Republic	Rwanda	Lesotho	Sierra Leone
17	Uganda	Djibouti	Denmark	Guyana	Haiti	Niger	Zambia	Bangladesh
18	Colombia	Honduras	Qatar	West Bank and Gaza	Myanmar	Guinea	Chad	Togo
19	Thailand	Afghanistan	Mauritania	Suriname	Morocco	Haiti	Mali	Chad
20	Indonesia	Tanzania	Guinea-Bissau	Haiti	Lesotho	Malawi	Guinea-Bissau	Guinea

The purpose of this research is to develop a method in order to identify the risk of disease outbreaks that each country is going to be confronted in future. This risk analysis is based on the vulnerability of countries against climate change and the history of disease outbreaks in each of those countries.

There are ten diseases that are identified to be exacerbated by the impact of climate change. These disease were discussed in the previous section. Many factors such as sea level rise, more frequent intense precipitation, flooding, increase in mean temperature, etc. might be the reason of more frequent and more severe outbreaks of these diseases which are not going to be analyzed and discussed in this research. Avian flu, Cholera, Ebola, Lyme Disease, Babesiosis, Plague, Rift Valley Fever, Yellow Fever, Tuberculosis and Sleeping Sickness are among the diseases that we estimated the risk of their outbreaks due to climate change in future.

The map of avian flu outbreaks is developed by United States Geological Survey (USGS), which represents the occurrence location of outbreaks in the world since 2011. The information for each location includes city, province, country, type of avian flu, date and bird species which were diagnosed with the disease. As it was all over the news in 2014, the Ebola outbreak hit three countries, Sierra Leon, Liberia and Guinea.

Almost, every country in the world has experienced Cholera outbreaks between 1974 and 2005 this period except a few countries such as Canada, Scandinavia and etc. (Emch et al. 2008).

Lyme Borreliosis, the most common type of Lyme Disease, has occurred mostly in Europe.

WHO, World Health Organization, has classified countries based on the number of plague cases observed during time period 2000 and 2009. Table 2, presents countries with their number of plague cases between 2000 and 2009.

Table 2. Number of Plague cases by country 2000-2009 (WHO)

Country	**Number of Plague Case**	**Country**	**Number of Plague Case**
Brazil	1-10	China	101-1000
Kazakhstan	1-10	Mozambique	101-1000
Libya	1-10	Peru	101-1000
Algeria	11-100	Tanzania	101-1000
India	11-100	Uganda	101-1000
Indonesia	11-100	Zambia	101-1000
Mongolia	11-100	Madagascar	1001-10,000
United States	11-100	Congo	>10,000

Based on Center for Disease Control (CDC) top ten countries with Tuberculosis can be listed as India, China, Indonesia, Nigeria, South Africa, Bangladesh, Ethiopia, Pakistan, Philippines, Democratic Republic of Congo. According to this report Rift Valley Fever, has occurred mostly in Africa which proves the high vulnerability of African countries against this sickness.

The result of this risk analysis for each country is a rank from A to F, which A represents that a country is in a good condition and although it is vulnerable against climate change, it does not have any history of that ten deadly disease outbreaks. F represents that a country is in a very poor condition in terms of vulnerability against disease outbreaks. Table 3 shown below explains the ranking process.

In this risk-level model, in order to consider the effects of being vulnerable to climate change in the risk allocation, top thirty most vulnerable country are evaluated. The rank of ten countries that are in the worst condition in terms of climate change starts from B level. This means that although a region has never experienced any dreadful outbreaks of climate change induced diseases in its history, it could not be placed in rank A since because of high rate of vulnerability against climate change there is potential danger of climate change induced outbreaks.

Table 3. Risk Ranking Scenarios

Rank	Number of diseases that a country had outbreaks in past
A	no disease had outbreaks event in the country
B	one disease had outbreaks occurred in the country
C	two diseases had outbreaks occurred in the country
D	three diseases had outbreaks occurred in the country
E	four diseases had outbreaks occurred in the country
F	more than five diseases had outbreaks occurred in the country

5. RESULTS AND ANALYSIS

The risk analysis has been done for the twenty country that are most vulnerable to climate change and results are shown in table 4 below. It is worthwhile mentioning that the vulnerability rank is a country's overall rank against climate change including economy, income and exposure to climate change derivatives.

Table 4. Risk level of top-twenty most vulnerable countries in the world

Overall rank	Country	Number of Diseases	Name of Disease	Rank
1	Somalia	0	--	B
2	Burundi	1	Yellow Fever	C
3	Myanmar	2	Cholera, Babesiosis	D
4	Central African Republic	2	Yellow Fever, Sleeping Sickness	D
5	Eritrea	0	--	B
6	Guinea-Bissau	0	--	B
7	Zimbabwe	3	Babesiosis, Rift Valley Fever, Sleeping Sickness	E
8	Liberia	3	Cholera, Ebola, Sleeping Sickness	E
9	Ethiopia	3	Babesiosis, Yellow Fever, Tuberculosis	E
10	Congo, Dem. Rep.	3	Cholera, Tuberculosis, Sleeping Sickness	E
11	Afghanistan	0	--	B
12	Niger	1	Avian Flu	A
13	Rwanda	1	Yellow Fever	A
14	Sudan	4	Sleeping Sickness, Yellow Fever, Rift Valley Fever, Babesiosis	F
15	Malawi	1	Sleeping Sickness	C
16	Sierra Leone	2	Ebola, Sleeping Sickness	D
17	Bangladesh	2	Avian Flu, Tuberculosis	D
18	Togo	1	Sleeping Sickness	C
19	Chad	1	Sleeping Sickness	C
20	Guinea	1	Ebola	C

According to Center for Global Developments (CGD) data base the most vulnerable countries against climate change have the lowest income rank in the world which proves the importance of economy and investment in infrastructure, in confronting with climate change and its further effects such as health issues.

The purpose of this model is not just informing countries that are most vulnerable to climate change of their health condition regarding endemic and hazardous diseases such as Ebola and Cholera. The power of this risk model is that it is dynamic meaning that can be used for different countries in different time frames. Table 5, presents countries which have the lowest rank in the model based on their historical outbreaks. For each country the direct rank of vulnerability and overall vulnerability rank against climate change is also addressed.

Table 5. Countries with the lowest disease rank and high probability of future endemic outbreaks

Country	**Direct rank**	**Overall rank**	**Number of Diseases**	**Name of Disease**	**Rank**
Nigeria	76	54	5	Cholera, Babsiosis, Yellow Fever, Tuberculosis, Sleeping Sickness	F
India	2	21	5	Cholera, Babsiosis, Avian Flu, Tuberculosis, Plague	F
Uganda	46	36	5	Cholera, Babsiosis, Yellow Fever, Plague, Sleeping Sickness	F
Brazil	120	110	5	Cholera, Babsiosis, Yellow Fever, Plague, Lyme Disease	F
South Africa	61	90	5	Cholera, Babsiosis, Rift Valley Fever, Tuberculosis, Lyme Disease	F
Indonesia	71	73	4	Avian Flu, Babesiosis, Plague, Tuberculosis	E
China	1	34	4	Lyme Disease, Babesiosis, Plague, Tuberculosis	E
Mozambique	52	26	4	Cholera, Plague, Rift Valley Fever, Sleeping Sickness	F
Tanzania	40	29	4	Cholera, Plague, Rift Valley Fever, Sleeping Sickness	F
Kenya	94	71	4	Cholera, Yellow Fever, Rift Valley Fever, Sleeping Sickness	E
Zambia	17	27	3	Babesiosis, Rift Valley Fever, Sleeping Sickness	E
Ghana	95	70	3	Cholera, Yellow Fever, Sleeping Sickness	D

6. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

6.1. Summary

In this study, we have identified countries that are going to be most affected by the adverse effects of climate change until the end of twenty first century. Although some regions are not going to be highly affected by a specific climate change derivative, social, economic, and anthropogenic characteristics of that specific region could make it highly vulnerable to climate change derivatives. Thus, the overall vulnerability of a region is considered in this study. The history of climate change induced diseases (diseases that are going to be more prevalent because of climate change) and number of outbreaks occurred in recent years in each of the countries that ranked among the top ones in vulnerability towards climate change, has been studied. All of these efforts were aimed to decide the health condition of different countries in the world that climate change impacts are tangible. The rank-based risk model that is developed allocates a rank between A to F to each country. Although this ranking is done on only the most vulnerable countries against climate change and countries which obtained lowest rank, this methodology can be used to evaluate the risk of any country against climate change induced diseases in the world.

6.2. Conclusion

By looking at the name of the most vulnerable countries against climate change, one can realize that the vulnerability has direct relationship with economic conditions, average income, and war. Somalia- the country that feels the impacts of climate change at the highest level- obtains the score of B, based on risk analysis which represents that their health system needs to pay special attention to climate change induced diseases. Zimbabwe, Liberia, Ethiopia, and Democratic Republic of Congo have experienced several outbreaks of diseases which identified as getting more prevalent in existence of climate change. Thus these four countries obtained the score E from our risk model which shows the probability of outbreaks occurrence is high in these regions. Several number of sleeping sickness, yellow fever, rift valley fever, and babesiosis diagnosis have been reported in Sudan in recent years. Considering the fact that this country is at the top of the list of vulnerable regions against climate change, Sudan scores F in our model with the least possible score. This demonstrates the criticality of situation in Sudan and the importance of immediate investment not only by the government and organizations in Sudan but also from developed countries that have sufficient resources and knowledge to help people in Sudan.

6.3. Recommendations

Although the risk level of top twenty vulnerable countries is a close approximation except for Sudan, Zimbabwe, Ethiopia, Liberia, and Democratic Republic of Congo, the governments should pay attention to their health system, invest in new infrastructures such as hospitals, and educate people by providing them with information about potential diseases and methods of prevention specially ones living in poor areas with less access to medical facilities. These efforts are vital for a country to improve its rank and decrease the chance of disease outbreaks. In addition, it is important for countries which are less vulnerable to climate change (Nigeria, India, Uganda, Brazil, South Africa, Indonesia, China, Mozambique, Kenya, Zambia, Ghana, Tanzania) to pay special attention to their health infrastructure because less vulnerability to climate change does not mean that they are protected against disease outbreaks that are going to be more prevalent because of climate change in future. They need to know which disease have most probability of occurrence in their region and invest in both strengthening the health care system foundations and increasing public knowledge about endemic disease through education and social media.

The Ebola out breaks in wester African countries in 2014 proved to the global society that health issues and outbreaks are not a regional concern and if one country is confronted with a deadly disease the whole world is facing the consequences. Therefore, the results of this study could be used not only by vulnerable countries but also it is practical for organization such as World Health Organization (WHO), or United Nations Children's Fund (UNICEF) to allocate their funds and resources to regions that are feeling the most effects of climate change in the context of health.

REFERENCES

[1] Marchi, Richard. 2015, "Climate Change Adaptation Planning: Risk Assessment for Airports,".

[2] Division of Energy and Climate, DNREC. 2014, "Delaware Climate Change Impact Assessment,".

[3] US EPA. 2012, "Climate Ready Water Utilities Adaptation Strategies Guide for Water Utilities,".

[4] Stocker, Thomas F. 2014, "Climate Change 2013: The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge University Press.

[5] United States Environmental Protection Agency. 2014, "Climate Change Indicators in United States,".

[6] Kennett, James P. 1982, "Marine Geology, 813 Pp,".

[7] Oldale, R. 1985, "Late Quaternary Sea Level History of New England: A Review of Published Sea Level Data," Northeastern Geology 7 (3/4): 192-200.

[8] Mercer, John H. 1968, "Antarctic Ice and Sangamon Sea Level1,".

[9] Barnett, TP. 1984, "The Estimation of “global” Sea Level Change: A Problem of Uniqueness," Journal of Geophysical Research: Oceans (1978–2012) 89 (C5): 7980-7988.

[10] Fairbridge, Rhodes W. and Oswald A. Krebs. 1962, "Sea Level and the Southern Oscillation," Geophysical Journal International 6 (4): 532-545.

[11] Smith, Joel B. 1990, "The potential effects of global climate change on the United States: Report to Congress," Taylor & Francis.

[12] Dettinger, Michael D., Daniel R. Cayan, Mary K. Meyer, and Anne E. Jeton. 2004, "Simulated Hydrologic Responses to Climate Variations and Change in the Merced, Carson, and American River Basins, Sierra Nevada, California," 1900–2099." Climatic Change 62 (1-3): 283-317.

[13] Kana, Timothy W., Jacqueline Michel, Miles O. Hayes, and John R. Jensen. 1984, "The Physical Impact of Sea Level Rise in the Area of Charleston, South Carolina," Greenhouse Effect and Sea Level Rise: A Challenge for this Generation.New York: Van Nostrand Reinhold Company: 105-150.

[14] Leatherman, Stephen P. 1984, "Coastal Geomorphic Responses to Sea Level Rise: Galveston Bay, Texas," Barth and Titus (Eds).Op Cit.

[15] Seneviratne, SI, N. Nicholls, D. Easterling, CM Goodess, S. Kanae, J. Kossin, Y. Luo, J. Marengo, K. McInnes, and M. Rahimi. 2012, "Changes in Climate Extremes and their Impacts on the Natural Physical Environment: An Overview of the IPCC SREX Report,".

[16] Trenberth, Kevin E. 2005, "The Impact of Climate Change and Variability on Heavy Precipitation, Floods, and Droughts," Encyclopedia of Hydrological Sciences.

[17] Vrac, M., ML Stein, K. Hayhoe, and X-Z Liang. 2007, "A General Method for Validating Statistical Downscaling Methods Under Future Climate Change," Geophysical Research Letters 34 (18).

[18] Jones, PD, KE Trenberth, P. Ambenje, R. Bojariu, D. Easterling, T. Klein, D. Parker, J. Renwick, M. Rusticucci, and B. Soden. 2007, "Observations: Surface and Atmospheric Climate Change," IPCC, Climate Change: 235-336.

[19] Trenberth, Kevin E. and Dennis J. Shea. 2005, "Relationships between Precipitation and Surface Temperature," Geophysical Research Letters 32 (14).

[20] Lins, Harry F. 2012, "USGS Hydro-Climatic Data Network 2009 (HCDN-2009)," US Geological Survey Fact Sheet 3047 (4).

[21] IPCC Forth Assessment Report. 2007, "Direct Observations of Recent Climate Change,".

[22] McMichael, Anthony J., Rosalie E. Woodruff, and Simon Hales. 2006, "Climate Change and Human Health: Present and Future Risks," The Lancet 367 (9513): 859-869.

[23] Campbell-Lendrum, DH, CF Corvalan, K. Ebi, A. Githeko, A. McMichael, J. Scheraga, and A. Woodward. 2003, "Climate Change and Human Health: Risks and Responses," Climate Change and Human Health: Risks and Responses.

[24] Patz, Jonathan A. and Melissa J. Hatch. 2014, "Public Health and Global Climate Disruption," Public Health Reviews 35 (1).

[25] John Balbus. 2014, "Climate Change Impact in United State," Chapter 9.

[26] White House. 2014, "The Health Impacts of Climate Change on Americans,".

[27] Haines, Andy, R. Sari Kovats, Diarmid Campbell-Lendrum, and Carlos Corvalán. 2006, "Climate Change and Human Health: Impacts, Vulnerability and Public Health," *Public Health* 120 (7): 585-596.

[28] Nelson, Gerald C., Mark W. Rosegrant, Jawoo Koo, Richard Robertson, Timothy Sulser, Tingju Zhu, Claudia Ringler, Siwa Msangi, Amanda Palazzo, and Miroslav Batka. 2009, "Climate Change: Impact on Agriculture and Costs of Adaptation," Vol. 21 Intl Food Policy Res Inst.

[29] Mu, Jianhong H., Bruce A. McCarl, Ximing Wu, and Li Gan. 2011, "Climate Change Influences on the Risk of Avian Influenza Outbreaks and Associated Economic Loss," Agricultural and Applied Economics Association.

[30] World Health Organization. 2005, "Avian Influenza: Assessing the Pandemic Threat,"

[31] Gilbert, M., X. Xiao, D. U. Pfeiffer, M. Epprecht, S. Boles, C. Czarnecki, P. Chaitaweesub, et al. 2008, "Mapping H5N1 Highly Pathogenic Avian Influenza Risk in Southeast Asia," Proceedings of the National Academy of Sciences of the United States of America 105 (12): 4769-4774.

[32] Parsons, Ken. 2014, "Human Thermal Environments: The Effects of Hot, Moderate, and Cold Environments on Human Health, Comfort, and Performance," Crc Press.

[33] London, Leslie. 2008, "Climate Change and Human Health.Risks and Responses,".

[34] Balashov, Yu S. 1967, "Blood-Sucking Ticks (Ixodoidea)-Vectors of Diseases of Man and Animals," Krovososushchie Kleshchi (Ixodoidea)-Perenoschiki Boleznei Cheloveka i Zhivotnkh.

[35] Duffy, D. C. and S. R. Campbell. 1994, "Ambient Air Temperature as a Predictor of Activity of Adult Ixodes Scapularis (Acari: Ixodidae)," Journal of Medical Entomology 31 (1): 178-180.

[36] Brownstein, John S., Theodore R. Holford, and Durland Fish. 2005, "Effect of Climate Change on Lyme Disease Risk in North America," EcoHealth 2 (1): 38-46.

[37] Murray, Christopher JL, Lisa C. Rosenfeld, Stephen S. Lim, Kathryn G. Andrews, Kyle J. Foreman, Diana Haring, Nancy Fullman, Mohsen Naghavi, Rafael Lozano, and Alan D. Lopez. 2012, "Global Malaria Mortality between 1980 and 2010: A Systematic Analysis," *The Lancet* 379 (9814): 413-431.

[38] Martens, WJM, TH Jetten, J. Rotmans, and LW Niessen. 1995, "Climate Change and Vector-Borne Diseases: A Global Modelling Perspective," Global Environmental Change 5 (3): 195-209.

[39] Martens, W. J., L. W. Niessen, J. Rotmans, T. H. Jetten, and A. J. McMichael. 1995, "Potential Impact of Global Climate Change on Malaria Risk," Environmental Health Perspectives 103 (5): 458-464.

[40] World Health Organization. 2000, "WHO Report on Global Surveillance of Epidemic-Prone Infectious Diseases,".

[41] Martin, Vincent, Véronique Chevalier, P. Ceccato, Assaf Anyamba, Lorenzo De Simone, Juan Lubroth, Stéphane de La Rocque, and Joseph Domenech. 2008, "The Impact of Climate Change on the Epidemiology and Control of Rift Valley Fever," Rev Sci Tech 27 (2): 413-426.

[42] Cornel, A. J., P. G. Jupp, and N. K. Blackburn. 1993, "Environmental Temperature on the Vector Competence of Culex Univittatus (Diptera: Culicidae) for West Nile Virus," Journal of Medical Entomology 30 (2): 449-456.

[43] Kay, B. H. and C. D. Jennings. 2002, "Enhancement or Modulation of the Vector Competence of Ochlerotatus Vigilax (Diptera: Culicidae) for Ross River Virus by Temperature," Journal of Medical Entomology 39 (1): 99-105.

[44] Pfeiffer, D., M. Pepin, M. Wooldridge, A. Schudel, M. Pensaert, D. Collins, T. Baldet, G. Davies, A. Kemp, and V. Martin. 2005, "The Risk of a Rift Valley Fever Incursion and its Persistence within the Community," Efsa J 238: 1-128.

[45] Cecchi, G., Fabrice Courtin, M. Paone, A. Diarra, JR Franco, RC Mattioli, and PP Simarro. 2009, "Mapping Sleeping Sickness in Western Africa in a Context of Demographic Transition and Climate Change," Parasite 16 (2): 99-106.

[46] Apted, FIC. 1970, "Clinical Manifestations and Diagnosis of Sleeping Sickness," The African Trypanosomiases: 661-683.

[47] Courtin, Fabrice, I. Sidibé, J. Rouamba, Vincent Jamonneau, A. Gouro, and Philippe Solano. 2009, "Impacts Des Évolutions Démographiques Et Climatiques Sur La Répartition Spatiale Des Hommes, Des Tsé-Tsé Et Des Trypanosomoses En Afrique De l'Ouest," Parasite 16 (1): 3-10.

[48] Thorpe, Lorna E., Thomas R. Frieden, Kayla F. Laserson, Charles Wells, and Gulshan R. Khatri. 2004, "Seasonality of Tuberculosis in India: Is it Real and what does it Tell Us?" The Lancet 364 (9445): 1613-1614.

[49] Nagayama, N. and M. Ohmori. 2006, "Seasonality in various Forms of Tuberculosis," The International Journal of Tuberculosis and Lung Disease 10 (10): 1117-1122.

[50] Barnett, E. D. 2007, "Yellow Fever: Epidemiology and Prevention," Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America 44 (6): 850-856.

[51] World Health Organization. 2000, "Climate Change and Vector-Borne Diseases: A Regional Analysis," Geneva: WHO Bulletin 78 (9).

[52] Watson, Robert T., Marufu C. Zinyowera, and Richard H. Moss. 1996, "Climate Change 1995 Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis," Cambridge University Press.

[53] Rueda, L. M., K. J. Patel, R. C. Axtell, and R. E. Stinner. 1990, "Temperature-Dependent Development and Survival Rates of Culex Quinquefasciatus and Aedes Aegypti (Diptera: Culicidae)," Journal of Medical Entomology 27 (5): 892-898.

[54] Paul R. Epstein. "Cholera and the Environment: An Introduction to Climate Change,".

[55] Wheeler, David. 2011, "Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance," Center for Global Development Working Paper (240).

[56] Emch, Michael, Caryl Feldacker, M. Sirajul Islam, and Mohammad Ali. 2008, "Seasonality of Cholera from 1974 to 2005: A Review of Global Patterns," International Journal of Health Geographics 7 (1): 1.