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Analyzing the Repercussions of Climate Change on the Outbreak of Chikungunya in Bangladesh

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Abstract

Climate change is intrinsically linked to public health and nowadays it taking a toll. A report published by World Bank titled "South Asia's Hotspots: the impact of temperature and precipitation change on living standard", says that, more than 75 percent of the population will be adversely affected by rising temperature, and the rate of vector borne and other infectious diseases will increase. We, Bangladeshi people, talk about climate change so often, probably, because we are living in a critical region on the earth where vector-borne diseases are emerging and reemerging. Climate change may lead to a greater spread of infectious diseases, like vector borne diseases, but the efforts to act accordingly are yet to be done. Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. Consequently, we saw an increasing rate of vector borne diseases and, according to weather experts, it is known as effect of climate variability. This study suggests that temperature and rainfall are significantly associated with chikungunya incidence in Bangladesh. Based on the findings, we conclude that the climate change plays a critical role in the transmission of chikungunya virus.

Keywords: Chikungunya; Aedes aegypti; Aedes albopictus; Temperature; DTR, Rainfall; Climate change; Bangladesh

1. Introduction

Chikungunya, a viral disease, was first detected in 1952 in Africa following an

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outbreak on the Makonde Plateau near the border area between Mozambique and Tanzania [1, 2]. The name Chikungunya was derived from the Makonde word meaning "that which bend up" in reference to the stooped posture develop as a result of the arthritic symptoms of the disease. In Swahili this means "the illness of the bended walker". The word Chikungunya was derived from the Makonde root verb kungunya, meaning to dry up. Chikungunya is an RNA virus that belongs to the alphovirus genus of the family Togaviridae, and transmitted to human by infected mosquitoes. Fever, sever joint pain, muscle pain, headache, nausea, fatigue and rash are the common symptoms of Chikungunya viral disease.

The Virus spread between people by two types of mosquitoes, *Aedes albopictus* (Asian Tiger mosquitoes) and *Aedes aegypti* [1, 2, 3, 4]. They mainly bite during the day time. Someone who gets infected by this virus would make the surroundings susceptible to this disease easily, because virus can spread out from the infected person to others by mosquitoes. There may be no symptoms for up to two to twelve days after bitten by an infected mosquito. Typically, there are no symptoms for three to seven days. Once symptoms appear, patient probably experience about ten days of Chikungunya symptoms before getting better. Most patients recover fully, but in some cases joint pains can persist for months or years. Occasionally, more severe complications such as heart and nerve system complications can occur, particularly in older people who have after pre-existing medical conditions. No vaccine exists to prevent Chikungunya fever and there is no effective antiviral treatment. However, death from complications of Chikungunya is very rare, but the virus sometimes causes severe problems, mostly in older adults with chronic illness. People who have been infected once are likely to be protected from future infections. Chikungunya virus infection is not considered to contagious, because there is no direct human to human transfer of this viruses, so infected individual can not directly transfer the virus to another human, virus has to pass through a mosquito first. Therefore prevention from this virus lies in that previous sentence.

Since *Aedes aegypti* and *Aedes albopictus* are mainly proven carrier for Chikungunya and more than 120 mosquito species have been recorded in Bangladesh during 1908-2017 and 25 of them are *Aedes* species, which are responsible for carrying and transmitting the Chikungunya virus, as well as many other diseases to humans, therefore Bangladeshi people are highly susceptible to this disease. Chikungunya virus is maintained in nature in man-mosquito-man cycle and illness is often acute and lasts for 2-12 days, an infected person, migrated from one nation to another, can spread the virus i.e. imported cases may result in virus introduction and local spread in some areas of Bangladesh. Majority (72% to 97%) of infected people develops clinical symptoms and acute symptoms typically resolve in 7-10 days, mortality is rare. Since Dengue and Chikungunya viruses both transmitted by same mosquito, viruses can circulate in same areas and cause co-infections [2].

Since 2004, CHIKV has exploded onto the global scene as a major emerging pathogen in a series of devastating outbreaks that have infected up to 6.5 million people [3] and have been associated with several thousand human deaths worldwide [4]. The major CHIK outbreaks were caused by virus strains of the Indian Ocean Lineage (IOL), which evolved from the East-Central-South-African (ECSA) enzootic genotype. This lineage first emerged in Kenya in 2004 and subsequently spread to several Indian Ocean Islands, India and Southeast Asia. A CHIKV strain of the IOL, presumably transported from India by a viremic traveler, also responsible for the small 2007 CHIKV outbreak in Italy [5].

The first recognized outbreak of Chikungunya in Bangladesh was identified in 2008 and in 2011 another outbreak of fever and severe joint pain was reported by local health official in dohar Sub-district in Dhaka district and in that period the Breteau index in some village of dohar was 35 per 100 and 89% of hatched mosquitoes were *Aedes albopictus* [6]. The recent outbreak of Chikungunya happened in Bangladesh in April, 2017, the Bangladeshi Ministry of Health reported 984 cases confirmed by real-time PCR assay and more than 13176 clinically confirmed cases in 17 of 64 districts[7] and it was anticipated because of suitable climatic conditions, excessively rainfalls from the very begging of the year. In this current study we will be looking into the outbreaks of Chikungunya in Bangladesh from 2008 to 2017, and also the effects of the climate change on the outbreak of Chikungunya in 2017 by some mathematical manipulation and data analysis.

2. Epidemiology of CHIKV

Chikungunya fever was first reported in 1952 from Makonde plateaus, along the borders between Tanzania and Mozambique [1, 2, 9, 10, 11] where the virus had been found to circulate in a sylvatic cycle between forest-dwelling *Aedes* species mosquitoes and nonhuman primates. In these areas, sporadic human cases occur, but large human outbreaks are infrequent. Chikungunya virus is maintained in nature in man-mosquito-man cycle and illness is often acute and lasts for 2-12 days, an infected person, migrated from one nation to another, can spread the virus that is imported cases may result in virus introduction of Chikungunya and Dengue.

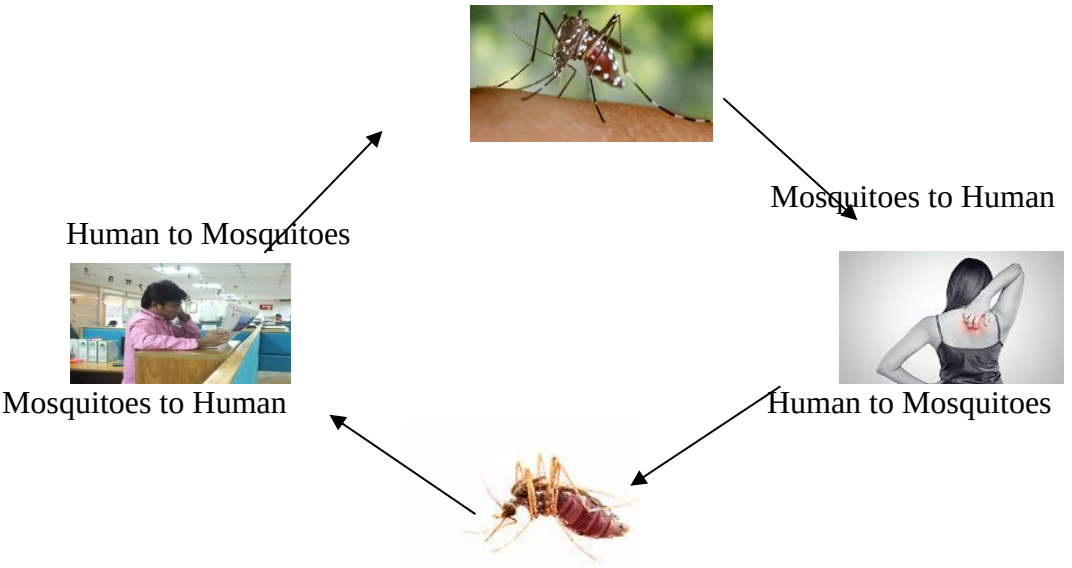


Figure 1: Man-Mosquito-Man cycle in the transformation circle of Chikungunya Virus. Chikungunya virus was first isolated by Ross in 1953 from the serum of a febrile human during an epidemic in Newala district of Tanzania [9, 12].

Table1: Countries and territories where chikungunya cases have been reported [8]: (Continued)

ASIA • Bangladesh • Bhutan • Cambodia • China • India • Indonesia • Laos • Malaysia • Maldives • Myanmar (Burma) • Pakistan • Philippines • Saudi Arabia • Singapore • Sri Lanka • Taiwan • Thailand • Timor • Vietnam • Yemen	**EUROPE** • Italy • France **OCEANIA/PACIFIC ISLANDS** • American Samoa • Cook Islands • Federal States of Micronesia • French Polynesia • Kiribati • New Caledonia • Papua New Guinea • Samoa • Tokelau • Tonga
AMERICAS • Anguilla • Antigua and Barbuda • Argentina • Aruba • Bahamas • Barbados • Belize • Bolivia • Brazil • British Virgin Islands • Cayman Islands • Colombia • Costa Rica • Curacao • Dominica	• Guatemala • Guyana • Haiti • Honduras • Jamaica • Martinique • Mexico • Montserrat • Nicaragua • Panama • Paraguay • Peru • Puerto Rico • Saint Barthelemy • Saint Kitts and Nevis • Saint Martin • Sint Maarten

• Dominican Republic • Ecuador • El Salvador • French Guiana • Grenada • Guadeloupe • Guatemala • Guyana • Guadeloupe	• Saint Lucia • Saint Vincent and the Grenadines • Suriname • Trinidad and Tobago • Turks and Caicos Islands • United States • US Virgin Islands • Venezuela

3. Outbreaks of Chikungunya in Bangladesh

In 2006, an increase in the incidence of Chikungunya in India prompted testing of serum samples collected from febrile patients from two different surveillance projects in Dhaka, Bangladesh. One hundred seventy-five serum samples were tested however none had antibodies against Chikungunya virus [13]. On 18 December 2008, the Civil Surgeon of Rajshahi district sent a line list of case-patients and a brief report of increased incidence of fever and joint pain among residents of a village of Poba Upazila (sub-district) to the Director of the Institute of Epidemiology, Disease Control and Research (IEDCR) at the Ministry of Health and Family Welfare. On 20 December 2008, an investigation team from the Institute of Epidemiology, Disease Control and Research (IEDCR) and International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) investigated the first outbreak of chikungunya fever in the Rajshahi and Chapianawabganj districts of Bangladesh. Institute for Epidemiology, Disease Control and Research, Ministry of Health and Family Welfare, Government of People's Republic of Bangladesh and Programme on Infectious Diseases and Vaccine Sciences, ICDDR, B collected 371 larvae [14]. The larvae were transferred to glass vials for transportation to the IEDCR laboratory where they were identified and quantified using the WHO Comprehensive Guidelines for larval speciation. Among the larva collected, the majority (351/371 [95%]) were identified as *A. albopictus*. A few (5%) were identified as Cx. Quinquefasciatus. The clinical features and laboratory results suggest that this was the first identified Chikungunya outbreak in Bangladesh. The larval survey showed that predominant mosquito species in the outbreak areas was A. albopictus, a known vector for Chikungunya. Case-patients (29 among 39) informed the investigated team that they still suffered from joint pain, one to two months after recovering from fever. None of the case-patients required hospitalization. They all sought medical treatment from the informal health sector and were prescribed steroids as analgesic and broad spectrum antibiotic which is traditionally prescribed by informal medical practitioners in the villages for any illness episode of fever [14].

Table 2: Clinical profile of case-patients in Bashontopur village of Rajshahi district and Baroghoria village of Chapainawabganj distric [13]

Characteristics Age (years)	N=39(%)
Mean	34
Median	35
Male	19 (49)
Fever	39 (100)
Joint pain (all type)	39 (100)
Myalgia	24 (62)
Patechial and/or maculopapular rash	15 (39)
Oral ulcer	3 (8)

During October 2011, a local health official from Dohar Sub-district, Dhaka District, reported an outbreak of undiagnosed fever and joint pain. Limited antibody testing for dengue and blood smears for malaria conducted at the local health clinic suggested that the illnesses were not caused by dengue or malaria.

In the first week of November, 2011, an outbreak investigation team began an investigation with the objectives of identifying the etiology of the outbreak, describing the clinical presentation of cases, and identifying associated vectors [6]. The team comprised of medical epidemiologists, entomologists, field research assistants and laboratory technicians from the Institute of Epidemiology Disease Control and Research (IEDCR), of the Bangladesh Ministry of Health and Family Welfare, and icddr,b conducted house-to-house surveys to identify suspected cases, defined as any inhabitant of Char Kushai village with fever followed by joint pain in the extremities with onset since August 15, 2011.

Team calculated the Breteau index for the village and identified the mosquito species. The village Breteau index was 35 per 100 and 89% (449/504) of hatched mosquitoes were *Aedes albopictus*. According to WHO, places with a Breteau index >20% have a high risk for dengue outbreaks [15]. The evidence suggests that this outbreak was due to Chikungunya.

Table 3: Number of suspected cases per household (N = 897) in Char Kushai, Dohar, Bangladesh, August 15–2 November 2011 [6].

No. of suspected cases	Households, n(%)
0	323 (36)
1	263 (29)
2	78 (20)
≥3	133 (15)

From April 1, 2017 to Sept 7, 2017 CHIKV has reemerged as a major threat to the public health of Bangladeshi people. The incident rate increases from May 1 to July 2 of 2017, drastically. The outbreak spread beyond the capital Dhaka. The impact of the disease was really fatal and around 737 people get affected by CHIKV between April and July.

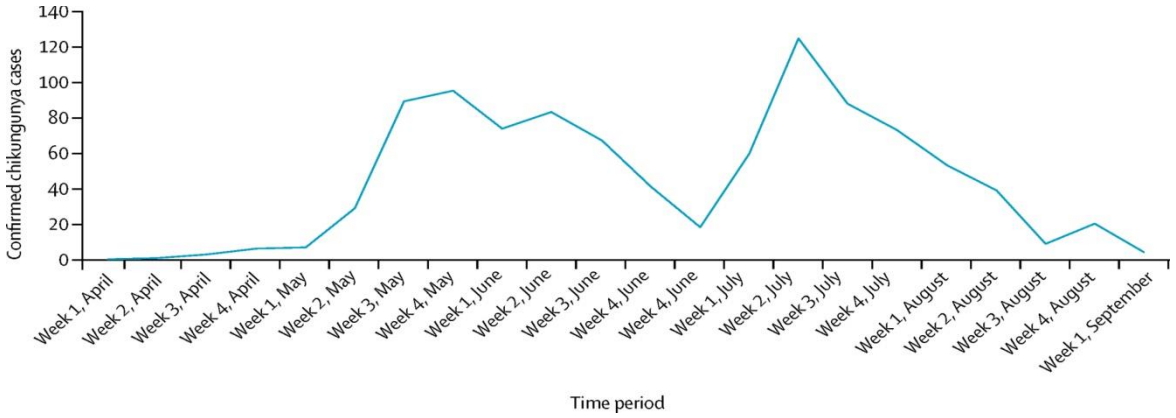


Figure 2: Chikungunya outbreak (cases confirmed by PCR) in 17 districts of Bangladesh, April 1–Sept 7, 2017

People made criticism on the controlling measure of this outbreak. In face of severe criticism over Chikungunya, mayor of South Dhaka had to launch a "crash programme" to eliminate mosquitoes and control the disease effectively. Around 296 armed and 156 fogger machines were work together for such [16].

Although CHIKV infection was first reported over half century ago, virus has been neglected until recent epidemics. According to the United Nations Development of Economics and Social Affairs, around 18.24 million people live in Dhaka city. One in 10 people in the city are at risk of the mosquito-borne fever, says a study. Both Dhaka South and North city corporations have come under heavy criticism following the outbreak of CHIKV. Health Minister Mohammed Nasim held the corporation authorities responsible for the alarming spread of the mosquito-borne disease.

Figure 2: South Dhaka mayor launches-anti mosquito drive amid chikungunya spread

The then Dhaka North Mayor Annisul Huq told a press conference that "the mosquitoes being bread in drains are not spreading the disease; rather the *Aedis* mosquitoes bred in stagnant fresh water at home is the main cause of the disease. He also said "I cannot go into your house and hang mosquito nets. I cannot spray insecticide on stagnant water pot inside your homes. The homegrown mosquitoes are spreading the disease. We cannot reach there". He was so true with his position. If anyone asked them to spray inside their house, then they would do that. That is certainly appropriate.

Figure 3: Workers with the South Dhaka City Corporation fumigate streets to control the spread of mosquitoes, July 14, 2017(Benar News)

According to a report of Health ministry about 4700 blood samples of patients with symptoms were collected. So far there is no report of fatalities. Most of the patients reported joint pain, high fever, rash, itching and myalgia. The joint pain was so serious that patients still suffering from the disease. We personally talked with some patients and they told us that still they suffering from severe joint pain, although long ago they had taken proper treatment. The burden of the

Chikungunya outbreaks in 2017 was very high since the mean age of the patients were approximately 34 year and most of the working people in Bangladesh ages 25 to 55.

4. Impact of Climate Change on the Outbreaks of Chikungunya in Bangladesh

In a natural population system the growth rate of a particular population controlled by many external factor and we know that the uncontrolled growth of a population is exponential. A famous biologist, Barry Commoner said that "Everything is connected to everything else." Warming and unstable climate is playing an ever-increasing role in driving the global emergence, resurgence and redistribution of infectious diseases [17]. In particular Climate change is expected to impact widely upon human health, including changes in the geographic distribution of vectors that carry severe diseases such as malaria, Dengue fever, Chikungunya, and others. In Bangladesh the case is similar; climate has huge affects on the spread of different named and unnamed infectious diseases.

Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. There are three distinct seasons in Bangladesh namely

- Hot, Humid Summer from March to June
- Heavy Raining Monsoon from June to October and
- Cool, Dry Winter from October to March

In January the average atmospheric pressure is 1020 millibars, and 1005 millibars from March to September. Usually January is the coldest month in Bangladesh. Average temperature in the country during July is about 27℃ to 29℃.Generally maximum summer (March to June) temperature ranges between 32℃ to 38℃. During June to September, relative humidity all over Bangladesh is 80% [18]. According to researchers, the infectiousness of vector-borne disease get increases when the diurnal temperature range (DTR) decreases and they also say decreases of DTR is evidence of **climate change**. A study on Dengue virus shows that, diurnal temperature range (DTR) has a direct effect on the infectivity of *Aedes aegypti* with dengue virus. A high diurnal temperature range (20°C) reduced the probability of infection while a low range (10°C) increased the rate of infection [19].

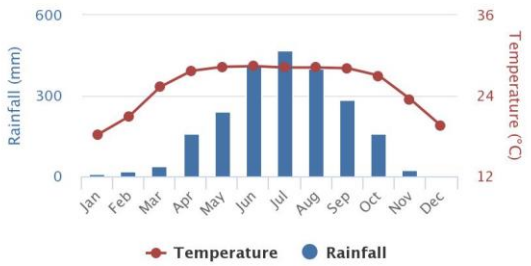
Heavy rainfall is a common phenomenon in Bangladesh, and different studies shows that almost 80% rain falls throughout June to October. Average temperature and average rain fall of Bangladesh, from 1991 to 2015 are 28.27℃ and 429.13 mm per month. It is a fact that birth rate of *Aedes albopictus* and *Aedes aegypti*

increases significantly when the precipitation rate increases. Consequently the rate of infected vectors increases and ultimately susceptible rate of human populations get increases [20, 21].

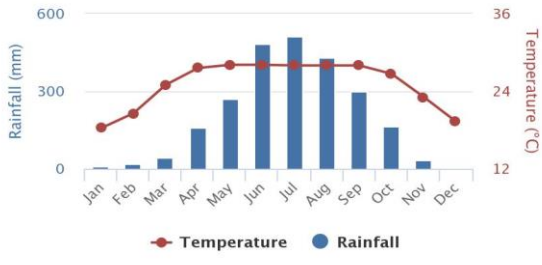
5. Discussion

During the hot and humid weather vector population reproduce faster, and also bite rate get increases. It is evidenced that climate change promotes the spread of infectious diseases. Chases of chikungunya have recently been reported in Bangladesh. It is a re-emerging arbovirous, though no mortality case has been reported yet, but causes significant morbidity. Global climate change leads us to a warmer temperatures and changes in rainfall pattern. It is also evidence that climate change increases the global habitat available to mosquitoes by increasing average temperature and heavy precipitation. Since climate change increases global temperature and causes more extreme weather, which ultimately increase the burden of the chikungunya diseases.

Consider figure 4, we can see that, the average temperature and rainfall of Bangladesh from 1901 to 2015 during the month of, June, July, and August are approximately 28.03℃ and 475.83mm. On the other hand if we again similarly consider the figure 4 again, we can also see that, the average temperature and rainfall of Bangladesh from 1991 to 2015 during the month of, June, July, and August are respectively 28.27℃ and 429.13mm.The greatest effect of climate change on transmission is likely to be observed at the extremes of the range of temperatures at which transmission occurs. For many diseases these lie in the range 14℃ – 18℃ at the lower end and 35℃ – 40℃ at the upper end [22]. From the above analysis we can depicts, that the average temperature is raising gradually, which is favorable for vector population, like *Aedes albopictus* and *Aedes aegypti* to increase their birth rate. Since they both are the carrier of the chikungunya virus, therefore, it would be a threat for human to become infected.



a. Average Monthly Temperature and Rainfall of Bangladesh from 1991-2015(The dataset was produced by the Climatic Research Unit (CRU) of University of East Anglia (UEA))



b. Average Monthly Temperature and Rainfall of Bangladesh from 1991-2015(The dataset was produced by the Climatic Research Unit (CRU) of University of East Anglia (UEA))

Figure 4: Average Monthly Temperature and Rainfall of Bangladesh (a. 1901-2015 and b. 1991-2015)

From first week of April 2017 to last week of August 2017 CHIKV has reemerged as a major threat to the public health of Bangladeshi people (Figure 2). The infected rate was very high from May 2017 to August 2017. If we, carefully look the data of monthly temperature, Humidity, and Pressure from April to July we see that the difference in maximum and minimum temperature, as well as the humidity was increasing gradual (Appendix A: Table 4.1, 4.2, 4.3, 4.4), some minor exceptionality happened although. During the month of June, 2017 the average temperature was 30℃ and, maximum and minimum temperature was 40℃ and 24℃ consecutively. We see that, the temperature and the humidity was so favorable for vector population, especially for *Aedes albopictus and Aedes aegypti*. These two species mostly spreads Chikungunya viral disease [22]. That same thing was happening during the month of April to July in Dhaka, and lately some other places in Bangladesh.

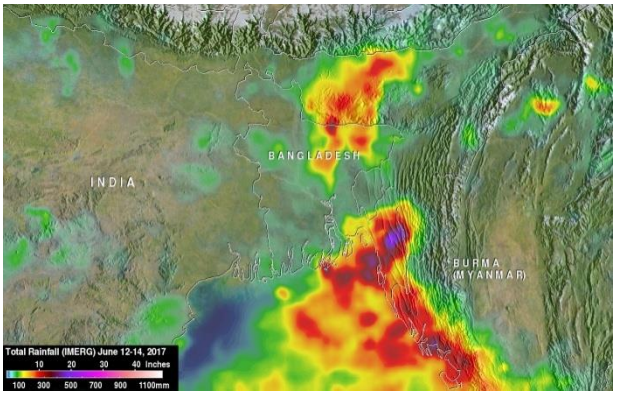


Figure 5: From June 12 to 14, 2017 heaviest rainfall accumulation estimates (purple) by IMERG were located over southeastern Bangladesh. IMERG estimates indicated that landslide inducing rainfall totals there were greater than 510 mm (20 inches). Credits: NASA/JAXA, Hal Pierce.

In 2017and 2018 during monsoon from June to September, the temperature was unbearable and rain fall was unprecedented. We noticed that, the rate of vector-borne diseases was high. People got highly infected, by Chikungunya and Dengue virus, and also other diseases. During the second week of June, 2017 rainfall accumulation estimates (purple) by IMERG were located over southeastern Bangladesh. This estimation indicates that, there was more than 510 mm rainfall including landslide. At least 156 people killed during that week by landslides and floods caused by heavy rainfall. In April, 2017 during the first three week nearly 9000 mm rain recorded, according to Meteorologist office statistic officer this rainfall was highest in 35 years also 119.7 percent higher than the average April rainfall. According to weather experts, it is known as "climate variability".

6. Conclusion

Climate change is global, increases unknown risk to human health and, burden of the diseases. It has a strong effect in changes in the status of vector-borne diseases not only in Bangladesh but also globally. Definitely the growth and transmission of vector-borne diseases is climate dependent. Study has been showing that climate of Bangladesh changing gradually. Study shows that, climate change of Bangladesh in the recent year is unprecedented. The diurnal temperature range (DTR) is gradually decreasing and in the month of May 2017 it was around 10℃-12℃, which is so favorable for vector population to increased the rate of infection. We see from figure 2 that, the infection rate of chikungunya suddenly increased up during the month May 2017. It was clearly a devastating effect of climate change on the disease spreading. Rainfall is another vital element of climate and it has a crucial effect on ecosystem. Bangladesh experienced heavy rainfall during the rainy season in 2017, and it was expected that, the bath rate of vector population could increase. According to Meteorologist office statistical officer, the rainfall in April, 2017 during the first three week was highest in 35 years also 119.7 percent higher than the average April rainfall. Consequently, in Bangladesh, we saw an increasing rate of vector borne diseases and, According to weather experts, it is known as effect of climate variability. This study suggests that temperature and rainfall are significantly associated with chikungunya incidence in Bangladesh. Based on the findings, we conclude that the climate change plays a critical role in the transmission of chikungunya virus.

Conflict of interest statement: We declare that there is no conflict of interests regarding the publication of this paper.

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Appendix

Table 4.1: High & Low Weather Summary for April 2017

	Temperature	Humidity	Pressure
High	36 °C (14 Apr, 15:00)	99% (23 Apr, 21:00)	1010 mbar (23 Apr, 21:00)
Low	20 °C (23 Apr, 00:00)	17% (11 Apr, 15:00)	1001 mbar (25 Apr, 18:00)
Average	28 °C	72%	1006 mbar
* Reported 1 Apr 06:00 — 30 Apr 21:00, Dhaka. Weather by Custom Weather, © 2018			

Table 4.2: High & Low Weather Summary for May 2017

	Temperature	Humidity	Pressure
High	36 °C (23 May, 15:00)	97% (2 May, 00:00)	1014 mbar (2 May, 00:00)
Low	21 °C (2 May, 06:00)	45% (11 May, 12:00)	993 mbar (30 May, 12:00)
Average	30 °C	71%	1005 mbar
* Reported 1 May 00:00 — 31 May 15:00, Dhaka. Weather by Custom Weather, © 2018			

Table 4.3: High & Low Weather Summary for June 2017

	Temperature	Humidity	Pressure
High	40 °C (24 Jun, 21:00)	100% (3 Jun, 00:00)	1006 mbar (3 Jun, 00:00)
Low	24 °C (19 Jun, 15:00)	43% (24 Jun, 21:00)	991 mbar (12 Jun, 15:00)
Average	30 °C	78%	1000 mbar
* Reported 1 Jun 06:00 — 30 Jun 21:00, Dhaka. Weather by Custom Weather, © 2018			

Table 4.4: High & Low Weather Summary for July 2017

	Temperature	Humidity	Pressure
High	36 °C (16 Jul, 15:00)	100% (20 Jul, 06:00)	1006 mbar (20 Jul, 06:00)
Low	25 °C (4 Jul, 06:00)	49% (15 Jul, 15:00)	996 mbar (16 Jul, 18:00)
Average	29 °C	81%	1000 mbar
* Reported 1 Jul 00:00 — 31 Jul 21:00, Dhaka. Weather by Custom Weather, © 2018			