Impact of Climate Change on Dengue Transmission in Bangladesh: A Critical Review

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Abstract

Dengue fever is a mosquito-borne tropical disease caused by The Ades mosquitoes carrying dengue viruses. The associations between climate conditions and dengue transmission have been found in many studies. However, the impression of climate change on dengue transmission is being discussed in this paper. This literature examined epidemiological evidence on the climate-dengue relationship with an emphasis on quantitative methods for evaluating possible climate change impacts on dengue transmission. Two systematic reviews were performed. We had searched Pub-Med, literature sources for documenting dengue outbreaks that are geographically identified. We also looked for finding out model the possible effects of climate change on dengue transmission through Pub-Med and Google scholar. We gathered evidence from researches that met the inclusion criteria and draws our conclusions. It is found that most studies showed dengue transmission is highly sensitive to climatic change. This analysis found some primary methodological issues and current knowledge gaps.

Key Words: Climate change, Dengue, Models, Projections, Dengue fever (DF).

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Introduction:

Dengue is the fastest spreading, mosquito-borne viral infectious disease worldwide with remarkable morbidity and mortality after malarial infection.[1] In recent decades, the spatial spread of dengue has been reported from urban to suburban or rural.[2] Dengue fever is an acute illness due to four forms of dengue virus (DENV1, DENV2, DENV3, DENV4) most of which are transmitted by *Aedes aegypti* and *Aedesal bopictus* tohumanhosts.[1] Several complex risk factors including host immunity, vector capacity, DENV circulation, environment or atmosphere, dengue control capability, and population movement influence the dynamics of dengue transmission.[2] Weather variables effect of dengue epidemiology through their indirect impact on mosquito biological aspects and DENV incubation periods in mosquitoes.[2] Temperature influences vector growth rates, survival and behavior and regulates mosquito viral replication variability in precipitation affects the availability of habitat for species *Ae.aegypti* and *Ae.albopictus* larvae and pupae.[3] Climate change alters DENV ecology spatial and temporal dynamics, possibly by increasing the flying range of vectors, increasing the vector activity length.[2] As the main evaporation regulator, temperature also interacts with rainfall, thus also impacting the quality of water ecosystems. Indirectly, the effect of heavy rainfall, increasing temperature and moisture content of land can encourage or hinder the growth of vector populations. [3] The rate of DF is correlated with indices of vegetation, tree cover and standard of housing and surrounding land cover. Change of climate could also alter how human interacts with nature, increasing its use also influence the extent of the mosquito population and the nature of the ecosystem. Consequently, literature predicting that climate change is one of the most significant changes in the environment will result in populations facing it in the coming decades.[1] DF is prevalent in tropical and subtropical regions.[1]In a recent analysis, it is observed that in each year 400 million people considered an endemic or infectious disease area.[1]

Approximately 52 % of people living in South-East Asia region countries are at the risk of dengue including Bangladesh.[4] There, since an initial epidemic in 2000, when 5551 cases and 93 deaths were reported, the disease emerge dasa major threat to public health.[4] Dengue fever was first identified in Bangladesh, during the late summer of 1964, an outbreak of a febrile disease called (Dacca

Fever); occurred in the capital (now Dhaka). Form 3 dengue virus has been isolated.[5] Sporadic cases and minor clinically suggestive out breaks of dengue occurred throughout the country between 1964 and 1999, but were not officially reported.[4] An outbreak in and around Dhaka started in the summer of 1999, followed by the first officially reported DF epidemic in 2000.[5] Severe dengue cases have also been reported. The epidemic was probably caused by a strain of the dengue virus from endemic countries in eastern Bangladesh. Dengue cases have been reported in all major cities in Bangladesh every year since2000.[4] Since 2002, the highest recorded outbreak occurred in 2002 with 6132 cases.[4] Notifications of hospital monitoring have decreased, although the true numbers of cases remain undetected. To understand how climate affects dengue is complex, the relationship between the present climate and diseases must be understood. The relationship between climate and diseases with different modes of transmission (vector, water, food, soil and airborne) was established with the strongest connections between climate and mosquito- borne diseases.[3] The goal of this study is to provide a systematic review of the scientific literature of Bangladesh on the occurrence of dengue and its connection to climate.

Research design:

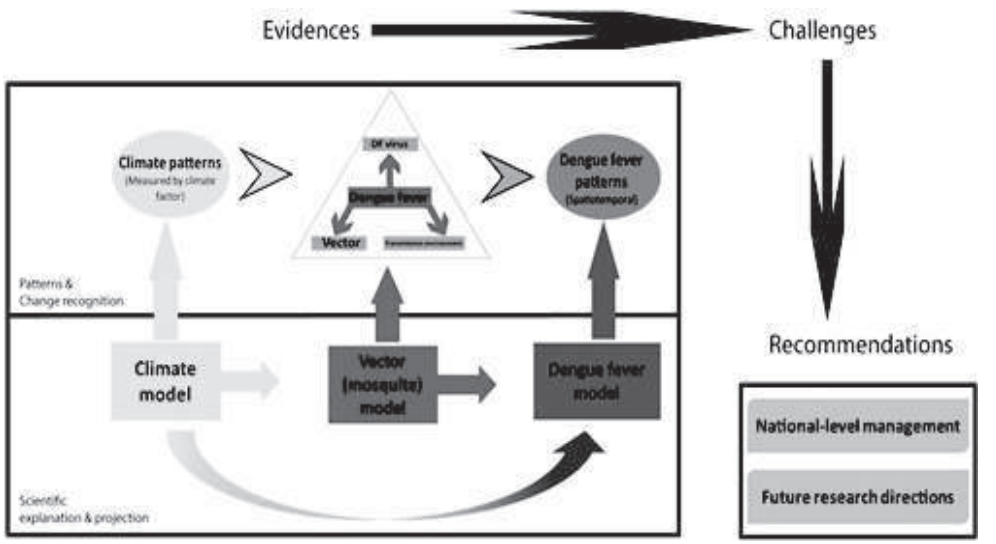


Fig-1. Tri-model supported the prediction of Dengue Fever distribution and patterns.

The focus of this analysis is to survey the literature for scientific evidence on the impact of temperature change on DF distribution in Bangladesh, and to look at the standing of and wishes for modeling and prediction of DF in Bangladesh considering temperature change. Temperature change includes changes in climate factors and extreme weather events, each of which may affect the distribution of DF. Temperature change affects DF transmission through impacting its 3 essential bio-ecological aspects: (The virus, The vector, and transmission surroundings).Therefore, underneath standing the dynamics of DF under temperature change necessitates to correct modeling and prediction of climate change, that of vectorial (mosquito) abundance and capability in which DF incidence underneath weather, particularly climate model, vector (mosquito) model, and weather-based DF model. A framework (Fig.-1) named "Tri-model Supported Prediction of dengue fever Distribution and Patterns" so as this figure let's say the connections between the assorted components. Prediction of dengue fever virus (DENV) transmission and its spatiotemporal patterns should be supported acceptable weather-based DF model, dengue mosquito model, and climate model. The weather-based DF model describes the connection between DF incidence and climate factors. The weather-based DF model is being used for predicting the spatiotemporal patterns of DF distribution. Mosquito model quantifies the dynamics of mosquito distribution and population that is closely associated with weather. The climate model uses quantitative strategies to simulate the interactions of the vital drivers of climate. Climate model not solely generates predictions of climate patterns and dynamics of weather however conjointly provides inputs for the mosquito model, which can turnout outlooks of mosquito abundance and vectorial capability across the house and thru time. Projection of DF refers to predicting DF distribution or spatiotemporal patterns supported weather-based DF model, once climate factors and their magnitude are similar because the connected amendment in mosquito activity. Thus the general prediction of DF distribution patterns, despite its stress on patterns and alter prediction, is made upon the knowledge based mechanisms which will make a temperature change, mosquitos' vectorial capability and DF incidence. Our choice of literature and style of this review analysis are guided by this framework as illustrated in Fig. (1).Considering the primarily records happening of the DF case in Bangladesh was according to the late summer of 2000. Our literature survey covers papers

and reports associated with DF in Bangladesh that were being printed from 1998 to 2017. Following the framework on top of (Fig.-1), the keywords outlined by 3 sets of terms were not to screen the literature; the obtained results should contain keywords from a minimum of one in every three sets (Table-2). The primary set describes patterns and alters recognition of DF transmission driven by temperature change in an Asian country. The terms are associated with temperature change and therefore the 3 aspects of DF in the Asian countries. Keywords enclosed climate factors like temperature, humidness, a dengue fever, dengue fever virus, mosquitoes, transmission, occurrence, Bangladesh. The second set of terms describes models of DF transmission in the Asian countries, which concerned models of DF incidence and climate factors, mosquitos' models and climate models. Keywords enclosed DF model, mosquito's population model, climate model, and Asian countries. The third set of terms describes projections of DF transmission and distribution patterns in Bangladesh. Keywords enclosed projection of mosquito's population, prediction of DF incidence, and Bangladesh. A comprehensive literature search was conducted using Google Scholar, Research gate, PubMed. Fig.1 showed the method we tend to at first the challenges for Asian countries to higher perceive and predict the impact of temperature change on DF and our recommendations.

Scientific publication: Climate change & Dengue in Bangladesh
Keywords: Climate, Dengue, Scamaries, Models, Projections, DF
Inclusion criteria: Review & original papers published in national & international journals from 1990-2017, included in selected electronic database

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Article identification from datebase : 30
(included duplicated articles)
▪ Google scholar ▪ Pubmed ▪ Research gate

↓

Article included for this study : 9
After removing the duplicate & performed full text review based on inclusion criteria

Table-1: Summary of strategies, process, and results of the literature search

Table-2. The list of keywords used to screen the literature.

Sets	Categories	Keywords
Set-1: Impact of climate change on Dengue fever.	Three aspects of dengue fever transmission	Dengue virus DENV, vectors, mosquito, *Aedes aegypti, Aedes albopictus*, transmission
	Weather Factor	Climate factor, weather factor (temperature, humidity, precipitation, wind, air-pressure), Extreme weather.
	Geographical Location	Bangladesh
Set-2: Model of Climate change on dengue fever.	Weather-based dengue fever model	Dengue fever model, transmission, climate, weather
	Mosquito model	Mosquito, model, climate, weather, population
	Climate Model	Climate Model
Set-3: Projection of dengue fever		Projection, prediction, dengue fever incidence, future climate condition

The impression of climate change on Dengue in Bangladesh:

Climate change refers to statistical shifts of climate conditions over an extended period, including alternations of one or more weather factors like temperature, precipitation, humidity, wind velocity.[1] These changes impact the incidence of dengue fever through affecting the survival, replication, development or distribution of dengue virus and mosquitoes, also because of the means and process of dengue transmission. During this section, we offer a scientific

literature summary of the impacts of weather factors on DF from three bio-ecological aspects: impact on dengue virus, impact on dengue vector (mosquito) and impact on dengue transmission in the environment.[1]

Weather and vector ecology:

Temperature:

Temperature plays a crucial role in the Replication of Aedes species at a particular range.[6] Literature suggests some factors like survival rate, reproduction, development within the host, mosquito Density, biting activity, ovarian development, mosquito flying distance that depend on temperature. The presence of heat survival rate is increasing and therefore the replication of the dengue virus is also increased. Laboratory studies assessing that factors indicate that the perfect temperature range for the survival of all life phases of *Ae. aegypti* is between 20°C and 30°C.[7] The rising temperature reproduction rate is also increasing.[1] By increasing temperature, the development period of the intermediate host is shortened, for example, development with in the intermediate host takes 12 days at 30°C and seven days at 34°C.[1] On the other hand, the event period in the intermediate host is going to be longer with the decreasing temperature. *Aedesaegypti*, the vector of DENV, does not regulate its blood heat, which is directly hooked into ambient temperature.[1] So it is sensitive to a particular climate condition. According to the study, mosquito density increases with the increase of temperature. But when the temperature is above 32°C, the mosquito density decreases significantly.[1] It is found that biting activities limited to a temperature between 15°C - 35°C.[1] The optimal temperature for biting activities range between 25°C - 30°C.[1] Ovarian development is also regulated by temperature.[1] Changes in temperature can impact mosquitos' flying distance. The favourable temperature ranges between 20°C - 27°C, where mosquitoes can fly quite 400m.[1] By decreasing temperature (18°C) their flying distance also decreases, generally within 50m.[1]

Precipitation:

Studies show that precipitation was positively related to dengue incidence. Mosquito breeding has a co-relation with precipitation. Precipitation is important to supply essential breeding sites for mosquitoes developed a DF model and proved that the mosquito density is positively correlated to

precipitation.[4] National surveillance data usually shows that dengue increases from June to August which is the rainy season in Bangladesh.[4]

Humidity:

Humidity is positively associated with DF incidence.[1] It also affects DF incidence by altering mosquito behavior. Higher humidity is related to increase *Aedes aegypti* feeding activity, therefore survival and egg development.[3] From literature, in dry season mosquito bites on average 19 bites per hour and wet season 60 bites per hour.[1]

Wind velocity, It features the harmful effect of dengue fever incidence. When the wind velocity is increased, the mosquito density decreases.

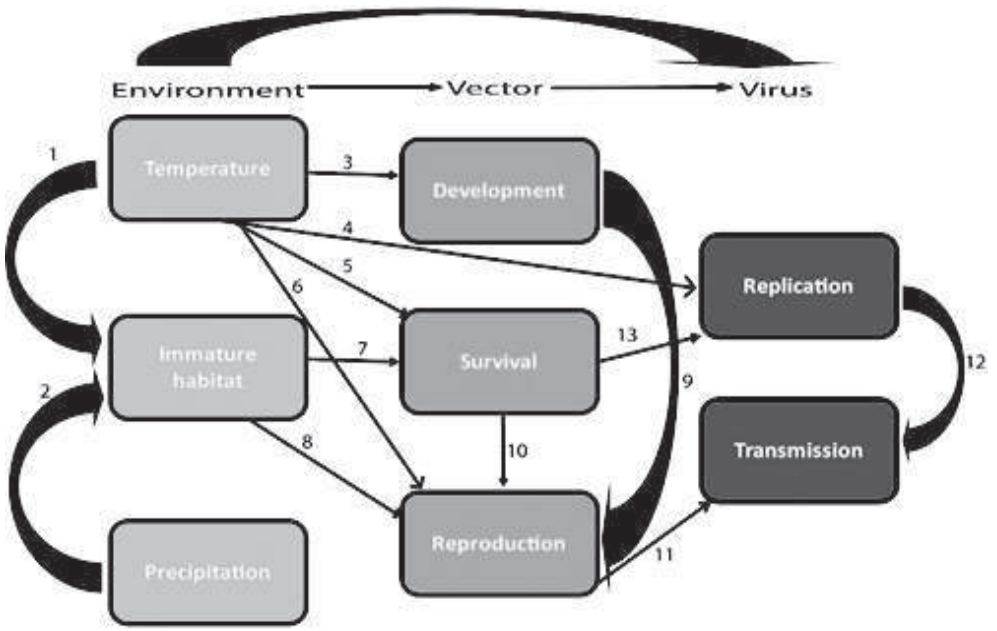


Fig.-2. Biophysical influences on dengue ecology showing the interactions between climate variables, vectors, and also the virus.

The numbers in figure: 2 identify relationships between variables supported by research within the field and under controlled laboratory conditions. Habitat availability for mosquito larvae is influenced by - (1) temperature through evaporation and transpiration, (2) incoming precipitation, Temperature could

be a major regulator of (3) mosquito development, (4) viral replication within infected mosquitoes, (5) mosquito survival, (6) the reproductive behavior of mosquitoes, Habitat availability is required for (7) survival, (8) egg- laying, Mosquito reproduction is accelerated by (9) faster mosquito development, (10) increased survival, Increased mosquito reproduction (11) enhances the likelihood of transmission by increasing the number of blood feedings, Faster viral replication (12) increases transmission by shortening the time for the virus to develop within the mosquito, increased survival of the adult mosquito (13) increases the number of viral replication. [7]

The studies on the connection between weather factors and DF are abundant, but the findings on the implications are not always consistent. Studies in several areas produced outcomes different from each other with relevancy the implications of similar weather factors.

Extreme weather factor:

Extreme weather events at the regional or local places in Bangladesh also can impact DF incidence. These events include drought, flood, cyclone and warmth wave. A study suggested that drought helps to reduce DF incidences by limiting the amount of mosquito breeding sites and therefore the growth environment of mosquitoes. Additionally, heat waves were found to be related to increase DF incidences and associated deaths, particularly within the riverside area. Similar extreme weather events may cause different health impacts, associated with the magnitude of change in climate factors. A study showed that flood tends to steer to rise in DF incidences and thus to increase mosquito habitats and high mosquito density. However, the flood also can damage mosquito habitats and flush away their eggs and larvae, which could decrease in the DF incidence.

To sum up, empirical studies on the connection between global climate change and therefore the three aspects of DF transmission are abundant and especially concerning DF vector. However, there are scarcity of investigations on the correlation between DF incidence and extreme weather events.[5] Moreover, there need for a transparent scientific prediction on how changes in extreme weather events may causes patio-temporal changes within the distribution of DF in Bangladesh.

Dengue incidence in Bangladesh:

Bangladesh is situated within the tropical and sub-tropical areas like other Southeast Asian (SE) countries.[5] It is located inside the south Asia and surrounded by India at the north, east, and west site. Southeast portion of Bangladesh is connected through Myanmar and the Bay of Bengal in south (Fig-3).[4] It is one of the principal appropriate countries for the habituation of the dengue vector.[4]



Fig.-3. Location of Bangladesh.[4]

In India, dengue fever has occurred in 1945 and in 1963 to 1964, a massive outbreak took place in Kolkata, about 567 km west of Bangladesh, partially coinciding with Dacca in Bangladesh. A most important outbreak of extreme dengue passed of fat Delhi in northern India in 1996. Myanmar had outbreaks at intervals of 3 to 5 years for the reason that the foremost outbreak in 1970. Dengue endemic international locations surround Bangladesh, placing it at chronic danger of importation of state-of-the-art dengue strains.[4] The first epidemic of dengue be falls in Bangladesh in 2000. During the epidemic 5551 reported instances and 93 deaths instances with 1.7% death rate were found in the country.[4] Dengue in 2000 in Bangladesh alongside 17 cities together with 4385 (79%) dengue and 1166 (21%) dengue hemorrhagic fever cases. The biggest epidemic came about in 2002 when 6132 cases mentioned with 1% death rate (61 deaths).[4] In 2010, 4097833 symptomatic infections came about however only 409 files officially registered. As countrywide surveillance is passive and hospital-based, it is eye-catching that incident cases are under-ascertained. From 2000 to 2009, 29 districts stated dengue instances with Dhaka constantly reporting the most vital range of cases (91%). From 2000 to 2014 an entire of 28000 cases pronounced with 242 dying cases occur. In 2017 the entire wide variety of instances were 40476 with 268 dying instances shown in Fig-4.[4]

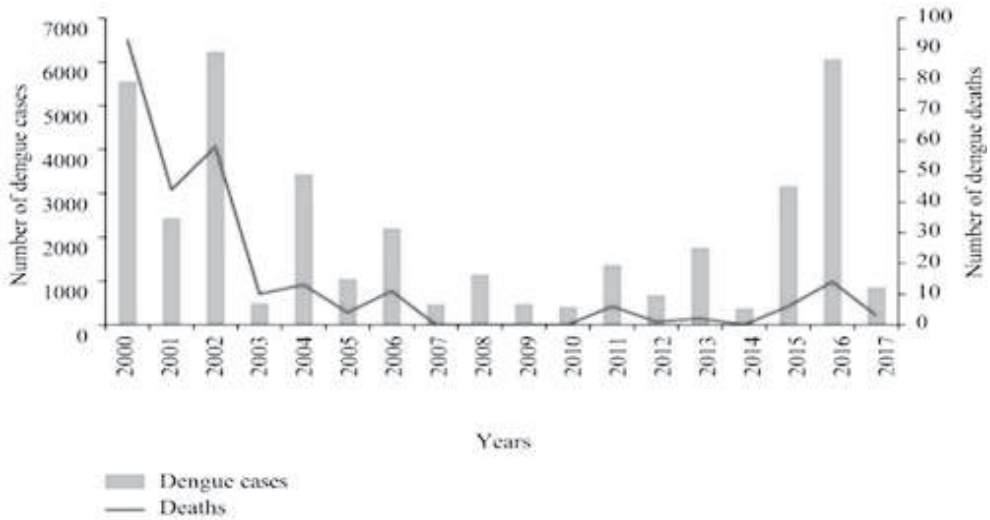


Fig-4: Trend analysis of report of dengue cases and deaths by years from 2000–2017.

The trend analysis, reported dengue cases and deaths by years from, 2000–2017 had shown in public and private health facilities by the control room, DGHS. It also showed that maximum number of deaths was in 2000 when dengue emerged as the first outbreak in Bangladesh, and the study analysis earmarked the period as the pre-preparation phase. The map also showed a sudden rise of dengue cases in 2016 and subsidence of dengue cases leads to an explosion of the Chikungunya outbreak for the first time in Bangladesh in 2017, which reflects the study hypothesis.[4]

The findings about the dengue incident is presented below by focusing on four (4) parameters. They are morbidity and mortality pattern, seasonal relationship, affecting dengue instances and deaths.

1. Morbidity and mortality:

The trends of dengue scenario in Bangladesh were analyzed from 2000 to 2017 in total 40476 verified dengue patients had been observed. Between 2002 and 2016 the utmost quantity of deaths happened in 2000. The bulk of deaths had been located in Dhaka city 93% and where percentage of men is 68% and within the 15 to 50 years age maturity corporations is 57%. Most causes of deaths (65%) have been reported as a complication due to dengue.[4]

2. Seasonal relationship:

There was an in-depth relationship between seasonal relationships and dengue instances in Bangladesh. From 2000 to 2017, 40476 patients stated the dengue cases have been broadly started in monsoon season (May to August) 49.73% and put up monsoon season (September to December) 49.22%. The peak season of dengue in Bangladesh is from July to October. From 2015 to 2017 the dengue instances reported in pre-monsoon season had been 7 times higher than that was evaluated in the previous 14 years. The dengue cases also high in the post-monsoon season to intermittent rainfall. Early onset of the monsoon and prolongation of monsoon. From literature, we found that, after 2014, rapid unplanned urbanization had been the robust predictors of an imbalance inside the existing ecology that had led to lengthening in dengue instances in 2016 [4] (Fig-5) (Table-3).

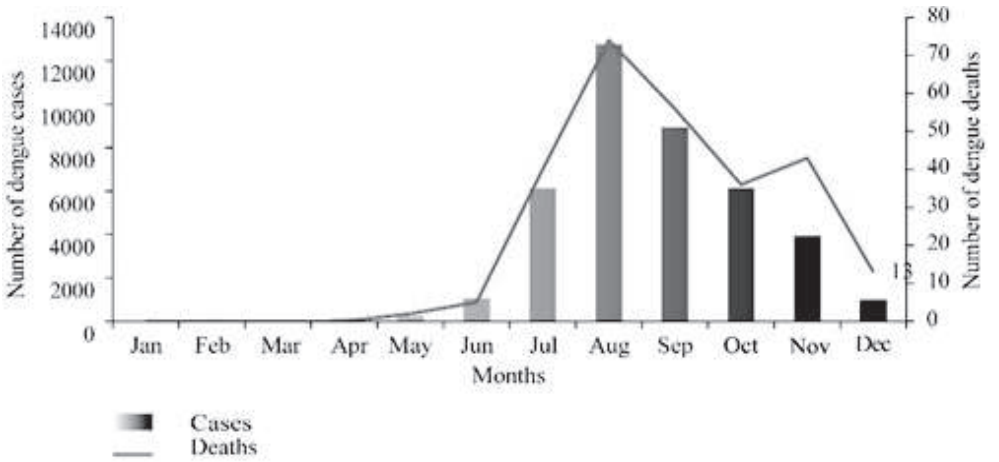


Fig.-5: Dengue cases and death ratio chart over the year (January–December, 2016)

Seasonal variation in the occurrence of dengue cases and deaths by month, 2000–2017, showed fewer cases in the pre-monsoon season (January–April), and maximum cases and deaths were reported in the monsoon season (May-August) and in the post-monsoon period (September–December). Figure-5 shows the peak season of dengue in Bangladesh is from July to October.[4]

Table-3: Seasonal variations of dengue cases: A comparison by year. [4]

Year	Pre-monsoon	Monsoon	Post monsoon	Total
2000-2002	0	7193	7020	14213
2003-2005	4	2802	2703	5509
2006-2008	0	2985	834	3819
2009-2011	0	1305	885	2190
2012-2014	43	1174	1587	2795
2015-2017	334	4671	6945	11950
Total (2000-2017)	381 (0.94%)	20130 (49.73)	19224 (49.22%)	40476

2. Dengue instances and deaths:

The total duration of the dengue deaths case is break up in two tiers pre-preparation phase (1998- 2002) and intervention segment (2003-2017). In the pre-preparation segment, the suggested case is used to be 14213 and deaths is 195. The case-fatality ratio is 1.38% in intervention phase. The whole case used to be 26263 and deaths are 173, in case of fatality ratio is 0.65%. In pre-preparation section there are an outsized quantity of cases and greater deaths with a case of fatality ratio (CFR) is 1.38% which is greater than the suitable and vary 73% of total deaths happened throughout this phase. Due to subsequent revolutionary motion taken with the aid of the CDC at some point in the intervention phase, a CFR under 1% (0.65%) used to be performed.

Table-4: Case fatality ratio (CFR) before and after the intervention by the operational plan from 1998- 2017.[4]

Phase	Cases	Deaths	CFR (%)
Pre-preparation phase			
1998-2002	14213	195	1.38
Intervention phase			
2003-2007	8530	38	0.44
2008-2012	4014	07	0.17
2013-2017	14121	28	0.19
Sub-total of intervention phase	26263	173	0.65
(2000-2017)	40476	268	0.66

*CFR = Case Fatality Ratio.

The dengue cases and death due to it are divided in to two stages. The first phase is pre-preparation segment where the duration of year is 1998 to 2002, here the suggested cases are used to be 14213 where The number of deaths is 195 and the case-fatality ratio is 1.38%.In second stage that is intervention phase the

whole cases used to be 26263 and deaths are 173 and the case fatality ratio is 0.65%. In pre-preparation section there are an outsized quantity of cases and greater deaths with a case fatality (CFR) of 1.38% which is greater than the suitable. Throughout this phase73% of total deaths happened. Due to subsequent revolutionary motion taken with the aid of CDC at some point in the intervention phase, a CFR under 1% (0.65%) used to be performed (Table-4).

Discussion on the findings of study:

One of the key findings from this study is Climate factors like Temperature, Precipitation, Humidity, Wind, Extreme Weather significantly associate with the transmission of dengue. It is found from the information analysis that 40,476 confirmed dengue cases reported in Bangladesh from 2000-2017 and the maximum cases are related to temperature. Different studies had shown that the elevated temperatures and relative humidity are determining factors in estimating changes of the dengue transmission.

High temperatures increase the larval development rate and decrease the emergence of adult mosquitoes, increase the biting rate of mosquito and reduce virus replication within the mosquito. Extreme higher temperatures may decrease the survival time of mosquito that would offset the positive impact on mosquito abundance. Evidence had shown that there is a relation between temperature and dengue incidence rates. Relative humidity is additionally a key factor that effect at different stages of mosquito life cycle. The combined effect of temperature and humidity remarkably affect the range of blood meals and also affect the vector survival rate and the chance that it will become infected and capable to transmit dengue. Literature showed that, relative humidity and temperature are the two most important factors with powerful impact on dengue transmission. Relative humidity has affected by a mixture of precipitation and temperature and affect the mosquito lifespan and thus the capacity for transmission of the virus. This literature had confirmed that annual average relative humidity was the foremost significant climatic predictor of worldwide dengue incident. Contrasting, precipitation failed to appear to play a crucial role because many breeding sites of *Ae. Aegypti* were more dependent to human behaviour than on precipitation for their development and survival.

Therefore, temperature, precipitation and relative humidity are important factors of the geographic limits within which dengue transmission is expected to sustain, mainly by their effects on the Aedes vector. Besides, within areas where minimum on set of those climate parameters is sufficient to maintain dengue transmission, seasonal fluctuations in these parameters are going to be important determinants of the duration and potentially the intensity of transmission. Different studies had shown that the elevated temperatures and relative humidity are determining factors in estimating changes of the dengue transmission. Contrasting, precipitation failed to appear to play a crucial role because many breeding sites of *Ae. Aegypti* were more dependent to human behaviour than on precipitation for their development and survival.

Another finding from this study, seasonal fluctuations is an important determinant in the transmission of dengue. Various surveillance data (fig: 5) shows that maximum cases and deaths occur from June to August which is the monsoon season in Bangladesh. The seasonal variation of dengue cases data (Table-3) from 2000-2017 shows that maximum dengue cases reported during the monsoon (49.73%) and post monsoon (49.22%) season. Furthermore, the seasonality of dengue transmission, periodic epidemics and more irregular intervals of outbreaks are usually observed. The information generated here were accumulated from different literatures, which provide only are strained scope for advanced analysis. It has been shown that 40,476 confirmed dengue cases reported in Bangladesh from 2000- 2017 and the maximum cases are related with temperature. The occurrence of dengue cases in Bangladesh show a noted seasonal variation, while this is often becoming less noted in current years. This study has demonstrated that maximum dengue cases occur within the monsoon and post-monsoon season. Such results of seasonal variation in dengue cases in Dhaka city were reported. The season-specific concentration of dengue cases was fairly indicated in many other similar studies in geographical region and in other countries. Within the pre-monsoon season for the last 14 years (2000–2014), a poor number of cases were reported; however, since 2015, the dengue cases began to be reported from early part of the year and within the last three years (2015–2017), the amount of dengue cases reported within the

pre- monsoon season is seven times higher than those reported within the previous 14 years. Additionally, in the early, a part of 2018, a dengue death occurred within the pre- monsoon season for the first time in Bangladesh and highest number of cases (10,148; although very relevant but not included within the study due to study time frame) were reported within last 18 years (Source: control room, DGHS), which is additionally in support of the study hypothesis. These findings both in terms of dengue morbidity and mortality are the evidence of an epidemiological trend in Bangladesh and surprisingly in 2017, we identified a deadly disease of chikungunya for the very first time in Bangladesh. So, we may assume that climate changes in precipitation, humidity and temperature since 2014 had caused an ecological imbalance within the environment that has resulted in an exceedingly major shift in disease incidence during the pre-monsoon season and facilitated the introduction of transmission of the chikungunya virus within the country. Another finding of our study is this work will help to control the fatality rate. The fatality rate comes down from 1.38% to 0.66% during 1998- 2017 after the intervention operational plan. From the study analysis, it reveals the increase in average and minimum rainfall which significantly correlated with a rise in dengue cases.

At the identical time, key findings of our review paper showed that the increase of average temperature was also linked to the increase of dengue infection. It is also known that temperature increases cause expansion of the area involved and also the number of cases of vector-borne diseases. Similarly, this study showed a highly significant correlation with humidity and also the increase in dengue cases. These conditions facilitate the growth and survival of mosquitoes needed for successful propagation of the virus within the environment. In our findings, the important reservoirs of vectors are almost same as in other Southeast Asian countries. It has shown that, within the pre-preparation phase (1998–2002), most lives lost because of sudden exposure to the dengue virus for the first time in Bangladesh. This was due to lack of proper management of the dengue cases in terms of lack of assessment. In subsequent years, we termed the intervention phase (2003–2017), the government took necessary steps to learn and develop capabilities to stay this emerging dengue situation in restraint successfully. The

aggregation of all these activities decreased the case fatality ratio to below 1%. This very satisfactory result was due to an aggregation of long-term efforts and interventions. It is therefore very difficult to evaluate the impact of any individual intervention. All the deaths reported within the last five years (2013–2017), more than 70% occurred within 24 hours. This is alarming in terms of case management of dengue-related complications, like DHF or DSS, and also the correct implementation of the disease- monitoring system. The results of our study revealed that 65% of the deaths were due to complications, like DSS or DHF. This study could not confirm such a difficulty owing to limited evaluation of information.

The problem in accuracy and efficiency of knowledge could be a clear challenge of this review work. Despite this data limitation, the information generated by the analysis has important implications at the policy level. Our study has some limitations, like we could not provide the specific data of individual district due to poor record keeping system. The model we used also has some limitations. Despite having data limitation, the information generated by the analysis has important implications at the policy level. This study will be helpful for prioritizing and targeting interventions at suitable times for dengue transmission control.

Conclusion:

This review paper summarizes the status of research regarding understanding, modeling and predicting the impact of climate change on Dengue fever (DF) in Bangladesh. Climate factors (e.g. temperature, precipitation, humidity, wind velocity, and air pressure) may affect DF through impacting its three essential bio-ecological aspects: Dengue fever virus, mosquitoes and transmission environment. The effects of climate change on DF are found to be varied spatially and temporally. Weather-based DF model, mosquito model and climate model are essential for the projection of DF considering climate change. Unique challenges exist for the three modeling aspects in Bangladesh. Conversely, human can play a very active role in controlling and preventing DF by spraying pesticides and using mosquito repellant as well as monitoring

systems. In addition, improvement in weather-based DF model, mosquito model and the climate model may help increase the accuracy of DF condition.

We believe this review paper will help in research world by gathering knowledge about dengue fever and its influential parameters, sessional influence in mosquito replication, death fluctuation ratio in every year (1998-2017) due to dengue and chikungunya and overall situation of dengue fever in our country in those mentioned years.

Finally, the study proposes four recommendations for future work on climate and DF in Bangladesh:

- To encourage more advanced research on the relationship between extreme weather events and DF.
- To develop regional-specific models for climate change, mosquito distribution and DF transmission for the high-risk regions in Bangladesh.
- To promote interdisciplinary collaboration between climate studies and health services.
- To enhance public health education and management at national, regional and local levels.

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