Effects of daily weather on *Aedes* genus (*Culicidae:Diptera*)arthropod mosquito vectors profusion abundance anddengue epidemics transmission: A systematic review

Abstract

Dengue is a mosquitovector borne *flavivirus*usuallycaused by DENV1 virus, and a quantity of cases reported with DENV2, DENV3, and DENV4 viruses transmitted by *Aedesaegypti* and *Aedes albopictus*(*Diptera*) day biting female vector mosquitoes, belongs to *Culicidae* family. The symptoms of dengue werefirst clinically confirmed in Japan during 1943, and later, it was recorded simultaneously in the Asia, Africa, and North America during the 1780. The occurrence of dengue outbreaks and it'sextendhave beenreported in the tropical and sub-tropical countries across the globelargely in metropolitan, small towns, and semi-urban settlements.The global incidence of dengue has been increased 30 - 40 % every year, especially, for the past two decades about 45% of the people living in the 142 countries estimated approximately450 million people at risk of infection, and 5,00,000 cases of severe dengue or dengue haemorrhagic fever (DHF)with25,000 deaths annually reported worldwide.It affects mainly below 14 years old children than the adult. The climate variables viz. temperature, relative humidity, saturation deficiency, and rainfall,are fuelled for conducing environment for the vector longevity, survival and also for dengue virus incubations in mosquitoes. Temperature ranges between > 21 and < 34, and relative humidity >70% and <90% has influence on the impact of variations on the vector survival, fecundity, fertility and longevity of female *Aedesaegypti*and flying capacity is reduced with temperature < 10 ^{0}C, and laying egg is reduced with increase of mean temperature >35 ^{0}C. Dengue epidemics clustersare directly correlated withabundance*of Aedes* speciesmosquitoeswhich are controlled by the annual averageprecipitation 300 mm to 1200 mm. The longitudinal dengue epidemics transmissions are mainly associated with monsoon and tend to have seasonal patterns, particularly, during and after the monsoon. Climatic factors are playing important role in the increase or decrease of vector mosquitoes as well as dengue epidemics. Therefore, the present study is addressed on the echelon of daily weather and seasonal change in climate condition and its control on the incidence of dengue outbreaks.

Key words:climate factors,dengue epidemics, *Aedes*speciesmosquitoes, dengue vectors, *Ae.aegyptiAe.albopictus*, *Ae.polynesiensis*, *Ae.scutellaris*, *Ae.pseudosctallaris*, *Ae.niveus*

Comment [u1]: No need to mention the symptoms here

Comment [u2]: It is important to mention /describe about the main factors contributing factors for the vector abundance across different agro-ecology. It is also necessary to indicate the relationship of the vector abundance and occurrence of dengue fever cases globally.

Comment [u3]: Is only apply for female mosquitoes

Comment [u4]: The result section should statistically indicate abundance of the mosquitoes per area or any other stratification

Comment [u5]: Limit the key words to 5-7 words and avoid phrases . stick to the principle of key word selections

Introduction:

Dengue is primarily transmitted by the infective female lvector mosquitoes *Ae.aegypti* and to a smaller extent by *Ae.albopictus* inthe tropical and sub-tropical countries[1], and other *Aedes species* namely *Ae. polynesiensis*, *Ae. scutellaris*, and *Ae. pseudosctallaris* are prime dengue vector mosquitoes in the Pacific Islands and New Guinea.*Aedesniveus*is the major dengue vector in Philippines[2,3]. The outbreaks of dengue occurred frequently in the low and middle income countries, and have effect on heavy economic loss to the affected individuals. Dengue epidemicshaveaccelerated 30-50 times over the past 50 years[4,5]. The extent of geographical distribution of dengue hadcertainly associated with climatic factors[6,7]. Though dengue serotypesof *flavivirus* infection is mainlymild asymptomatic illnesswhile exposed first time, it has been triggered with symptoms included high fever, pain behind the eye balls, severe headache, muscle pains, joint pains, nausea, vomiting, inflated glands, or rash, and painstaking dengue, including severe dengue haemorrhagic fever turned serious mortal or dengue shock syndrome (DHF/DSS)when they gets infection subsequently[5]. At present, no medicine or no vaccine is available to treat the illness. The nature of DENV infection has been continuous processes in the transmission cycle between man to vector to man, wild primates to vector to wild primates or man. DENV incubation takes about 7 to 8 days to develop the virus in the *Aedes*speciesmosquito's body, andsubsequently, transmit it to human body, and takesminimum 3-14 days to appear symptoms.Climate parameters are acted as major determents andtend to have complete control over the dengue virus transmission cycle[5,6,7], vertical transmission and the longitudinal spreads[8,9]. Therefore, the knowledge of geographical distribution of dengue epidemics over the space and time, vector breeding sources, vector survival in association with climate factors, vector density and DENV-1, DENV-2, DENV-3 and DENV-4 cases, virus incubation period[10], and vector survival limits and climate determinants[10,11-14] are essential background for the comprehensive vector control as well as epidemic control, and thus, the currentstudy is made to review the influence of climate change and daily weather determinants control the*Aedes*species mosquito vectors, and dengue epidemicsacross the world.

Comment [u6]: This section discussed poorly on the vectors where it should assess and give highlight

Global Dengue Epidemics:

Dengue is geographically ubiquitous in most of the tropical and sub-tropical countries viz., Africa's, Americas, Eastern Mediterranean regions, South-East Asian countries and most of the Western Pacific nations[5,11-14]. The Latin America nations, South-East Asian countries and

Western Pacific regions are verybadlyaffected with approximately 390 million people every year[7]and South East Asia region alone has the prevalence of reports more than 70 % every year, particularly, after 2006, a major outbreaks were recorded in the world[5]. The spatial extents of dengue epidemic cases are distributed to the new areas of Europe in the recent years[15]. The co-circulation of DENV 1-4 dengue virus are found in almost all the endemic countries[16,], and has estimated >50 % spatially predicated at risk of DENV1-4 virus infection[5,16]. The first epidemic cases of dengue was reported in Afghanistan,[17] during 2019, and many of the developing and low income countries have experienced with increase of dengue epidemic records during the year 2020, namely, Bangladesh, Brazil, Cook Islands, Ecuador, India, Indonesia, Maldives, Malaysia, Mauritania, Mayotte (Fr), Nepal, Philippines, Singapore, Sri Lanka, Sudan, Thailand, Timor-Leste and Yemen, and Vietnam. Dengue epidemics situation was reported in the 142 countriesacross the world[5] and the epidemics had been changed toendemic situation in many of the countries for the past 2 decades, and the people who have been living in the epidemic countries estimated at risk about 450 million.Only 20 % of the incidence of dengue epidemics are being clinically confirmed and recorded[4]. Dengue reported cases are classified in to 2 category: 1) indigenous cases within the country; a person get infection transmitted by the bites of infected female *Aedes*speciesmosquitoes locally, 2) foreign /migrant cases mostly associated with their activities in link with continuous international travel on tour or a person who has involved extensive travel related with NGO activities or research projects across the third world developing and low income countries[5].After 2006, both horizontal and vertical distribution of dengue was triggered 3-4 times.DENV-1 and DENV-2 have persistently been reported in Africa and America, DENV-1 in Europe, DENV 1-4 in Southeast Asia, DENV-2 and DENV-3 in Eastern Mediterranean, and DENV-1 have predominant in the Western Pacific region[5]. The major epidemics were reported from the developing countries, particularly, in India, China, and Brazil[7] during 1990-2015. According to the World Health Organization (WHO) report on dengue and severe dengue fever, the confirmed cases 505,430 and 960death were recorded during 2000, and it was increased to 2.4 million during 2010, and was further increased to 4.2 million cases and4032deaths during 2019, and the trend of dengue was increased to more than 8 fold over the last 2 decades[1-3,5,16].

Comment [u7]: Too long sentence this should be classified based on the ideas discussed

Dengue in India:

India is known for dengue prevalent country and the epidemics are spread over from dense settlement metropolitan to semi-urban, and to rural settlement areas almost all the parts of the country. In the past, dengue were reported from 24 States and 3 Union Territories of India,[18-20], and maximumcaseswere recorded in the 5 major States viz., Tamil Nadu, Kerala, Karnataka, Punjab and West Bengal[18]in 2019. Based on the Geography of India, dengue outbreaks in the rural areas can be classified in to 3major regions, viz., 1). Peninsular States 69%, 2) Plains region of North India 23%, 3) North-Eastern states contribute 7%, including the hilly region 1% of the rural outbreaks in the recent years[21]. Malaria is the first common etiologic outbreaks, and dengue is the second common suspected epidemic disease in India[18]. Dengue confirmed cases were reported in Tamil Nadu 14.65% of the total dengue casesrecorded, and followed by Kerala 12.67%, Karnataka 10.82%, Punjab 9.74%, and West Bengal 6.8% in India[18]during 2017. Dengue virus DENV1 was clinically confirmed in Vellore in the Tamil Nadu State of South India, during 1956. The geographical extent of dengue DENV1 virus epidemics in India during 1963-1964, and subsequently, DENV1-4all the four dengue virus types were recorded. A major epidemics was occurred, during 1967-1968, and then, epidemics were spread over to major cities of India, during 1983, 1985, 1990, 2003, 2004, 2005, and again the major outbreaks was occurred during 2006, 2010, and subsequently, it was increased every years from 2010 onwards. The sporadic cases of dengue DENV1-4 were recorded throughout the year in the Southern States of India and it was occurred from April to November in the Northern States, which are belongs to American African genotypes[19-20].Dengue epidemics in India (1994-2019), the linear trend line has the three times peak outbreaks of the disease outbreaks for the past 25 years, and the mathematical exponential model has predicted the trendof epidemics, and the trend line has accelerated progressively every year with increasing average risk of infection rate 3.75 per 1,00,000 population, and particularly, after the major epidemics was occurred during 2012, and it has been happened to increasing of 6.3 per 1,00,000 population for every subsequent years (Table.1 &Fig.1), shows the alarming and warning to the public health, despite the fact that, the mortality risk rate has been drastically reduced yearly with an average of 1.02 %. The predicted trend of increasing disease epidemics R^2 value 0.68, (68%) by the year 2025, and the longitudinal trend of dengue epidemics pattern in India illustrates that the dengue epidemics has been steadily increased of68% for the period of 2012 – 2019 when compare to the previous epidemics during the period of 1996 – 2011, which might have been produced by the environmental transition including land use / land cover dynamics[11,25], huge population movements from rural to urban and wise versa, poor dengue surveillance and insufficient vector control activities, lack of awareness among the people[61,63], and climate changes[8,20-23]. Based on the temporal aspects of dengue epidemics in India (1994-2019), it can be classified in to 3 periods, viz. 1) manageable situation (1994-2005), 2) difficult situation (2005-2011), and 3)highly challenging situation (2012-2020), and the increasing trend of 84% during the 2012-2020 periods is very critical for the public health personnel.

Comment [u8]: Why in India ?still this paragraph in not well articulated please minimize and structure the approach

Table.1.Dengue Epidemics in India during 1994-2019

Comment [u9]: Why you selected these age ranges

Dengue Epidemics in India (1994-2019)*					
Years	Dengue Cases	Deaths	Dengue Incidence	Mortality Risk	Epidemic Risk
1994	7494	4	7.494	0.05	0.793
1995	7847	10	7.847	0.13	0.814
1996	16517	545	16.517	3.30	1.681
1997	1177	36	1.177	3.06	0.118
1998	717	18	0.717	2.51	0.070
1999	944	17	0.944	1.80	0.091
2000	650	7	0.65	1.08	0.062
2001	3306	53	3.306	1.60	0.308
2002	1926	33	1.926	1.71	0.176
2003	12754	215	12.754	1.69	1.147
2004	4153	45	4.153	1.08	0.368
2005	11985	157	11.985	1.31	1.044
2006	12317	184	12.317	1.49	1.057
2007	5023	62	5.023	1.23	0.425
2008	12561	80	12.561	0.64	1.046
2009	15535	96	15.535	0.62	1.276
2010	28292	110	28.292	0.39	2.292
2011	18860	169	18.86	0.90	1.508
2012	50222	242	50.222	0.48	3.968
2013	75808	195	75.808	0.26	5.919
2014	40571	137	40.571	0.34	3.131
2015	99913	220	99.913	0.22	7.626
2016	129166	245	129.166	0.19	9.752
2017	188401	325	188.401	0.17	14.074
2018	101192	172	101.192	0.17	7.481
2019	136422	132	136.422	0.10	9.984

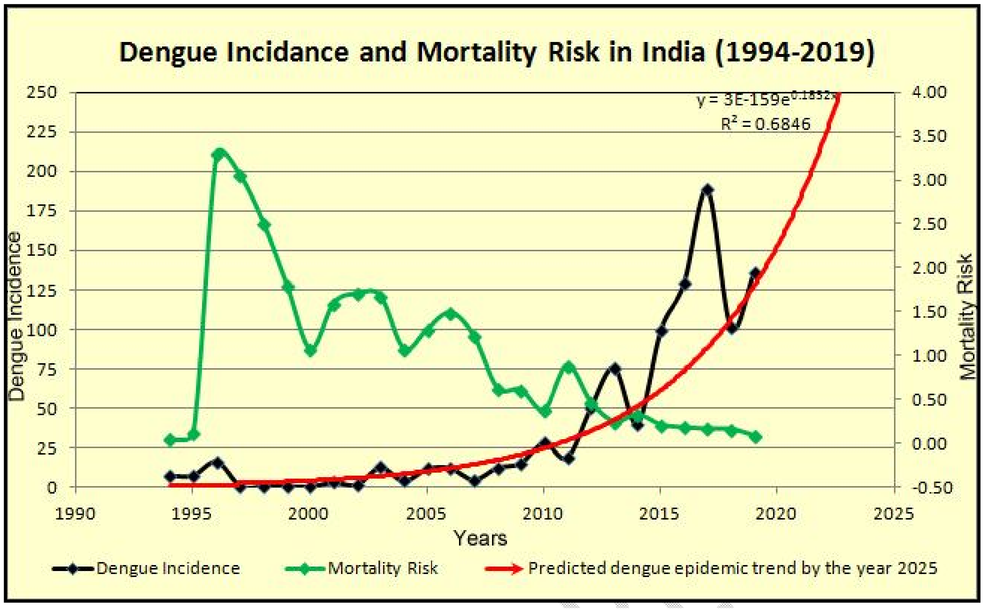

Fig.1. Illustrate the trend of dengue epidemics and mortality risk in India during the period of 1994-2020

Dengue Epidemic Trend:

The reported dengue epidemic cases were spatially heterogeneous and intermittent in the 9 selected tropical and sub-tropical countries, during 1970, and subsequently, it was increased to more than 100 countries[5]. The epidemic situation has been changed to endemic and progression to hyper endemicin the many of tropical and sub-tropical countries[5,8], especially, in the larger urban agglomerations, and now, it isspread to semi-urban and rural areas, and the result leads to accelerating trend across the worldaccount to about 90 million infected cases, and morbidity 25,000 cases each year[5], and WHO is included the DENV1-4 virus in the world's top 10 public health threats. The prevalence of dengue epidemics are multiplied by 3 to 4 times and have major threatens to the public health in the dengue endemic countries in the world[5,] and it has new phase in extent of sporadic spread to the newer areas of many countries in the Europefor the recent years[2,14], and also, the occurrence of dengue has increased 30fold during the past 5 decades in the epidemic countries all over the world[4] with an increase of dengue cases from 2.4 million to over 3 million confirmed cases from the three major affected regions;namely, South-East Asia, Americas, and Western Pacific countries in the world[5], and the estimated 824 million populations in urban and 763 million in rural are at risk of dengue infection in the tropical and sub-tropical countries[2]. In general,male

<34 years old age group about 54.7 %,and 45.3% are females with an average of <30 years age group are affected with dengue worldwide[5].The major outbreaks of dengue serotypes are reported[7] with DENV-1, and followed by DENV-2, DENV-3 and DENV-4during 1990-2015. The environmental and socioeconomic covariates are hypothesized to have an effect on dengue transmission[1, 21-26], and these studies were conducted in many of the countries, and accordingly,geo-spatialmodel has beendeveloped across the globe.A model predicted the risk of dengue epidemics occurrences increased in the spatial extent of 142 counties in China with 168 million people at risk of infection[27] who are living currently in the high risk areas of dengue by 2100s, and the community at risk infection will be stretched high risk areas would increase 4.2-times and 2.9-times than the past period 1981–2016 based on the climate condition[27] for the period of 1981–2016.The risk of epidemic cases are increased every year mainly dogged by the climate variables[21-27], which are changedthe global scenario of dengue epidemics[28-34].The increase of global temperature 2 ^{0}C - 6^{0}C makes major climate changes in global warming by next century[35-37]pilot to the longitudinal extent of sub-tropical boundary linesfuelled to make conducing environment for the abundance of mosquitoes and the extent of disease occurrences[36].

Comment [u10]: Needs major adjustments

Breeding Ecology:

Aedes species female mosquitoes mainly feed on human beings inandaround domestic circumstancesmainly active during daylight hours, and habitually bite during the morning and evening hours, and rest in the indoor domestic living areas of dark corners of the houses, on hanging objects, and furniture[1,5,25]. *Aedes*speciesmosquitoes are breeding in the containers (water storage metal vessels, mud pots, plastic and cement containers, tires, plastic cups, coconut shell, flower vessels, cisterns, bottles, tins, roof gutters, refrigerator drip pans, stone grinder, stone mining holes, rubber latex milk collecting containers, etc.,)[32], and natural breeding habitats[5,11,18,38](tree holes, bamboo stumps, pineapple leaf axis segments, crab holes and small animal burrows, natural hard rockhaving even a small quantity of fresh water storage, etc.,). *Aedes* species mosquito eggs can stay alive up to 1 year without water, and the eggs develop into larvae and then adult mosquitoes when water is available[5]. The profusion of *Aedes* species mosquitoes are determined by the breeding sourcesand climate variables which are creating conducing environment, and are fuelling for sporadic disease epidemics in the urban and semi-urban settlement areas for the recent years. Pineapple is cultivated in the 90 countries with total area of 909.84 thousand hectors in the world, and 89 thousand hectares with total production of 1,415 thousand tons produced in India.It has been abundantly cultivated in India, in particularly, almost entire part of North Eastern states, West Bengal, Kerala, Karnataka, Bihar, Goa and Maharashtra. The natural rubber production in the world during 2019 accounted over 13.6 million metric tons with an increasing rate of 4.6 per cent natural rubber was produced globally, and India alone has contributed to 1,000 thousand hectares during the fiscal year 2019, and 800 thousands hectares of land under natural rubber cultivation in the Kerala State of Southern India is the leading producer of natural rubber in the country.Both natural rubber plantation and Pineapple is growing at temperatures >21^{0}C and < 36^{0}C, which is most suitable climatic factor for profusion of dengue vector mosquitoes around the world[11,39-41]. The flight range of *Aedes species* mosquitoes is < 500 meters (400 meters), and as a result, it can easily fly from one place to another place of human dwelling for blood feeding[5]. Land use / land cover categories viz. built-up-land,crop land, forest cover,wet land, plantations, and water features(dams, reservoir, streams/rivers, lakes, ponds/ water pools)are directly associated with climate conditions[11,39-41,54]and physiographic landforms[55], has perfect match over the mosquitoes profusionharmonize with to high proximity of vector borne disease infection, and dengue too[1-55].

Climate Factors Vs Dengue Epidemics:

The spatial extent of dengue has spread in Europe, Japan, Afghanistan, Korea, Canada, etc., due to the effect of climate change for the recent years. Dengue cases are mostly asymptomatic about 80%, and severe fever 5%, complicated cases 5%, and fatal is insignificant rate, however, it has great economic loss to the individual who are living in the developing and low income countries[1,5]. Dengue vaccination was trailed in the selected countries namely; Philippines and Indonesia, and it has been approved in Mexico, Brazil, Costa Rica, VSingapore, Paraguay, Europe, and the United States[5].However, it needs ethical clearance to huge production for the market launch mass proposition in the most affected countries all over the world. Many climatologists were predicted the increase of temperature 1.16^{0}C, by the year 2050, and the similar study was conducted by the United Nations Intergovernmental Panel on Climate Change (IPCC), during the last century revealed that temperature was raised of approximately 0.5°C, and the same manner, the normal global temperature may be raised[35] to 2.0°C (range, 1.0-3.5°C) by the year 2100,and the consequence, scientists are believed that potential increase of dengue vector mosquitoes and definite increase of longitudinal disease epidemics will be occurred[16,65-70].In India, the epidemics are found throughout the year[18]however, the epidemics are directly influenced by both the South West monsoon and North East monsoon in India[11]. The climate variables are stimulating to creating favourable conditions for profusion of dengue vector mosquitoes *Aedes*speciesmosquitoes[1,11,42-50] (*Ae. aegypti*, *Ae. albopictus*, *Ae. polynesiensis*, *Ae. scutellaris*, *Ae. pseudosctallaris*, and *Ae.niveus*). Linear Discriminant Analysis and Quadratic Discriminant Analysis are statistically significant with *Aedes*species eggs hatching and intensity of rainfall, it is highly induced egg hatching during the beginning and end of the monsoon at a lesser amount of rainfall, and as a consequence, *Aedes* species mosquitoes eggs are hatching from the source of breeding habitats even a small amount of water is available in the breeding in the containers and natural sources[11,34]. Better understanding of the influence of climate on both vector abundance and epidemiological differences in DENV1-4 infection rates, severity of cases across nation as well as global context has important role for the future planning and provide effective guidelines for public health prevention and control measuresfor the sustainable health joint hands with social mobilization, and advocacy for health recovery through all effortsat the gross root level, and forproper treatment extended to the affected nationsacross the globe.

Comment [u11]: Sub title selection, messages under each sub title shows mismatch and needs correction,. As usual long passage which is not suitable for scientific community is observed, pleas make corrections

The increased latitudinal distributions and seasonal fluctuations of *Aedes species* mosquito abundance is influenced by the climate during warmer months and monsoon rainfall[11,51,52]. The geographical extent of horizontal and vertical dengue fever transmission could be influenced by the climate change[52].A geospatial model provided the geographical limits of dengue transmission in association with climate change long-term average vapour pressure for the perspective view of about 100 years, and estimatedpopulation of 5-6 billion i.e. 50-60% of the global population would be at risk of dengue transmission[52]. Due to the monsoon ruinous gives below average rainfall leads to irregular and insufficient water supply for the domestic purpose, and therefore, people have remedy to storing water in the containers, and then, stored water provides potential habitats for the *Aedes* speciesvector mosquitoes' breeding grounds[32].The extrinsic incubation period (EIP) is contradicting in different climatic zones of India, the model provides a result of extrinsic incubation period in Kerala (8-15 days at 30.8^{0}C and 23.4 °C) and it is varied in Punjab, Haryana, Gujarat, Rajasthan, and concluded thatdaily weather condition, particularly, temperature is important in virus incubation period / virus development and it is varied in different climatic regions[53].Due to climate change major or minor level, the geographical distribution of vertical and longitudinal extent of dengue vectors, *Ae.aegypti* and *Ae.albopictus*, is transformed, and dengue viruses DENV1-4 circulation mainly between human to vector to human has beenrestricted by the spatial distribution of vectors profusionconstrained by the changing climatic condition and changing environment.The minor variation in temperature 23°C to 27 °C (mean 25 °C); 28 to 32 °C (mean 30 °C) and 33 to 37 °C (mean 35 °C), and relative humidity 60±8% and 80±6% has influence on the impact of variations on the presents of vector mosquitoes, fecundity, survival,fertility and permanence of female *Aedes aegypti*, laying egg is reduced with increase of mean temperature[54]>35 ^{0}C. The linear relationship between temperature and vector fecundity has directly associated with increaseof 3 ^{0}C temperature,but it has been limited within the range between>23 ^{0}C and < 34 ^{0}C[11,54], and elevation range between 1,700 m to 2,130 m controlled the presents of*Aedes*speciesmosquitoes abundance[55], and was correlated with weather parameters statistically significance[11,54,55]. A comparative study of dengue vector mosquitoes *Ae.aegypti and Ae.albopictus* during the monsoon, vector indices and vector populations was higher than the pre and post monsoon period[56-61], and altitude has spatially correlated with vector abundance with geographic limit of certain elevation range[56], because of the air temperature is decreased by 6.5 ^{0}C for every 1000 meters, and thus, increase of altitude is in a straight line controlled over theair temperature, air pressure, rainfall and relative humidity of climate variables, has direct influence on the abundance of *Aedes* mosquitoes, provided only with particular range of climate.Seasonal micro-climate variations are directly influenced over the mosquito density driven to correlation with both vertical and horizontal transmission of DENV1-4dengue virus infection across the world[66-70]. Meteorological risk factors has significant correlation with vector density Vs blood feeding patterns, and the virus extrinsic incubation period (EIP) has altered with different climatic zones[20], and dengue cases (97%; r= 0.987, p value < 0.001) and has relationship between number of showery days', intensity of rains and epidemics[58].

Comment [u12]: Pleas first category each message in thematic way,.

The prevalence of vertical and longitudinal transmission of dengue epidemics duringthe past, present, and model based future prediction aremost probablydepends on the climatic factors. The geographical distribution of *Aedes*species mosquitoes are found high in the humid tropical rain climate region, and followed by humid sub-tropical climate[1,5,11], and semi-arid climate region[11], and the vector density is insignificance in the Arid / dry desert climate region[11], and absolutely absent in the Polar climate region.The geographical distribution of dengue vectors *Aedes*speciesmosquitoes are depending on the suitability of environmental determinants, which includesthe climate suitability and land use / land-cover categories[11,61-

[63]which are statistically significance to predict the global distribution of *Aedes* species dengue vector mosquitoes[4].Dengue virus DENV1-4 transmission is extremelysubjectiveto the climate suitability[61-63]. Dengue incidences are statistically significant with seasonal variation of climate variables (temperature, relative humidity, and precipitation) and other socio-ecological changes[15]in the humid tropical and humid sub-tropical countries, viz., Thailand, Taiwan, Singapore, and Brazil[48-50.]The effect of climate factors, in particular, the influence of temperature and the amount of rainfall variation on dengue transmission dynamics[48], and vector population anddengue virus infection in mosquitoesare having sensitive to the local micro climate change, and are directly correlated[48-50].The generalized additive models and multinomial logistic analysis could be provided the identification keys to map risk of transmission patterns, and accordingly, to prepare the proper controlling measures to manage and control the epidemic situation[61,63]. The incidence of vector borne disease risky areas, particularly,dengue epidemics in India[11] has substantially predicted with statistical linear model for the mean annual temperature r = 0.638, and < 0.05, relative humidity (RH), r = 0.674, p value <0.05, and has the collective effect of climatic factors r=0.78, and p value <0.001. Several experts and scientists who have publicized reasons for the increase of dengue epidemicsincluding in India might possiblyhave due to a considerable amount of rainfall received in the epidemic regions where it makes conducing environment for mosquito'sprofusionfor the recent years[59, 61].The monsoon season has influence on the abundance of major dengue vector mosquitoes (*Ae. aegypti* and *Ae. albopictus*) in the Western Ghatsrange in Tamil Nadu, Southern India[60],and it has attention in the view of new emergence of dengue cases at higher altitudes in association with micro-climate change at the regional level as well as the changing global warming scenarios[7,60,65].The impact of climate change in the Indian sub-continent region during the past 25 years, create a warm climatic conducing environment for the wide spread of vector borne diseases including dengue, chikungunya, and malaria across the nation needs prevention and intensive health care measures to manage, control, and recovery of major epidemics, and also attention to lessening of climate change and public health will be supported to health recovery strategy[64,68].*Aedes aegypti* (urban dengue and chikungunya vectors), and *Aedes albopictus (rural dengue and chikungunya vectors)*, the both vector mosquitoes are extended their geographical boundary areas constructively with climate pre and post monsoon conditions, number of rainy days, temperature, air-pressure, relative humidity, and hence, climate variables may be acted as a determinants of dengue vector mosquitoes distribution and

density, and facilitate to spread in both vertical and the longitudinal magnitudeof vector borne diseases including dengue in the non-endemic areas where it was absent for the past, and it has new face to spread of dengue serotypes DENV 1-4 transmission. South Korea and Japan have experienced 2 types of climate seasons, 1) summer season,and 2) winter seasons,. During the winter season, these countries has very low temperature which is not supporting for the survival of vector mosquitoes, and which is also prevent the virus transmission, however, both countries are having conducing climate (temperature, humidity, and rainfall) during the summer season as same of climate condition in the South and South-East Asian countries may positively be created suitable grounds for dengue outbreaks in near future[14]. Denguespread in the sub-polar or cold climate regions was not possible in the past, due to the climate condition, is not suited for the *Aedes*species mosquito survival and DENV virus incubation during the winter, but it has changed its weather condition during the summer,as a result, monsoon makes conducing environment for the abundance of dengue vector mosquitoes[66-70], consequently dengue transmission were recorded recent years, particularly, in the non-epidemic areas highly influenced by the climate factors across the world[8,66-70].

Comment [u13]: Needs re-write and adjustment. This should not be presented for scientific community.

Conclusion:

Climate is blamed for the increase of dengue epidemics across the globe, but is it really makes spatial difference? Need for the review of the studies on climate change and dengue epidemics for the past 50 years. Of course, a dramatic global increase of all serotypes DENV 1-4 dengue transmission and geographical distribution of dengue epidemic cases are spatially associated with climate factors, and it has been acted as a key role in the emergence of dengue epidemics extend to the newer areas. During the recent years, due to the climate change and global warming, epidemics of dengue transmission are spatially extended to the many of the newer areas of the non-epidemic countries including Japan, Korea, Taiwan, Europe, etc., and also newer regions at the global level. Even micro level fluctuation in the climate factors has major effect on dengue transmission. Dengue transmission reported cases are increased every year and has accelerated trend mainly because of changing climate conditions,ecological changes, and other socio-economic risk factors, insufficient drinking water supply, land use/ land cover changes, urban agglomerations,population density, Industrialization, environmental transition, tourism attraction, globalization, and population movements. However, dengue epidemics transmission is mainly associated with monsoon season and longitudinally tends to have seasonal patternsduring, beginning, and after the monsoon. Climate factors (temperature, relative humidity, and precipitation) are having influence on reproduction, fecundity, survival, andblood feeding patterns of dengue vector female mosquito populations, as well asthe dengue virus incubation development period, and the change in increase or decreaseof dengue reports promote to changes of dengue transmission of global scenario including the move towards the disease spread in the non-epidemic countries. Better understanding of the impact of climate on dengue endemic situation could be a lead to development of comprehensive vector control in a site specific activity step towards the more proactive and preventive measures for epidemic control for sustainable health.

Comment [u14]: The conclusion also needs correction after going through each section of the paper

References:

1. Samir Bhatt, Peter W. Gething, Oliver J. Brady, Jane P. Messina, Andrew W. *et al.*, The global distribution and burden of dengue, *Nature;* 2013; 496(7446): 504–507

2. Brady, O.J, Peter W Gething, Samir Bhatt, Jane P Messina, John S Brownstein, et al., Refining the global spatial limits of dengue virus transmission by evidence-based consensus. *PLOS Neglected Tropical Diseases*, 2012; 6(8): p. e1760.

3. Yukiko Higa.. Dengue Vectors and their Spatial Distribution, *Tropical Medicine and Health*, 2011; 39 (4): 17-27

4. Kristie L.Ebi, and JoshuaNealon, Dengue in a changing climate, *Environmental Research*, 2016; 151 (11): 115-123

5. Dengue and severe dengue, Global Strategy for dengue prevention and control, (2012–2020), South East Asia, WHO, 2020

6. Nils Benjamin Tjaden Stephanie Margarete Thomas, Dominik Fischer,Carl Beierkuhnlein. Extrinsic Incubation Period of Dengue: Knowledge, Backlog, and Applications of Temperature Dependence. *PLos Neglected Tropical Diseases*, 2013; 7(6): e2207, p5.

7. CongcongGuo, ZixingZhou,ZihaoWen,YumeiLiu,ChengliZeng, *et al.*,Global Epidemiology of Dengue Outbreaks in 1990–2015: A Systematic Review and Meta-Analysis,*Front Cell Infect Microbiol*. 2017; 7: 317. doi: 10.3389/fcimb.2017.00317

8. Hales S, de Wet N, Maindonald J, Woodward A. Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *Lancet*. 2002; 360:830–834.

9. Dom NC, Ahmad AH, Latif ZA, Ismail R. Application of geographical information system-based analytical hierarchy process as a tool for dengue risk assessment. *Asian Pacific Journal of Tropical Disease,* 2016; 6(12):928-935

10. Lambrechts L, Paaijmans KP, Fansiri T, Carrington LB, Kramer LD, et al. (2011) Impact of daily temperature fluctuations on dengue virus transmission by Aedes aegypti . *Proc Nat AcadSci,*. U S A 2011; 108: 7460–7465

11. M.Palaniyandi. The environmental aspects of dengue and chikungunya outbreaks in India: GIS for epidemic control, *Int. J of Mosq. Res.*, 2014; 1(2): 35-40

12. Hopp MJ, and Foley JA. Global-scale relationships between climate and the dengue fever vector, Aedes aegypti. *Climate Change*, 2001; 48: 441–463.

13. Babita Bisht, Roop Kumari, BN Nagpal, Himmat Singh, Sanjeev Kumar Gupta, AK Bansal and NR Tuli. Influence of environmental factors on dengue fever in Delhi. *Int. J of Mosq. Res.*, 2019; 6(2): 11-18

14. Jung-Seok Lee, and Andrew Farlow. The threat of climate change to non-dengue-endemic countries: increasing risk of dengue transmission potential using climate and non-climate datasets,*BMC Public Health*, 2019; volume 19, Article number: 934.

15. Suchithra Naish, Pat Dale, John S Mackenzie, John McBride, Kerrie Mengersen and Shilu Tong. Climate change and dengue: a critical and systematic review of quantitative modelling approaches, *BMC Infectious Diseases*, 2014; 14: Article number: 167

16. A.Patz, Willem J.M. Martens, Dana A. Focks, and Theo H. JettendJonathan. Dengue Fever Epidemic Potential as Projected by General Circulation Models of Global Climate Change, *Environmental Health Perspectives*, 1998; 6(3): 147-153. doi.org/10.1289/ehp.98106147

17. Mohammad NadirSahak. Dengue fever as an emerging disease in Afghanistan: Epidemiology of the first reported cases,*International Journal of Infectious Diseases*, 2019; volume 99**:** 23-2**7.** doi.org/10.1016/j.ijid.2020.07.033

18. National Vector Borne Disease Control Programme, Ministry of Health and Family Welfare, Government of India, New Delhi, 2019

19. Gupta N, Srivastava S, Jain A, Chaturvedi UC. Dengue in India. *Indian J Med Res*, 2012; 136: 373–390

20. SrinivasaRaoMutheneni, Andrew P Morse, Cyril Caminade, and SuryanaryanaMurty Upadhyayula. Dengue burden in India: recent trends and importance of climatic parameters., *Emerging Microbes & Infections*, 2017; 6, e70; doi:10.1038/emi.2017.57

21. PratipShil. Rainfall and dengue occurrences in India during 2010–2016, *Biomedical Research Journal*, 2019; 6 (2): 56-61

22. M Palaniyandi, PH Anand and T Pavendar. Environmental risk factors in relation to occurrence of vector borne disease epidemics: Remote sensing and GIS for rapid assessment, picturesque, and monitoring towards sustainable health, *Int.J of Mosq. Res.*,2017; 4(3): 09-20

23. M.Palaniyandi, T. Sharmila, P.Manivel, P.Thirumalai, and PH.Anand. Mapping the geographical distribution and seasonal variation of dengue and chikungunya vector mosquitoes (*Aedes aegypti and Aedes albopictus*) in the epidemic hotspot regions of India, Journal of Applied Ecology and Environmental Sciences, 2020; 8(6): 428-440 http://pubs.sciepub.com/aees/8/6/15; https://doi.org/10.12691/aees-8-6-15

24. Kolivras KN. Changes in dengue risk potential in Hawaii, USA, due to climate variability and change. *Climate Research*, 2010; 42: 1–11

25. M.Palaniyandi. Socio-economic and environmental determinants of dengue and chikungunya transmission: GIS for surveillance and epidemic control - a systematic review, *Int. J of Scientific Research*, 2019; 8(2): 4-9

26. Thammapalo S, Chongsywiwatwong V, Geater A, Lim A, Choomale K. Socio-demographic and environmental factors associated with Aedes breeding places in Phuket, Thailand. *Southeast Asian Jof Trop. Med. and Pub. Health*, 2005; 36:426-433

27. Jing-ChunFAN, and Qi-YongLIU. Potential impacts of climate change on dengue fever distribution using RCP scenarios in China, *Advances in Climate Change Research*; 2019; 10 (1): 1-8. https://doi.org/10.1016/j.accre.2019.03.006

28. TW Kesetyaningsih, Sri Andarini, Sudarto,and HennyPramoedyo. Determination of environmental factors affecting dengue incidence in Selman district, Yogyakarta, Indonesia, *African J of Infectious Diseases* (AJID). 2018; 12(1 Suppl): 13–25

29. M.Palaniyandi. Remote Sensing and GIS for Mapping the Geographical Distribution and Ecological aspects of vector borne diseases in India, *GIS India*, January 2013; 4-7

30. Babita Bisht, Roop Kumari, BN Nagpal, Himmat Singh, Sanjeev Kumar Gupta, AK Bansal and NR Tuli. Influence of environmental factors on dengue fever in Delhi. *Int. J of Mosq. Res.*, 2019; 6(2): 11-18

31. Sankari T, Hoti SL, Singh TB, Shanmugavel J. Outbreak of dengue virus serotype-2 (DENV-2) of Cambodian origin in Manipur, India - association with meteorological factors. *Indian J Med Res*. 2012; 136: 649–655

32. M.Palaniyandi. GIS based community survey and systematic grid sampling for dengue epidemic surveillance, control, and management: a case study of PondicherryMunicipality, Int. Journal of Mosquito Research, 2014; 1 (4): 72-80

33. DM Watts, DS Burke, BA Harrison, RE Whitmire, A Nisalak, Effect of temperature on the vector efficiency of Aedes aegypti for dengue 2 virus, *Am J Trop Med Hyg*,1987; Jan;36(1):143-52., doi: 10.4269/ajtmh.1987.36.143.

34. Johansson MA, Dominici F, Glass GE. Local and Global Effects of Climate on Dengue Transmission in Puerto Rico. *PLoS Neglect Trop Dis*, 2009; 3: e382.

35. Houghton JT, Meira Filho LG, Callander BA, Harris N, Kattenberg A, Maskell K, (1996). Climate Change, 1995-the Science of Climate Change: Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: *Cambridge University Press*, 1996.

36. Thomas R. Karl, Anthony Arguez ,Boyin Huang, Jay H. Lawrimore, James R. McMahon, Matthew J. Menne Thomas, et al., Possible artifacts of data biases in the recent global surface warming hiatus, *Science*, 2015; 348(6242): 1469-1472

37. National Snow & Ice Data Center. NASA, 2010.

38. Selvan SP, Jebanesan A, Reetha D. Entomofauna diversity of tree hole mosquitoes in Western and Eastern Ghats hill ranges of Tamil Nadu, India.*ActaTropica*, 2016; 159:69-82.

39. Hyojung Lee, Jung Eun Kim, Sunmi Lee, and Chang Hyeong Lee, (2018). Potential effects of climate change on dengue transmission dynamics in Korea, *PLoS One*. 2018; 13(6): e0199205. doi: 10.1371/journal.pone.0199205

40. Lauren B. Carrington, M. Veronica Armijos, Louis Lambrechts, and Thomas W. Scott, Fluctuations at a Low Mean Temperature Accelerate Dengue Virus Transmission by Aedesaegypti, *PLoSNegl Trop Dis*. 2013; 7(4): e2190.doi: 10.1371/journal.pntd.0002190

41. Carrington LB, Seifert SN, Willits NH, Lambrechts L, Scott TW. Large diurnal temperature fluctuations negatively influence Aedes aegypti (Diptera: Culicidae) life history traits. *J Med Entomol*. 2013; 50: 43–51

42. Tun-Lin W, Burkot TR, Kay BH. Effects of temperature and larval diet on development rates and survival of the dengue vector Aedes aegypti in north Queensland Australia. *Med Vet Entomol*, 2000; 14: 31–37.

43. Turell MJ, Lundstrom JO. Effect of environmental temperature on the vector competence of Aedes aegypti and Ae. taeniorhynchus for Ockelbo virus. *Am J Trop Med Hyg*, 1990; 43: 543–550

44. Meyer RP, Hardy JL, Reisen WK. Diel changes in adult mosquito microhabitat temperatures and their relationship to the extrinsic incubation of arboviruses in mosquitoes in Kern County, California. *J Med Entomol*, 1990; 27: 607–614

45. Derrick EH, Bicks VA. The limiting temperature to the transmission of dengue. *Australas Ann Med*, 1958; 7: 102–107

46. Alto BW, Juliano SA. Temperature effects on the dynamics of *Aedesalbopictus* (Diptera: Culicidae) populations in the laboratory. *J Med Entomol*, 2001; 38: 548–556

47. Delatte H, Gimonneau G, Triboire A, Fontenille D. Influence of temperature on immature development, survival, longevity, fecundity, and gonotrophic cycles of Aedes albopictus, vector of chikungunya and dengue in the Indian Ocean. *J Med Entomol*, 2009; 46: 33–41

48. Chen SC, Hsieh MH, 2012.Modeling the transmission dynamics of dengue fever: implications of temperature effects, *Sci Total Environ*. 2012;; 431(8):385-91.

49. Alto BW, Bettinardi D.Temperature and dengue virus infection in mosquitoes: independent effects on the immature and adult stages. *Am J Trop Med Hyg*. 2013; 88(3):497-505

50. Chen SC, Liao CM, Chio CP, Chou HH, et al., Lagged temperature effect with mosquito transmission potential explains dengue variability in southern Taiwan: insights from a statistical analysis. *Sci Total Environ*. 2010; 408(19):4069-4075.

51. Marianne Hopp, and Jonathan A. Foley, (2001).Global-scale relationships between climate and the dengue fever vector, Aedes Aegypti, *Climatic Change* 48(2):441-463

52. Simon Hales, Neil de Wet, John Maindonald, and Alistair Woodward (2002). Potential effect of population and climate changes on global distribution of dengue fever: an empirical model, *The Lancet*, 2002;360(9336):830-834

53. SrinivasaRaoMutheneni, Andrew P Morse, Cyril Caminade, and SuryanaryanaMurty Upadhyayula. Dengue burden in India: Recent trends and importance of climatic parameters, Emerging Microbes and Infections, 2017; 6(8): 1-10

54. EthieneArrudaPedrosa de Almeida Costa , Eloína Maria de Mendonça Santos, *et al.*, , Impact of small variations in temperature and humidity on the reproductive activity and survival of Aedes aegypti (Diptera, Culicidae), *RevistaBrasileira de Entomologia*, 2010; 54(3): 488–493

55. Saul Lozano-Fuentes, Mary H. Hayden, Carlos Welsh-Rodriguez, Carolina Ochoa-Martinez, *et. Al.*, The Dengue Virus Mosquito Vector Aedes aegypti at High Elevation in Mexico, Am. *J. Trop. Med. Hyg.*, 2012; 87(5): 902–909

56. Reshma Tuladhar, Anjana Singh, Megha Raj Banjara, Ishan Gautam, et al., Effect of meteorological factors on the seasonal prevalence of dengue vectors in upland hilly and lowland Terai regions of Nepal, *Parasites & Vectors*, 2019; volume 12, 42:1-15

57. Babita Bisht, Roop Kumari, BN Nagpal, Himmat Singh, et al., Influence of environmental factors on dengue fever in Delhi, *Int. J of Mosq. Res.*, 2019; 6(2):11-18

58. Yi-Horng Lai. The climatic factors affecting dengue fever outbreaks in southern Taiwan: an application of symbolic data analysis, *Biomed Eng Online*. 2018; 17(2): 148. doi: 10.1186/s12938-018-0575-4

Comment [u15]: Please avoid heading in the reference section

59. SanjeetBagcchi. Dengue surveillance poor in India, *The Lancet*, 2015; WORLD REPORT, 386(10000): p.1228. doi.org/10.1016/S0140-6736(15)00315-3

60. R. Ravikumar, A. Daniel Reegan, P. Chandrasekar, and C. Senthil Kumar..Distribution of Dengue Vectors during Pre- and Post-Monsoon Seasons in Higher Attitudes of Nilgiri Hills of Western Ghats, India, *Journal of Insects*, 2013; volume 2013; Article ID 627304, 5 pages | https://doi.org/10.1155/2013/627304

61. M Palaniyandi, P Anand, R Maniyosai, T Mariappan, P Das. The integrated remote sensing and GIS for mapping of potential vector breeding habitats, and the Internet GIS surveillance for epidemic transmission control, and management, *Journal of Entomology and Zoology Studies*, 2016; 4(2): 310-318 7 (12), 14-16

62. Yoon LingCheong, Pedro J.Leitão, and TobiaLakes. Assessment of land use factors associated with dengue cases in Malaysia using Boosted Regression Trees, *Spatial and Spatio-temporal Epidemiology*, 2014; 10 (7): 75-84. doi.org/10.1016/j.sste.2014.05.002

63. M Palaniyandi. Need for GIS based dengue surveillance with Google internet real time mapping for epidemic control in India, *J Geomatics& Geosci*ences, 2014;4(4):132-145

64. Ummar Raheel, Muhammad Faheem, Mohammad NasirRiaz, NaghmanaKanwal, *et al.*,Dengue fever in the Indian Subcontinent: an overview, *J Infect DevCtrie*. 2011; 26; 5(4):239-247. DOI: 10.3855/jidc.1017.

65. R. Krishnan · J. Sanjay · Chellappan Gnanaseelan · Milind Mujumdar, Ashwini Kulkarni,and Supriyo Chakraborty . Assessment of Climate Change over the Indian Region: A Report of the Ministry of Earth Sciences (MoES), Ministry of Earth Sciences, Government of India, 2020

66. Su Hyun Lee, Kwang Woo Nam, Ji Yeon Jeong, Seung Jin Yoo, Young-Sang Koh, *et al.*, (2013). The effects of climate change and globalization on mosquito vectors: evidence from Jeju Island, South Korea on the potential for Asian tiger mosquito (Aedes albopictus) influxes and survival from Vietnam rather than Japan, *PLoS One*, 2013; 24;8(7): e68512. DOI: 10.1371/journal.pone.0068512

67. Walter Leal Filho, SvenjaScheday, JulianeBoenecke, Abhijit Gogoi, AnishMaharaj, SamuelaKorovou. Climate Change, Health and Mosquito-Borne Diseases: Trends and Implications to the Pacific Region, *Int J Environ Res Public Health*, 2019; 16(24): 5114. DOI: 10.3390/ijerph16245114

68. Ludwig A, Zheng H, Vrbova L, Drebot MA, Iranpour M, Lindsay LR. Increased risk of endemic mosquito-borne diseases in Canada due to climate change, *Can Commun Dis Rep*. 2019; 45(4): 91-97. doi: 10.14745/ccdr.v45i04a03.

69. Banu, S., Hu, W., Hurst, C. & Tong, S. Dengue transmission in the Asia-Pacific region: impact of climate change and socio-environmental factors. *Tropical Medicine & International Health*, 2011; 16, 598–607, doi.org/10.1111/j.1365-3156.2011.02734.x

70. Hsieh, Y.H. & Chen, C.W.S. Turning points, reproduction number, and impact of climatological events for multi-wave dengue outbreaks. *Trop. Med. & Int. Health*, 2009; 14: 628–638, https://doi.org/10.1111/j.1365-3156.2009.02277.x.

Comment [u16]: Avoid the heading sections