Workshop Proceeding

Climate Change and Assessment of Dengue geography in India

12th August, 2021

Supported by:

National Mission on Strategic Knowledge for Climate Change (NMSKCC)

under

Department of Science and Technology (DST, Government of India)

सत्यमेव जयते
Department of Science and Technology
Ministry of Science and Technology
Government of India

Prepared by:

15 YEARS
IRADe Integrated Research and Action for Development

Integrated Research and Action for Development (IRADe)

"Prediction of Dengue with Climate Change Over Delhi and Rajkot"

Supported by: National Mission on Strategic Knowledge for Climate Change (NMSKCC),Department of Science and Technology (DST, , Government of India)

Acknowledgment

We thank the Department of Science and Technology (DST), Government of India, for supporting the project under the National Mission on Strategic Knowledge for Climate Change (NMSKCC). We express our sincere thanks to the Delhi government, South Delhi Municipal Corporation (SDMC), and the other stakeholders for their support and cooperation.

Disclaimer

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1. Background

Incidences of Dengue has shown a rapid surge in last decade. In 2017, India witnessed a big increase in dengue cases-1,88,401 cases and 325 deaths, according to the National Vector Borne Disease Control Programme. India saw comparable large number cases in 2018 and 2019. During 2019, the states of Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Gujarat, Maharashtra, Uttar Pradesh, Bihar, Rajasthan, Uttarakhand, Kerala and Delhi saw 1,28,582 dengue cases which is 82 percent of the total cases load. The trend seems to be a major concern for public health. Vector breeding and disease transmission of Dengue have close connection with environment and climate change[1]. Therefore, it is important to understand the degree of association of Dengue with local climatic factors and demographic parameters in order to predict its spread in future and to build a robust warning system as a part of mitigation measures.

Realizing the criticality of Dengue as an important aspect and the threat it poses, it becomes important that available evidence-based knowledge base on Dengue is shared to build an effective policy- research interface for developing comprehensive strategies on Dengue in India. This calls for an immediate and urgent action and a multiple and prolonged responses by the government, civic bodies and medical authorities beyond health sector to undertake mitigation and adaptation measures to resist its escalation.

2. About the Workshop

IRADe has successfully completed its project funded by DST on "Prediction of Dengue with Climate Change over Delhi and Rajkot" under the National Mission on Strategic Knowledge for Climate Change (NMSKCC). This mission has been envisaged to encourage research in the areas of climate change impacts on important socio-economic sectors like agriculture, health, natural ecosystem, bio-diversity, coastal zones, etc. With this view, our project aims to assess health geography of Dengue, assess relationship between climatic parameters on dengue prevalence and propose a dengue management action plan.

The key objectives of this project are as follows:

1. To map the distribution and intensity of Dengue spread in India on a fine spatial scale for the last few years
2. To analyze the variation of climatic parameters including temperature, rainfall, relative humidity over the years in India.
3. To find the co-relation between climatic parameters and socio-economic factors such as demography, slum distribution pattern at municipal/ward levels.

Objectives of the Workshop

To disseminate knowledge on Dengue and possible solutions to the manage dengue in India in context of changing climate in the country.

[1]https://www.nature.com/articles/s41590-020-0648-y

3. Inaugural Session

Prof. Jyoti K Parikh

Executive Director, IRADe

Prof. Jyoti Parikh gave the welcome address citing Dengue as one of the significant challenges for public health. The rising number of Dengue cases in India indicates that concrete actions are required. This Workshop is relevant and timely, which will help disseminate evidence-based knowledge generated through the project on "Prediction of Dengue with Climate Change over Delhi and Rajkot" under the National Mission on Strategic Knowledge for Climate Change (NMSKCC). IRADe team has assessed the health geography of Dengue; examined the relationship between climatic parameters on dengue prevalence, and has developed a dengue management action plan for the cities of Delhi and Rajkot

Ongoing India's Amrit Mahotsav and IRADe's 20-year celebration is coinciding together, and this Workshop is the first event in this series. She expressed her sincere thanks to the Department of Science and Technology (DST), Government of India, for their support and funding of this project. She hoped that the project results would be very helpful in bringing policy changes in the management of Dengue in the country.

Mr. Rohit Magotra

Deputy Director, IRADe

Mr. Magotra shared a brief overview of the project. He mentioned that two cities of Delhi and Rajkot were selected to analyse the spatial and temporal spread of Dengue in these cities, especially at the ward level, making it a unique study. The climate parameters of the average temperatures, monthly temperatures, changes in the pattern of rainfall and humidity were also analysed to understand its linkages with Dengue. The project also examined the socio-economic factors of demography, slum distribution patterns at the municipal/ward levels.

He emphasised that one of the critical outcomes of the project is that a statistical model was developed based on the climate parameters for predicting future dengue outbreaks. A statistical model was developed to forecast dengue outbreaks. However, its development is in its early stage, and further refinements can be done to make it a more predictive modelling framework. Based on the key findings, a Dengue action plan for the project cities is developed. In this process, IRADe received a lot of cooperation and support from various agencies such as South Delhi Municipal Cooperation (SDMC), Rajkot Municipal Corporation (RMC), ICMR-National Institute of Malaria Research (NIMR), and the NCDC.

The project also assessed how the scientific knowledge benefits the society by identifying the targeted areas of vulnerability in cities along with identifying the periodicity of dengue and prediction model and the mitigation action plan that will help develop an integrated surveillance plan.

Shri Somnath Bharti

Member Legislative Assembly, Delhi

In his inaugural address, Shri Bharti highlighted the role of the community in finding climate change solutions to tackle it better. The Delhi government's programme of "10 hafte, 10 baje, 10 minutes" involving communities has played a vital role in bringing down Dengue-related morbidity and mortality. The policy-making has to be based on research and suggest ways to spend the public money judiciously through applying knowledge based on the scientific understanding and scientific method of implementation. He complemented IRADe for carrying out research of Dengue and mentioned that these results would be of immense benefit to society and the government. This Workshop is a suitable medium where the government and the policymakers have come together to discuss and deliberate and come out with good inputs in developing a cost-effective public policy. He expressed his happiness that such an important topic discussed today and its recommendations will help the government further decrease the dengue cases reported in Delhi.

Shri Pradip R Dav

Mayor, Rajkot Municipal Corporation

In his special remarks, Shri Dav highlighted that 2010 and year 2013, 2018, 2019 saw a considerable rise in dengue cases. However, the city of Rajkot is sensitive and aware of Dengue in the city. The Rajkot Municipal Corporation (RMC) is implementing ward wise dengue management plan. The dengue prevention and control are conducted in each ward of the city. The measures include larval killing, fogging, distribution of dengue larva eating fishes, dengue awareness among the residents, stakeholder participation in dengue management. July is celebrated as dengue prevention month, and the RMC is undertaking every possible measure to prevent Dengue. He welcomed suggestions from IRADe in further strengthening the efforts of RMC to control Dengue in Rajkot. He thanked IRADe for support to RMC and organising such a relevant workshop.

Dr. K.K.Sarma

Director, North Eastern Space Applications Centre (NESAC)

In his special remarks, Dr. Sarma emphasised the importance of geospatial technology in preventing and managing vector-borne diseases. He shared that with the support of ICMR- Dibrugarh, an early warning system to predict Japanese Encephalitis was developed. Here, GIS has played an important role in developing an early warning system and creating a statistical model to predict its possible time, probable villages of the outbreak, and outbreak intensity. The NESAC dashboard of African swine fever for Assam using the data reported from the location of fever, resources are allocated accordingly to ensure better disease management. Similarly, the GIS can work wonders to manage Dengue better. He expressed that the workshop deliberations will throw more light on the model that predicts Dengue. The North Eastern Space Application Centre (NESAC) will be more than happy to collaborate on this critical issue.

1. The total number of Dengue cases in India indicates that concrete actions require immediate measures.
2. Study examines the relationship between climatic parameters on dengue prevalence and developed a dengue management action plan.
3. The project's critical outcome includes a statistical model developed based on the climate parameters for predicting future dengue outbreaks.
4. The workshop provided a platform for the government and the policymakers to discuss and deliberate for dengue management plan.

3.1 Workshop Participation

The webinar saw the participation of over 100 participants from a wide range of stakeholders from Urban Local Body, research institutes, academic institutions, experts, practitioners, and the different organisations nationally and internationally such as ISET-International, US, East Delhi Municipal Corporation, Surat Municipal Corporation, Climate Change Research Institute, Rajkot Municipal Corporation, ICMR-National Institute of Cholera and Enteric Diseases, CSTEP, IIT-Kanpur, CSIR-Indian Institute of Chemical Technology (IICT), India Meteorological Department.

4. Session I: Mapping the health Geography of Dengue

Prof. Ajit Tyagi

Senior Advisor, IRADe

Heset the context about Dengue in terms of monitoring and prediction modelling. He stated that technology plays a significant role- Remote Sensing, GIS, Climate Data, and Surveys are essential components that help us monitor, model, and predict Vector-Borne Diseases. Mapping disease and its visual representations provide an overview of the dengue situation in a defined geographic area. It will help investigate the causes of diseases and often help investigate and explain environmental and climatic factors.

Shri Pradip R Dav

Mayor, Rajkot Municipal Corporation

Dr. Dav informed that only 62 cases were reported in Rajkot Municipal Corporation in 2020. The number stands at only 16 cases in 2021 to date. RMC is working to bring down the case number to zero. The suggestions and case studies presented in this webinar will be helpful and further implemented by the RMC.

4.1 Mapping Health Geography of Dengue- Rajkot

Ms. Moumita Shaw

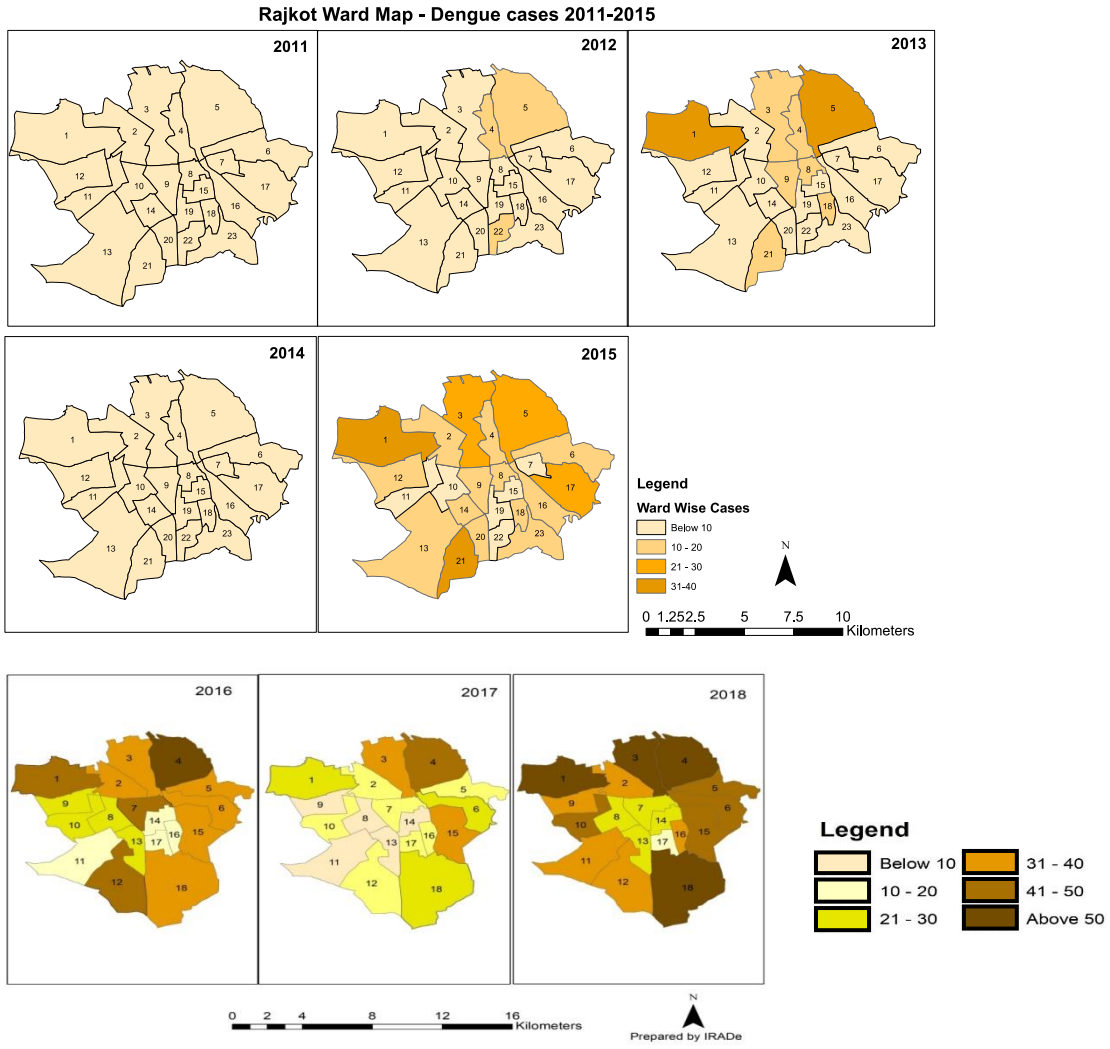
Research Analyst, IRADe

In her presentation on the mapping of the health geography of Dengue in Rajkot, she shared that in 2019, about 136,422 Dengue cases and 132 deaths were reported (NVBDCP, Government of India). The current geographical distribution of Dengue shows its inclination towards the Southern parts of India followed by western and eastern regions, respectively

The state of Gujarat faced major outbreaks in 2013 (6272 cases, 15 deaths), 2015 (5590 cases, nine deaths), 2016 (8028 cases, 14 deaths), and 2019 (19219 cases and 17 deaths) (NVBDCP, Ministry of Health and Family Welfare, , Government of India ,2018).

Rajkot city comprised 23 wards spread across 104.86 sq km till 2015, which has increased in size, engulfing the nearby villages and sub-urban areas to 170 sq km. (urban / metropolitan population is

13.90 lakh). However, the wards are now rearranged to 18 wards. The city's climate is characterized by Hot and Dry in Summer, wet southwest monsoon season, and mild winter with low humidity. An average of 360 cases was reported every year from 2010-2018 in Rajkot. The seasonality of Dengue has been observed between September- November. There has been a consistent rise in dengue incidences in all the wards. Over the years, wards 1, 4, 12 & 18 have recorded the highest dengue cases& 4 wards recorded above 50 incidents in 2018. The zonal dengue incidences from 2010- 2018 indicate East Zone records the highest number of cases.



Map 1: Dengue distribution in Rajkot from 2011-2018

Source: IRADe

The environment and the immediate surrounding add up to the incidence and increase in Dengue cases Accumulation of scraps, like old used tyres, solid waste, air coolers, broken water storage drums, flower pots/ planters, rooftop plastic sheet covers, water supply pits, and so forth are enablers in A. aegypti mosquito growth. Significant occurrences of the Dengue cases were found in wards number 23,21,18,1 &12- the top five wards for 2010-15. For the year 2016 -18, the major wards affected by Dengue were 4,1,18,1&12. It is observed that the wards with a large number of slum pockets have recorded high dengue incidences.

Mitigation and Adaptation Approaches by RMC:

Awareness Measures: Mass media awareness campaigns and Programmes are carried out by the Rajkot Municipal Corporation (RMC). It also observes Dengue Awareness Month in July every year; Sensitizing school teachers and school children and their immediate community. IRADe, along with RMC, disseminated Awareness posters. The prevention and control were based on 4 S methods- Search and Destroy, Self-Protection Measures, Seek Early Consultation, and Say Yes to Fogging.

-Medical Measures: Dengue symptoms usually begin 2-3 days after infected mosquito bite; No specific medication, patients are given a pain reliever and paracetamol/ crocin; bed rest, plenty of fluids intake are recommended. Dengue takes 15-20 days to recover

Public Health/Environment Measures: Measures adopted by the health department of the Municipal Corporation are: Scrap removal drive; Distribution of mosquito nets; Fogging of the areas.

Other RMC Intervention: Larval surveillance and supervision at ward level; Biological control methods Gambusiaaffinis (mosquito fish) distribution (22,845 Households); Sprinkling of Temifose medicine, MLO/BTI Larvicide solution (18,74,242 Households); Pamphlets, hoarding and LED screen displays, socials media communication, workshops.

4.2 Mapping Health Geography of Dengue- Delhi

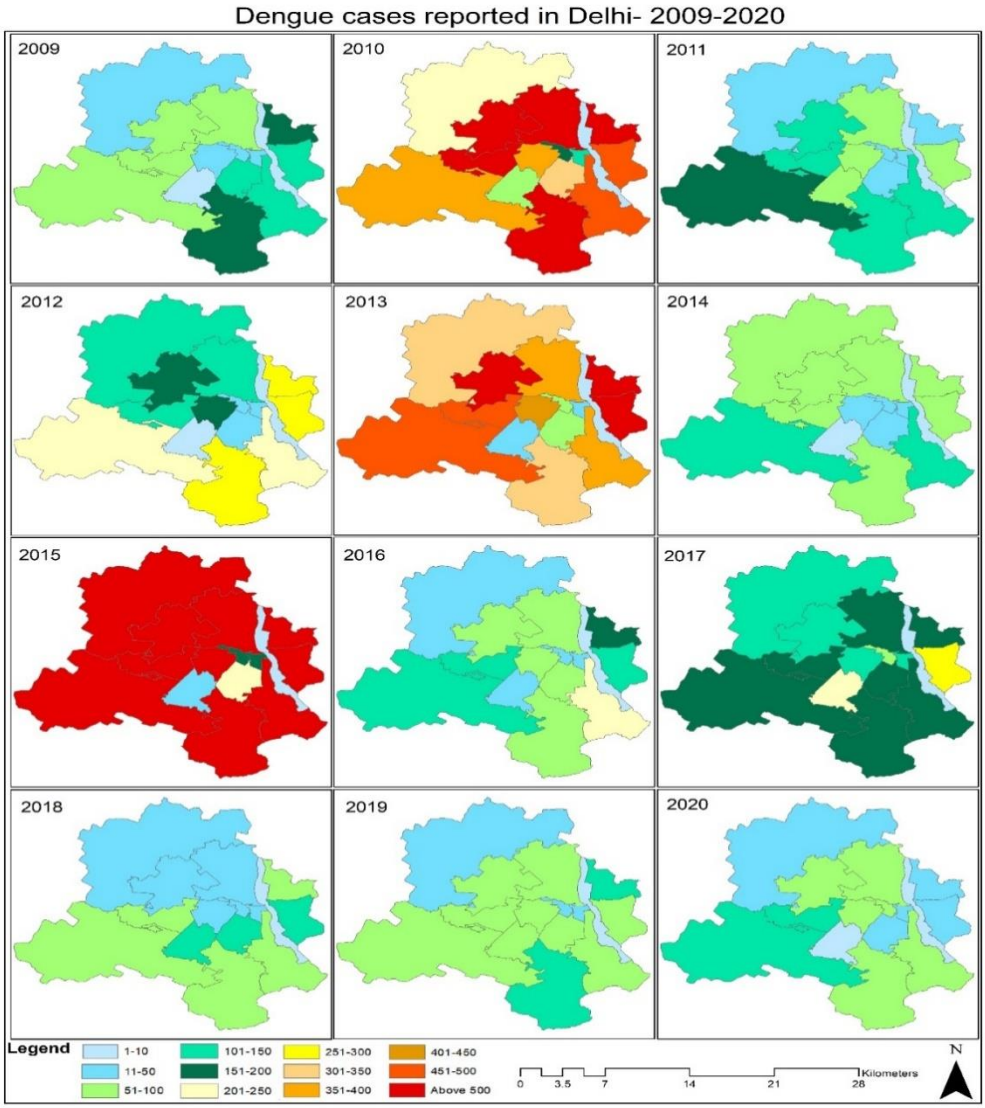
Dr. Nimisha Jha

Senior Research Analyst, IRADe

She made a presentation on the mapping of the health geography of Dengue in Dengue on the spatial and temporal scale. Explaining the epidemiology of Dengue in Delhi is changing over the years and making it more endemic. The cases are rising and spreading faster than before. In the project city of Delhi, IRADe mapped the distribution and the intensity of Dengue spread in the city. Since 1996, Dengue cases have been observed every year in Delhi with rising numbers. Delhi reports about 6.4% Dengue cases to the total National cases. The first outbreak of Dengue in Delhi was in 1967. Since 2009 there has been consistency in the rise of dengue cases in Delhi. However, a significant decline in death is observed due to dengue cases in Delhi, especially since 2018.

Since 2003, almost all the four serotypes of dengue viruses are detected. After that, all four serotypes are found to be present in the epidemic years. However, DENV-3 and DENV-1 were more active from 2000 onwards. The highest dengue cases were reported in August- November, with a peak in October, but the period may stretch till mid-December. Dengue cases are present throughout the year, especially since 2017 there is a year-round presence indicating the sub-perennial presence of Dengue vector in Delhi. The dengue vector is not showing any uniform pattern, with some years reporting very high numbers. In the following year, the numbers have dropped except for the years from 2015-2017 where Delhi saw the highest number of dengue cases. However, a sustained effort at the state level's in spreading awareness about the dengue vector has shown a decline in the preceding years. This, this does not apply to the year 2020, as this was a

pandemic year. With people primarily working indoor, there was a comparatively low reporting of dengue cases in Delhi.



Map 1: Zonal level distribution of Dengue in Delhi 2014-2020

Source: IRADe

She highlighted that the climatic factors have some role in the spread and intensity of Dengue in the city. The dengue characteristics show that there has been a shift in its pattern from being a seasonal disease from July- October months every year to being present in Delhi all year round. At the zonal level, Dengue is present in all parts of Delhi, with Dengue showing a more intense presence in some parts of the city. The years 2010, 2013, and 2015 showed the highest number of dengue cases.

A detailed analysis indicates that a maximum number of cases are reported from ward number 47s(Dwarka), 46s (Rajnagar), and 62 s (Hauz Khas) in all the years from 2017- 2019. These areas are high-density areas with a vast amount of people living in a small geographical area. She highlighted that the Wards reporting no or fewer dengue cases have decreased over the years. Henceforth, it indicates that Dengue vector is spreading into newer areas where it was not present before. South

Zone has reported the maximum number of cases from 2017- 2019. In 2018- 2019, there has been a decline in the number of reported cases for Dengue.

4.3 Burden of Dengue Infections in India

Dr. Santosh Kumar

Scientist, ICMR National Institute of Epidemiology, Chennai.

He highlighted that in 2010, 390 million infections were reported, out of which 294 million were asymptomatic, and over 500000 were hospitalised globally. This year also reported approx. twenty-five thousand deaths in which the majority deaths were of children. According to a 2013 study, 4 billion people are at risk of Dengue globally.

About 34% of the global apparent dengue infections contributed by India (Bhatt, Nature 2013) and primary dengue infections were estimated among individuals aged 5-45 years in 2017. Dengue Surveillance in India is carried out by National Vector Borne Disease Control Programme, Integrated Disease Control Programme, Virus Research, and Diagnostic Laboratory Network. These reports capture the no. of outbreaks every year in the country and which part is most affected

According to a study by Virus Research and Diagnostic Laboratories (VRDL) network from 2014-17, 211, 432 suspected patients were tested for Dengue, out of which 60, 096 (28.4%) had a dengue infection, and 190 dengue clusters were detected. The seasonality of Dengue in India starts in July and peaks in September and October, coinciding with Monsoons in India. VRDL network tested and classified 1372 dengue cases, out of which 65% were primary, and 35% were secondary. The systematic review & meta-analysis of Dengue burden in India showed that the prevalence of laboratory-confirmed dengue infection among clinically suspected patients was 38.3%, seroprevalence in the general population was 56.9%, and case fatality ratio among laboratory-confirmed dengue patients was 2.6%. The recommendations included to generate age-specific estimates of incidence and seroprevalence.

ICMR conducted a serosurvey in 15 states of India and divided the country into five regions (East, North, North-East, West, South) and three age groups (5-8, 9-17, 18-45). From each region, three states were selected, and from each state, four districts with two urban and two rural clusters were selected. The study covered 60 districts covering all geographical regions. The study estimated the seroprevalence of 48.7% at the national level. In all regions, seroprevalence increased with age. Sero Prevalence was highest in Southern, Northern, western regions and was least in North-eastern and Eastern regions. According to a study by CMC, Vellore, a subset of Children was tested for Dengue infection, and 6648 children aged six months to 14 years were tested

ICMR is working towards generating dengue incidence data by initiating community-based cohort studies, developing sites for conducting dengue vaccine trials, and strengthening disease surveillance.

4.4 Expert Remarks

Mr. Olivier Telle

Research Scientist, CSH Delhi

Olivier Telle elaborated that the virus has to be studied in the context of health geography and the biological factor, and other related factors. Understanding the inter-linkages of the urban fabric and the spread of Dengue and other infectious diseases in India is important. This progress must go forward with more innovation and research in the field. Earlier, due to a lack of data, studies were constrained. With ICMR's studies in India across regions and cities, we now have an insight due to access to lots of data to understand how to counter the spread of Dengue in the country. The involvement of municipalities, the right level of counter-attack against Dengue, and knowledge of areas will certainly help combat Dengue.

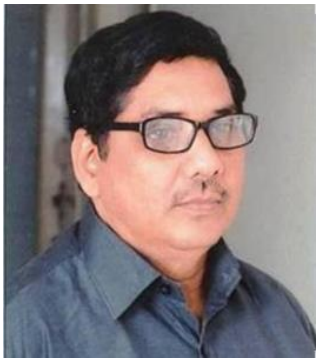
4.5 Highlights:

1. Remote Sensing, GIS along with Climate Data and Surveys are important components which helps us to monitor, model and predict Vector Borne Diseases.
2. The current geographical distribution of Dengue shows its inclination towards the Southern parts of India.
3. The seasonality of Dengue in India starts in the month of July and peaks in September and October, coinciding with Monsoons in India.
4. The environment and the socio economic factors such as water storage(Rajkot) add up to the incidence and increase in the cases.
5. The seasonality of Dengue has been observed between September- November. There has been a consistent rise in dengue incidences in all the wards in Rajkot.
6. It is observed that the wards with a large number of slum pockets have recorded high dengue incidences in Rajkot.
7. The epidemiology of Dengue in Delhi is changing over the years and it is making it more endemic Disease, cases are not only rising, but spreading faster than before.
8. Highest dengue cases were reported during August- November, with a peak in October, but the period may stretch till mid-December.
9. The climatic factors have some role in the spread and intensity of dengue in the cities.
10. The dengue characteristics show that there has been a shift in its pattern from being a seasonal disease from July- October months every year to being present in Delhi all the year-round.
11. At the zonal level, the dengue is present in all parts of Delhi, with dengue showing a more intense presence in some parts of the city.
12. The prevention and control based on 4 S methods- Search and Destroy, Self-Protection Measures, Seek Early Consultation and Say Yes to Fogging.

5. Session II: Assessment of Dengue Linkages with Short Term Climate Parameters

Dr. Ramesh C. Dhiman

Former Scientist G, ICMR- National Institute of Malaria Research (NIMR)



Dr. Dhiman explained that linking Dengue with Climate Variability is a tedious job, as the correlation between variables like rainfall and temperature is difficult to establish. He discussed in length the relation of Dengue and other vector-borne diseases with the increasing rainfall, with the Correlation coefficient between vector-borne diseases and climatic variables. He also discussed the Dengue Transmission dynamics across India. The Extensive Incubation Period (EIP) in Kerala is the lowest (indirect relation with temperature), hence increasing the number of dengue cases in this region. He presented three cities' cases studies – Delhi, Coimbatore, and Haridwar conducted by ICMR to establish the correlation between climatic parameters (Rainfall and Relative humidity, EIP, and dengue cases.

Along with the rainfall, water storage has also trigged dengue incidences across the cities and within city limits. Parameters like Temperature Condition Index (TCI) indicate that a temperature lower than 50^0C triggers dengue outbreaks (in regions across Tamil Nadu); again, conditions of EL Nino also showa higher correlation between positive ONI and dengue incidences across the Indian States. Dr. Dhiman concluded that climate variability differs from area to area; hence, Dengue Early Warning Systems need to be developed locally, along with dengue Thresholds and Breatau Index. There is a need for developing a dengue database system with weekly updates.

Dr. Kalpana Baruah

Additional Director (C), National Vector Borne Disease Control Programme

Dr. Baruah explained the increasing co-relation between dengue incidences and the climatological variances. She introduced the two presentations in the session and remarked that along with Delhi, Rajkot has also become important in terms of dengue incidences. Over the years, Gujarat has shown a perennial nature of transmission in dengue incidences. In the context of climate change, it has become increasingly essential to relate such vector-borne diseases like Dengue with climate parameters. She appreciated IRADe's effort to organize the Workshop when the dengue cases are increasing across the country.

5.1 Climatological Analysis of Delhi and Rajkot

Dr. Mohit Kumar

Research Analyst, IRADe

Dr. Kumar presented and discussed the work carried out by IRADe on Climatological Analysis of Delhi and Rajkot. The mean monthly climate data of last one and half decades for variables such as temperature (both maximum and minimum daily temperature), rainfall, and relative humidity (measured two times during the 24-hour period, one in the morning at 8:30 AM and another in the evening at 5:30 PM)were procured from IMD for both the cities. The data were analysed for four seasons: Summer/Pre-monsoon, monsoon, post-monsoon, &winter, to study the climatological variations across the cities over decadal period. The variations were ascertained by comparing the observed climate data against the long-term climatological mean established by IMD for each city for each month.

The intensive study indicated that Delhi had registered an increasing trend of Tmax (maximum temperature) across all four seasons during 2006-2020. In particular, the iincreasing trend was more sharp in monsoon, post-monsoon, and winter seasons. Across the entire monsoon and post-monsoon season, an increasing trend in Tmax was observed, with three out of the last four years recording the total (of Tmax of all three months) in excess of the climatological mean of Tmax for the entire monsoon season. Individually, except for the months of March, April and May, the rest of the months showed an increasing trend of Tmax in Delhi during the study period. Similarly, an increasing trend was observed in rainfall across all four seasons. In particular, summer, monsoon, and winter seasons showed more increase in rainfall in Delhi during the study period. Individually, January, March, June, July, August, October, and December showed an increasing rainfall trend in Delhi during the study period.

The analysis of climatological parameters for Rajkot indicates that the climate of the city is progressively becoming hotter and drier. Thewarming trend was more pronounced for March and April months, with a significant rise in mean Tmax and Tmin, and a decline in relative humidity.During the study period (2001-2017), the mean Tmax for each of the summer months was observed to be more than the climatological mean for that month in 16 out of 17 studied years. Further, the mean seasonal minimum temperature for summer was found to be excess of the climatological mean of the season for all the 17 studied years.

5.2 Econometric model for prediction of Dengue cases using climate variables

Dr. Probal Ghosh

Assistant Director, IRADe

Dr.Probal Ghosh presented the Econometric model developed by IRADe for the prediction of Dengue cases in Delhi and Rajkot using climate variables such as Rainfall, Relative Humidity, and temperature**.** For Delhi and Rajkot, monthly data from January 2012 to December 2016 on dengue cases and climate variables of average rainfall, maximum relative humidity during 24

hours of the day (measured in the morning at 8:30 AM), minimum relative humidity during 24 hours of the day (measured in the evening at 5:30 AM), maximum daily temperature, and minimum daily temperature are used for the analysis.

For Delhi**,** it was observed that the Dengue cases peaked in the winter months of September to December each year with the decreasing temperature, and the peaks in dengue cases were preceded by peaks in rainfall, with the increasing humidity levels during the monsoon period. The dengue outbreak in 2015 was also caused due to climate variability; low rainfall in September 2015 was preceded by heavy and significantly above normal rainfall in June 2015, followed by months of low rainfall up to September 2015 when the dengue outbreak happened. The study analysed the impact of climate variables like relative humidity in morning and evening, maximum and minimum temperature, and rainfall on Dengue cases in Delhi and Rajkot. It was found that relative humidity and rainfall strongly contributed to dengue incidences in Delhi and Rajkot. The correlation analysis found that no linear correlation existed between dengue cases and climate variables in Delhi. In the case of Rajkot, linear correlation existed only between dengue cases and rainfall. Importantly, the study found that dengue cases were related nonlinearly with relative humidity in the morning and evening. However, the nature of the nonlinear relationship varied between Delhi and Rajkot. In the case of Delhi, Dengue cases are related to the relative humidity in the morning and evening through an exponential relationship i.e., beyond a threshold level of relative humidity, even a small increase in relative humidity leads to an exponential increase in dengue cases. While in the case of Rajkot, Dengue cases are related to the relative humidity in the morning and evening through a logarithmic relationship, i.e., beyond a threshold level of relative humidity, dengue case incidences stabilise even if relative humidity increases. Multiple statistical equations were estimated explaining dengue cases using various combinations of relative humidity in morning and evening, maximum and minimum temperature, and rainfall. Some of the statistical equations were able to adequately forecast peaks of dengue outbreaks in Delhi and Rajkot. The study found that most of the statistical equations were able to predict the month and severity of dengue cases in Delhi and Rajkot both within and outside estimation samples. But the models could not predict as accurately the number of dengue cases during each outbreak. This indicated that climate variables like relative humidity, temperature, and rainfall created conditions for the growth of Dengue but may not be the only determinants of the spread of Dengue in the populations. In conclusion, we can say that there is adequate evidence of climate variables impacting a number of dengue case incidences in Delhi, and Rajkot and dengue cases seem to be strongly correlated with relative humidity and rainfall.

5.3 Expert Remarks:

Dr. L.R Verma

Addl. Medical Health Officer (MHO), South Delhi Municipal Corporation (SDMC)

Dr. Verma congratulated both the presenters on the exhaustive study and the relevant data for analysing the correlation of climate parameters with dengue incidences. Dr. Verma discussed the lag period of dengue incidences, and the rainfall and early rainfall prediction (15 days) obtained from IMD can help set up early warning systems within the cities. Apart from the climatic parameters, human-induced environmental problems also peak dengue

incidences like water stagnation and breeding grounds, which can be dealt with minor engineering/ infrastructure changes. There is a need to focus on the civic amenities (water supply, waste management), poor socio-economic issues to minimise dengue incidences. In South Delhi Municipal Area, almost 90% of the dengue hotspots (slums/squatter settlements & unauthorized colonies) have poor civic amenities.

Dr. Kalpana Baruah

Additional Director (C), National Vector Borne Disease Control Programme

Dr. Baruah emphasised that along with climatological variance, entomological factors/observations can also be considered for predicting dengue incidences.

5.4 Highlights:

1. Dengue Early Warning Systems should be established at a local level, as climate variability differs significantly between cities, and within cities.
2. The co-relation between dengue incidences and the climatological variables is increasing. Along with other Indian cities Gujarat has also shown perennial nature in dengue incidences over the decades.
3. The analysis of the climatological parameters (temperature, rainfall and RH)presents a trend of progressively hotter and drier climate in Rajkot city
4. Relative humidity and rainfall strongly contributed to dengue incidences in Delhi and Rajkot.
5. Climate variables like relative humidity, temperature and rainfall creates conditions for growth of dengue but may not be the only determinants of the spread of dengue in the human populations.
6. Apart from the climate variables, human-induced environmental conditions and the availability of the urban/ civic amenities also play an important role in determining dengue incidences across cities.

6. Session III: Developing Action Plan for Dengue Management

Prof.Ajit Tyagi
Senior Advisor, IRADe

Prof. Tyagi welcoming the panel expressed the importance of the policy and action plans in research. He explained how the actions plans are a bridge between the local authorities and researchers, facilitating implementation.

6.1 Dengue Management Action Plan in Delhi

Mr. Rohit Magotra
Deputy Director, IRADe

Mr. Magotra made a presentation on 'Dengue Management Action Plan in Delhi.' He explained that the translation of research into action had been the top priority and one of the critical objectives of the study. He stated that the various factors, including climatology, geography, and their relation to the varying Dengue cases, focused on developing the action plan to enhance its usefulness to the civic bodies and concerned stakeholders. He thanked SDMC (Delhi) and RMC (Rajkot) for their continuous support and valuable input in designing and developing the Action Plan. He expressed his trust in the deliberation, finalization, and implementation of the city action plans to combat Dengue by the respective city authorities. He appreciated the progressive initiatives by Delhi and Rajkot's city governments, congratulating and expressing his gratitude to the ULBs for their kind support.

Explaining the importance of Action Plans, he highlighted that new geographies are affected by an increase in Dengue cases. A clear relationship between the climate variability and rising Dengue cases pushes for better preparedness. In addition, increasing health risk, weak early warning systems, and socio-economic vulnerability as leading factors in developing an Action Plan for the city. He elaborated on the Action Plan contents such as spatial-temporal distribution, vulnerability assessment, mapping hotspots, and Dengue management in Delhi, including interdepartmental coordination. He described various factors affecting Dengue vulnerability, such as the detailed overview of Climate change, socio-economic factors, behavioural factors (including people's response), awareness, and decision-making capacity of the locals in assessing the vulnerability. He highlighted that mapping of the vulnerabilities includes both the areas and the affected groups.

The areas include temporary shelters, urban flooding sites, high population density, and likewise whereas, and the groups include various occupation types, Urban poor, Children, etc. He stated that the case of Delhi is unique due to the involvement of multiple stakeholders - central, state, and local

governments- and it needs better interdepartmental coordination. Inter-agency coordination is also essential as it is responsible for the effective implementation of action plans. He presented the unique features of the action plan, which covers the vector management approach, provides a pre, during, and post-Dengue Phase, emphasizes intra-inter sectoral collaborations, citizen participation, improved communication, and effective monitoring and control program. He elaborated on the importance of roles and responsibilities of key stakeholders by mapping them from the commissioner to ward level active groups.

Further, he highlighted the significance of awareness and the role of a strong IEC in both the prevention and management of Dengue. He encouraged the need for new modes of communication which is accessible and legible to the people. While concluding, he welcomed the feedback from the concerned stakeholders. He urged to give suggestions on the action plans to facilitate its implementation.

6.2 Experts Remarks:

Dr. Vikas Desai:

Technical Director, Urban Health & Climate Resilience Centre of Excellence, Surat

Dr. Desai appreciating the work, linked it with the Surat experience, and elaborated on the critical action points for the service providers. She emphasized the importance of translating research into an Action Plan and expressed her belief that Dengue is an outcome of various factors to be dealt with by the city's health department. Henceforth, an inter-sectoral convergence is of equal importance. She shared her experience of Surat and stated that real-time coordination to combat the vulnerability is a task as expressed by the ULB. She accentuated that the ULBs need legible knowledge information as they cannot comprehend the changing climatology trends. Citing her experience, she explained that Surat considers the first case of Dengue reporting as an early warning for the onset of Dengue. She suggested specific SOPs for the concerned authorities should be developed to facilitate better dengue management. She also recommended considering available funds, capacity, and existing structure the action points on dengue management should be accommodated. She explained that Surat has a long history of dealing with the changing types of vector-borne diseases and highlighted that Surat's minimum temperature and heat index are strongly correlated with the rising dengue cases in the city.

In context to Rajkot, she highlighted that the city faces a water shortage and is compelled to store water for a prolonged time. The habit of water storage is another factor affecting dengue cases. She expressed the need and sensitization of basic housing designs such as proper ventilation. Concluding, she emphasized the translation of knowledge to the service providers and suggested the need for Standard Operative Procedures to ease Dengue control.

Dr. N.R. Tuli:

DHO, South Delhi Municipal Corporation

Dr. Tuli expressed that inter-departmental coordination is the key to prevent and control of Dengue. He highlighted that disease surveillance is also crucial in controlling it. He pointed out that in Delhi,

the load is shared by both the government and the private sector. He emphasised that the focus should be more on nursing homes and small-scale clinics. He suggested that an inter-sectoral online system can be handy to control and manage the disease spread. It can also help in monitoring and highlighting the vulnerable areas of focus. He stated that the dengue cases are not limited to the seasonal pattern and are observed across the year. Hence, developing surveillance for the non-transmission period is required. He suggested the need for a unified vector surveillance program. It should prioritize the vulnerable areas but not neglect the other regions to avoid sudden outbreaks. In addition to the Domestic breeding checkers, the focus should also be laid on the behaviour change. Concluding, he stressed the need for training of the health workforce to improve sensitization and accountability among the people.

6.3 Highlights:

1. Decadal Spatial-temporal distribution at ward level depicts the spread of the disease into new localities of the cities.
2. Inter-agency coordination is essential as it is responsible for the effective implementation of action plans.
3. Action plan provides the vector management approach, plan for pre, during and post-Dengue Phase.
4. Action Plan elaborates on the importance of roles and responsibilities of Key stakeholders.
5. Early Warning models to be used to incorporate the change as and when observed due to the high adaptability of the vectors.
6. Need for a unified vector surveillance program to manage the spread of dengue.
7. Training of the health workforce to improve sensitization and accountability among the people.

7. Key learning and way forward

1. Dengue can be managed best at the decentralised level of government With the involvement of municipalities, they have the right level of counter-attack against Dengue with the knowledge of areas where most impact is required.
2. There is a need for developing a dengue database system with weekly updates.
3. Along with climatological variance entomological factors/observations, socio-economic factors can also be considered for predicting dengue incidences.
4. There is a need to focus on the civic amenities (water supply, waste management), triggered by the poor socio-economic issues that increase the dengue incidences.
5. The dengue action plan should have a strong monitoring and evaluation component to ensure its transparency and effectiveness.
6. To manage Dengue in the city, the city government should develop Standard Operative Procedures to ease Dengue control.
7. Community involvement and behavioural change programmes can play a very important role in dengue prevention and control.

Annexure

Detailed Agenda

Climate Change and Assessment of Dengue geography in India

Date: 12th August,2021,Time: 11:00 AM-2:00PM

11:00 - 11:35 am	**Inaugural Session**
Details	**Speakers**
Welcome Remarks	**Prof. Jyoti Parikh**, Executive Director, IRADe
Inaugural Presentation – Project Overview	**Mr. Rohit Magotra**, Deputy Director, IRADe
Inaugural Address	**Shri Somnath Bharti**, MLA, Malviya Nagar, Delhi
Special Remarks	**Dr. Pradip R Dav** Hon. Mayor, Rajkot Municipal Corporation, Rajkot
Special Remarks	**Dr. K K Sarma,** Director, North Eastern Space Applications Centre (NESAC)
11:30-12:30pm	**Session I : Mapping Health Geography Of Dengue**
Session Chair	**Prof. Ajit Tyagi**, Senior Advisor, IRADe& Former DG, IMD, GoI
Session Co-Chair	**Dr. Pradip R Dav**, Hon. Mayor, Rajkot Municipal Corporation
Presentations	
"Mapping Health Geography Of Dengue – Rajkot"	**Ms. Moumita Shaw**, Research Analyst, IRADe
"Mapping Health Geography Of Dengue – Delhi"	**Dr. Nimisha Jha**, Senior Research Analyst, IRADe
"Burden of dengue infections in India"	**Dr. Santhosh Kumar**, Scientist, ICMR National Institute of Epidemiology, Chennai
Expert Remarks	**Mr. Olivier Telle**, Research Scientist, CSH Delhi
Q & A	
12:30-1:10pm	**Session II: Assessment of Dengue Linkages with Short Term Climate Parameters**
Session Chair	**Dr. Ramesh C. Dhiman** Former Scientist G, ICMR- National Institute of Malaria Research (NIMR)
Session Co-Chair	**Dr. Kalpana Baruah** Additional Director (C), National Vector Borne Disease Control Programme
Presentations	
"Climatology of Delhi and Rajkot"	**Dr. Mohit Kumar** Research Analyst, IRADe

"Econometric Model for Prediction of Dengue cases using Climatic Variables"	**Dr. Probal Ghosh** Assistant Director, IRADe
Expert Remarks	**Dr. L.R Verma** Addl. Medical Health Officer (MHO), South Delhi Municipal Corporation (SDMC)
	Prof. Ajit Tyagi Senior Advisor, IRADe& Former DG, IMD, GoI
Q & A	
1:10-2.00 pm	**Session III : Developing Action Plan For Dengue Management**
Session Chair	**Prof. Ajit Tyagi** Senior Advisor, IRADe& Former DG, IMD, GoI
Presentations	
"Dengue Action Plan – Delhi"	**Mr. Rohit Magotra** Deputy Director, IRADe
Expert Remarks	**Dr. N.R.Tuli** DHO, South Delhi Municipal Corporation
	Dr. Vikas Desai Technical Director, Urban Health & Climate Resilience Centre of Excellence, Surat
Q & A	
Vote of Thanks	

Participants:

S.No.	Name	Organization
1	Ritu P	Prayas
2	Mr. Subhadip Pal	The Neotia University, Diamond Harbour Campus
3	SampurnaBhunia	Neotia University
4	Saheb Garain	The Neotia University
5	Parul Jain	EDMC
6	Pradeep Khandelwal	EDMC
7	Shashikant Chopde	ISET-International, US
8	Hilal Lone	Student
9	Apurva Verma	IIT Kanpur
10	Shruti Singh	ICAR-IIVR Krishi vigyan Kendra
11	Swastik Bhattacharjya	The Neotia University
12	Shirish Darak	Prayas (Health Group)
13	Jitendra Dutt Sharma	IIT Kanpur
14	Malti Goel	Climate Change Research Institute
15	JaysukhVagadia	Surat Municipal Corporation
16	Jotirmoy Bhandari	The Neotia University
17	Surendra Chawla	Winnerspitch Energy Pvt Ltd
18	Prathayan Choudhury	The Neotia University
19	Jyoti Sharma	IIT Kanpur
20	Provash Chandra Sadhukhan	ICMR- National Institute Of Cholera And Enteric Di
21	Phil Watkins	Green and Affordable
22	Kiran Katoch	IIHMR university, Jaipur
23	Suvadip Mondal	The Neotia University
24	Ppn Raj	AVP
25	Yashi Sharma	IRADe
26	Falguni Debnath	ICMR-National Institute of Cholera & Enteric Diseases
27	Subhadeep Halder	Deptt. of Geophysics, Banaras Hindu University
28	Diwakar Singh	The Neotia University
29	Srinivas M	IICT
30	Sc Bhan	India Meteorological Department
31	Rajan Varshney	NTPC
32	AvirupSaha	The Neotia University
33	SaumyaVaish	Integrated Research and Action for Development
34	Tashina Madappa	CSTEP
35	Edi Shivaji	Maharishi International University
36	Braj Chaudhary	Nepal Electricity Authority
37	MoumitaNayek	The Neotia University
38	Prithviraj Sinha	The Neotia University
39	Sourav Bag	The Neotia University
40	Mojahidul Islam	The Neotia University
41	ShaptarshiMaity	The Neotia University
42	Shamistha Ghosh	IRADe

43	Mahima .	The Energy and Resources Institute (TERI)
44	Sudatta Patra	The Neotia University
45	PrativaPramanik	The Neotia University
46	Indranil Dey	The Neotia University
47	Niharika Pal	The Neotia University
48	Susanta Ghosh	The Neotia University
49	Ajay Shah	Jindal Global University
50	Kaushala P. Mishra	Ex Bhabha Atomic Research Center
51	Puja Dutta	The Neotia University
52	Swayambhu Shankar Chakraborty	Agriculture
53	Alok Perti	NITCON
54	Abhik Jana	The Neotia University
55	Vijay Gadade	North Eastern Space Applications Centre, Umiam, Meghalaya
56	Aritra Mondal	The Neotia University
57	Ankush Pal	The Neotia University
58	Pa Azeez	Freelance
59	Binet Mishra	The Neotia University
60	Abhirup Roy Chowdhury	The Neotia University
61	Naishadh Shah	Rotary Club Of Ahmedabad Metro
62	SusmitaBangal	The Neotia University
63	Aheli Singha	The Neotia University
64	Subhadeep Dutta	The Neotia University
65	Suraj Pal	The Neotia University
66	Aleksander Golas	Tetratech
67	Ishita Chatterjee	School Of Agriculture And Allied Sciences, TheNeotia University, Kolkata
68	ParthaSamanta	The Neotia University
69	AkshayDhariwal	Former Advisor, Nvbdcp
70	Chandra Kant Pathak	The Neotia University
71	Rajkumar Maity	The Neotia University
72	Dr.Shraddha Bhattacharjee	The Neotia University
73	Md Abdus Samad Zia	The Neotia University
74	Nakul Sukai	The Neotia University
75	Kiran Katoch	ICMR
76	Brendon Thomas	USEA
77	Souvik Roy	The Neotia University
78	Bindu Prasad	Psychologist In Private Practice
79	P Azeez	Freelance (Retired As Director, SACON - A Research Organisation In India)
80	Subhasish Mondal	The Neotia University
81	Sayani Pal	The Neotia University
82	Subarna Dey	TNU
83	Rahul Chowdhury	Sister Nivedita University (Techno India Group)

84	Moumita Malik	The Neotia University
85	Ayesha Sultana	The Neotia University
86	Sarah Farheen Khan	International Centre For Climate Change And Development
87	Shanta Bera	School Of Agriculture And Allied Science
88	PurnaBdr Rai	Bhutan Power Corporation Limited
89	SwarnenduBhowmick	The Neotia University
90	Abusamad Khan	The Neotia University
91	PayelPanja	The Neotia University
92	Prabal Ghosh	Student
93	Prithvi Raj	
94	Ahammed Kabeer	
95	Upasana Baskey	
96	Priya Verma	
97	Chandra Mukherjee	
98	Souvik Mondal	

About the Project

The inter-disciplinary research study is being carried out to connect meteorology, statistical climate modelling and geospatial mapping to develop the warning system for Dengue across Delhi & Rajkot cities. To maps the distribution and intensity of Dengue spread across the cities, climate modelling using Rainfall, Relative Humidity and Temperature (Minimum and Maximum daily temperature) data for the last two decades were procured from IMD for Rajkot and the changes in the pattern of these climate parameters has been analysed, the same process in eon carried out for Delhi. Dengue hotspots maps have been developed and a correlation with urbanization and increasing scatter settlements is being established.

About CoE

As a Centre of Excellence, IRADe is furthering the agenda of integrating various urban development efforts and documenting best practices and policy level prescriptions that could be understood and adopted by state and national level decision-makers; local administrations to help them link climate issues with the existing programmes in urban development. The project findings, results, methodology, cities covered and future strategy for India's Urban Climate Resilience has been delivered to various forums like IPCC-SREX, European Union and others. For more details, check **www.climateandcities.org**

About IRADe

IRADe is an independent advanced research institute that aims to conduct research and policy analysis to engage stakeholders such as government, non-governmental organizations, corporations, academic and financial institutions. Energy, Climate Change, Urban Development, Poverty, Gender Equity, Agriculture and Food Security are some of the challenges faced in the 21st century. Therefore, IRADe research covers these, as well as policies that affect them. IRADe's focus is effective action through multidisciplinary and multi-stakeholder research to arrive at implementable solutions for sustainable development and policy research that accounts for the effective governance of techno-economic and socio-cultural issues. For more details, check **www.irade.org.**

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