Climate-Disease Interaction Model

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***Abstract*—Now a days the climate parameter dependent human disease are spreading as there is clear signature of climate change at the regional scale i.e. over all-India. Recent research indicated that the climate over India is changing i.e. Rainfall pattern, temperature pattern etc. shows a drastically change pattern in recent times. As the bacteria and virus main vectors of the disease spread are very sensitive to the changes in weather and climate parameter so there are changes in the distribution of human diseases because of climate pattern change. As a result several health hazards occurs in particular the human diseases are being emerging and the infectious diseases spread across the region at multiple scales both in time and space.**

In this study, we quantify climate changes and its impacts on diseases like malaria over North east India using data mining techniques, dynamical disease model using the climate model forcings etc. Finally a frame work of climate-disease interaction modelling platform is presented.

Keywords—Health; disease burden;Climate change; human health ; India - vector-borne disease ; water-borne disease.

I. INTRODUCTION

In the present time there is increasingly concerned on the global climate change and its impacts on various sectors at regional scale. Their impacts are in some cases to result in damage to our environment, for example increased coastal flooding, severe drought, more extreme rain events, frequent heat waves and cyclones. Weather and climate play a significant role in health of a people. Climate change affect the average weather conditions that we are accustomed to. Warmer temperatures will lead to hotter days and more frequent and longer heat waves. This could increase the number of heat-related illnesses and deaths. Increases in the frequency or severity of extreme weather events such as storms could increase the risk of high winds, dangerous flooding, and other direct threats to people and property. Warmer temperatures could increase the concentrations of unhealthy air and water pollutants. Temperature Changes , precipitation patterns, and extreme events could enhance the spread of some diseases. The impacts of climate change on health will depend on so many factors. These factors consist the effectiveness of a community's public health and safety systems to address or prepare for the risk and the behaviour of a gender, age and economic status of individuals affected. Impacts will likely differ by region, the extent and length of exposure to climate change impacts[1], and society's ability to adapt to change, the sensitivity of population. The following list outlines some of the consequences of climate change that clinicians in India could expect to see over the coming years:

- Increased deaths and illness from more severe heat waves
- Increased death, injury, and post-traumatic stress disorders from increases in cyclones, storms, and floods
- Increased risks of diarrhoeal related disease
- Change in the range, distribution, and incidence of vector-borne diseases (e.g. dengue, chikungunya)

• Adverse health effects of more severe drought and long term drying conditions on rural and remote communities:- Fresh water shortages with consequences for hygiene and sanitation -Mental health (depression and suicide -Exposure to extremes of dust, heat and smoke -Childhood and developmental and emotional experiences.

II. CLIMATE CHANGE AND HEALTH IN INDIA

The effects of climate change on human health in India is a large topic, covering areas from weather events to shifts in vector-borne diseases and water born diseases. In South Asia, scientists predict an increased frequency of floods due to greater intensity of rainfall events and to glacier lake outburst floods (GLOFs) in mountainous regions. These trends are already being seen. In 2007, floods resulting from monsoon rains displaced more than 20 million person and killed more than 2,000 persons and in India, Bangladesh and in Nepal [2].In the Himalaya region of a South Asia, the frequency of GLOFs rose during the second half of the 20th century, and GLOFs have occurred recently in Nepal, India, Pakistan, and Bhutan[3,4]Floods create conducive environments for numerous health consequences resulting from disease transmission. For example, if floodwaters become contaminated with animal waste or human, the rate of faecal-oral disease transmission might increase, allowing diarrhoeal disease and other viral and bacterial illnesses to flourish. Faecal-oral transmission of diseases is of particular concern in regions such as South Asia because of limited access to clean water and sanitation. In developed countries, sanitation infrastructure, flood control efforts, and surveillance activities to detect and control outbreaks minimize disease risks caused from flooding[5]. In developing countries, increase in diarrhoeal disease, dysentery, cholera, and typhoid is of specific concern[6]. For example, after flooding in West Bengal , cholera was thought to be the cause of an outbreak of diarrhoea that resulted in 276 deaths[7]. Numerous studies have linked previous floods in Bangladesh and parts of India with outbreaks of diarrhoea as well as respiratory infections[8-11]. Flooding can also contribute to increased rodent and vector-borne and other infectious diseases. For example, potentially aiding in the spread of malaria because of collections of stagnant water

provide breeding grounds for mosquitoes. Other studies have linked flooding in Bangladesh and parts of India with outbreaks of rota-virus and leptospirosis. Rising sea-surface temperatures are expected to increase in the height of storm surges and tropical cyclone intensity . . Although cyclones originating in the Arabian sea and the Bay of Bengal have decreased in frequency since 1970, these have increased in intensity, causing significant damage in Bangladesh and India. Public health effects of cyclones include diseases and illnesses associated with the loss of clean water, sanitation and hygiene, loss of belongings and Shelton, population displacement, hunger and malnutrition risk due to food scarcity and toxic exposures.

A. Water-borne diseases

A warmer climate could cause water-borne diseases to become more frequent, including diarrhoeal and cholera diseases. Diarrhoeal diseases are already a major cause of mortality and morbidity in South Asia, particularly among children. It is estimated that one-quarter of childhood deaths in South Asia are due to diarrhoeal diseases[12]. As rising ambient temperatures increase proliferation ,bacterial survival time and thus the incidence of diarrhoeal diseases might further increase[13].

Diarrhoeal diseases are largely attributable to unsafe drinking water and lack of basic sanitation; thus, reductions in the availability of freshwater are likely to increase the incidence of such diseases[14]. Rapid industrialization and urbanization , inefficient water use and population growth are already causing water shortages in India.

Cholera is a well-known water-borne diarrhoeal disease that has afflicted humankind since ancient times. Outbreaks of cholera have occurred in Bangladesh, India and more recently Africa and Latin America. Molecular techniques have shown that bacteria are now recognized as naturally occurring in aquatic environments, with bacterial population peaks in spring and fall in association with plankton blooms

B. Malaria

Malaria is one of the most complex and serious public health problems about 400-500 million cases of malaria and more than 1 million malaria-related deaths occur globally every year. Several factors have caused the global resurgance of malaria including the emergence insecticide and drug resistance, human population growth and movement, land-use-change and detoriating public health infrastructure. Changes in temperature, rainfall, humidity, and immunity levels also affect malaria transmission. All these factors can interact to affect adult mosquito densities and the development of the Plasmodium parasite within the mosquito. Currently, all of India's population is at risk for contracting malaria except for those in the areas above 1700 m above sea surface. More than 973 million persons are exposed to vector borne malarial parasites in India, and in 1998 an estimated 577,000 disability adjusted life years (DALYs) were lost due to malaria

c. Other vector-borne and zoonotic diseases

Climate change might affect other diseases endemic to South Asia. These include mosquito-borne diseases such as chikungunya fever and dengue, parasitic diseases such as leishmaniasis, lymphatic filariasis and onchocerciasis, and tick-borne diseases, which may exhibit changes in transmission intensity or shifts in their geographical ranges due to the impact of climate on the relevant vector populations. Climatic factors might also influence human plague, a bacterial disease carried by rodents and transmitted by fleas. Temperature and rainfall are important determinants of rodent population abundance and distribution. Combined with the influence of temperature and humidity on flea survival and development, changes in any of these climatic components may result in changes in plague incidence[15]. Murine typhus, a rickettsial disease, is also transmitted by fleas and thus may exhibit similar climate sensitivity[15].

III. THE DRIVERS OF CHANGE

Environmental change and its attendant health impacts are driven by many factors, including economic growth population growth and movements, urbanization, transportation, and war, to name just a few. The three broad trends -- the intensification of agriculture, industrialization, and rising energy use -- which stand out in terms of their profound impacts on the physical environment and their enormous potential for influencing human health. But all these changes are essential for economic development and improved welfare of our wellbeing. Yet, all lead to pressures on the environment, such as emissions, pollutant and resource depletion, that can increase human exposure to threat in the environment. Intensification of agriculture is essential for producing more food but, when not managed, creates substantial risks, such as contaminating groundwater supplies, exposing workers and creating pesticide-resistant pests and communities to toxic pesticides. Irrigation, land clearing, and dams can bring increases in vector-borne diseases such as schistosomiasis and malaria , both of which exact a huge toll in rural areas of the developing world. Industrialization is the key to economic growth and, like urbanization to which it is closely related, is associated with major profit in health. Yet, along with increasing standards of living -- at least for a majority of the population -- industrialization often means increased exposure to large amount of metals, persistent chemicals such as polychlorinated biphenyls (PCBs), and other toxic chemicals. This is especially true for workers and the poor who often live close to factories. Such exposures are to be increasingly pronounced in the world, where the most rapid industrialization is occurring. Energy demand, which is already huge in the rising countries, is rising fastest in the rising world. Rising energy use is needed to fuel industrial growth but brings many attendant problems. Local air pollution from vehicle emissions and industrial emission has proved difficult to manage even in developed countries. Fossil fuel use also has the potential to alter the climate, with a predicted range of impacts from drought, severe storms, to flooding, to an increase in insect-borne diseases such as malaria, cholera. In the real world, these three trends rarely occur in isolation. Rising energy use, for instance, is part and parcel of industrialization and agriculture. The effects of industrialization are often difficult to disentangle from those of urbanization. Many of the effects of these trends are well

known and predictable (for example, increased air pollution that accompanies rising use of fossil fuels, or exposure to toxic chemicals through improper disposal of industrial wastes). Others, however, are far less certain, though potentially large, such as those associated with global climate change and wide-scale ecological disruption.

A. Environmental risks and the disease burden in India

In India, premature death and illness due to major environmental health risks accounts for nearly 20 percent of the total burden of disease in India —second to malnutrition and larger than all other preventable risk factors and causal disease groups. The premature death and illness accounted in India is the result of diarrhoeal diseases, hepatitis, intestinal nematode infections, tropical cluster diseases and respiratory infections in children and infant under the age of 5. A large part of this burden was the result of the death of infants under the age of 1, while the second largest component consists of the death of children between 1 and 4 years of age 5.Respiratory illnesses related to particulates exposure remain the top health concern, especially among children. The levels of urban air pollution in India are among highest in the world. The causal link between air pollution and respiratory diseases is less well characterized than is the link between waterborne pathogens and diarrhoea . Increasing evidence from studies of the health effects of air pollution indicates that particles of small diameter can lead directly to respiratory infections and indirectly to exacerbated asthma attacks, allergies, and cardiac dysfunction. A variety of sources contribute to this problem: household stoves, vehicle engines, refuse burning, industrial boilers, and power plants, together with a significant level of―background dust‖ from unidentified sources. However, a recent assessment by the WHO relates most of the respective disease burden to exposure to indoor pollution due to the use of ―dirty‖ solid fuels in the household. Women and young children are the primary victims of this exposure.

B. Preventing Disease through Healthy Environment

Health and environmental issues have been included in several high-level initiatives, including the United Nations Millennium Declaration, and regional inter-ministerial conferences on health and the environment. Based on the principles of the Rio Declaration and Agenda 21 as a route to sustainable development in the 21st century, the world's leaders recognized the importance of investing in improvements to people's health and their environment.

Despite the visibility of these issues, the importance of environmental health interventions in preventing disease is not always fully appreciated. Public and preventive health strategies that consider environmental health interventions can be very important. Such interventions are cost-effective and yield benefits that also contribute to the overall well-being of communities. Many environmental health interventions are economically competitive with more conventional curative health-sector interventions. Examples include phasing out leaded gasoline. Mental retardation due to lead exposures in general was estimated to be nearly 30 times higher in regions where leaded gasoline was still being used, as compared with regions where leaded gasoline had been completely phased out.

III. METHODS

A. Background

India is a country with total population of 1.252 billion as at end of 2013. the area of india is 3,287,590 km2. India's geography and geology are climatically pivotal: the Thar Desert in the northwest and the Himalayas in the north work in tandem to effect a culturally and economically break-all monsoonal regime. India is home to an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The India Meteorological Department (IMD) designates four climatological seasons: Winter, summer or pre-monsoon, monsoon or rainy, post-monsoon or autumn.

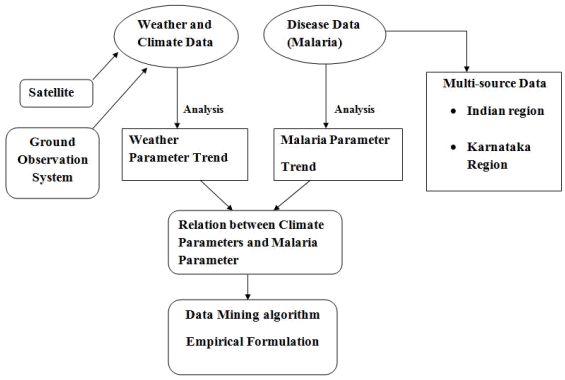

Figure 1: DFD of the data processing for the Data Mining Approach.

Figure 1 shows Architectural Design of Weather and climate studies using Algorithm for extracting the data values. There are three steps are required: First, extract the data values into a text file from multi-format files, Second scan the text file to find out the required values, in third step, Data analysis using the data mining and modelling. The CMMACS MALARIA MODEL Platform used for the malaria simulation.

B. Data collection

The data understanding phase starts with an initial data collection and proceeds with activities in order to get familiar with the data, to identify data quality problems, to discover first insights into the data, or to detect interesting subsets to form hypotheses for hidden information. The data preparation phase covers all activities to construct the final dataset from the initial raw data. Data preparation tasks are likely to be performed multiple times. Weekly notified cases of Diseases were retrieved from Ministry of Health India , the official organization publishing the notifiable disease data .

C. Data Analysis

The statistical relationship between weather data and diseases was assessed by correlation analysis. Having more than one independent variable is useful when predicting the dynamics of Diseases, as weather are all likely to be influenced by some combination of several factors. A set of independent variables can be tested precisely and knowing

which variable is most influencing the transmission of Diseases. n this paper, the relationship between diseases and weather is investigated. Variables such as pressure, air temperature, relative humidity, wind speed, and rainfall might contribute towards the transmission of Diseases. By analysing all the available weather parameters against the Diseases we may be able to identify which of these weather parameters that show significant effect to the transmission of Diseases.

IV RESULTS AND DISCUSSION

The malaria case is being simulated and the data are analysed for the year 2008-2013. The observed analysis of malaria over the north east India are presented below.

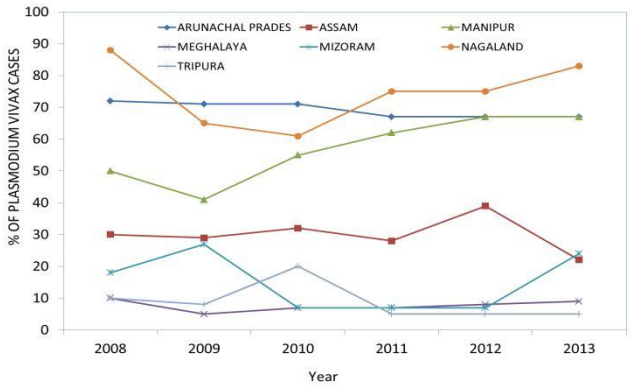

Figure 2: Year to year variation of Plasmodium vivax cases over NE India.

Under the NE region of India cases 1 type of malaria Vivax cases were also found 42-67 per cent from region of Manipur, in the different region of NEI like Assam also found case 1 type for only 23 to 31 % while seeing near other region with subtropical to tropical climate. The lowest population of *P. vivax* cases were found Meghalaya. In the above figure 2 vivax case found over the region of NEI are Arunachal Pradesh and Nagaland were knockout the maximum result about(60 to 80%) and it was also noted that in the region of NEI , Manipur were slightly increases from 2011 and also cross nearly with other region of the state. In NEI the fast developing state Assam has low percent of cases and which is almost half i.e. (30%) and the state of Tripura and Meghalaya were lesser while compare to other region of NER of India which indicate approximate of 10%.

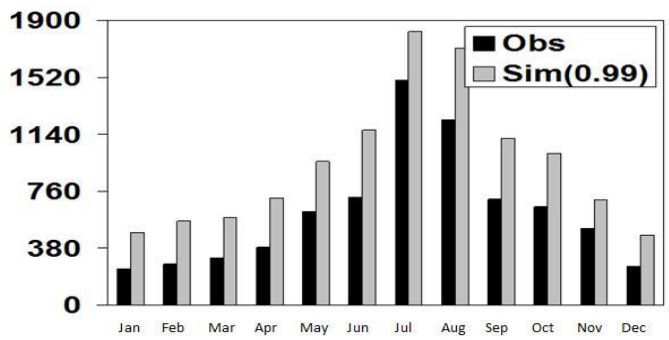

Figure 3 : Monthly climatology (2006-2010) of observed (NBSP) and simulated (NM) epidemiology over Assam is being calculated using only daily temperature

In the above Figure 3 is Monthly climatology (2006-2010) of observed (N_{BSP}) and simulated (N_M) epidemiology over Assam is being calculated using only daily temperature. The meteorological parameter (temperature) for each district has been adopted for the corresponding year from NCEP daily reanalysis data. The number in the bracket represents the correlation coefficient between observed and simulated epidemiology.

V CONCLUSIONS

In this paper, we found that there are significant relationships between air temperature, pressure and wind speed with diseases. Hence, we can conclude that weather can influence the dynamics of diseases. These result might be considered in the prediction of future patterns of Disease transmission. The prediction outbreaks will provide public health officials with the relevant information to plan and to implement their intervention programmes to reduce the disease burden in the years. Although this is not expected to prevent the outbreaks entirely, effective public health measures put into place early enough can limit the spread, reduce mortality and reduce the burden on the community and the health system.

REFERENCES

[1] Washington, DC: The National Academics Press; 2003.National Research Council. *Microbial threats of health: Emergence, detection and response*.
[2] Available from: http://www.unicef.org/media/media40495. html, accessed on October 18, 2013.
[3] Bajracharya SR, Mool PK, Shrestha BR. The impact of global warming on the glaciers of the Himalaya. International symposium on Geo-disasters, infrastructure management and protection of world heritage sites, November25-26, 2006; Nepal Engineering College, Ehime College and National Society for Earthquake Technology Nepal, p. 231-42.
[4] WHO/SEARO. Protecting human health from climate change, Report of the Technical Discussions. New Delhi: WHO/ SEARO; 2009.
[5] Hales S, Edwards SJ, Kovats RS. Impacts on health of climate extremes. In: McMichael AJ, Campbell-Lendrum DH, Corvalan CF, Ebi KL, Githeko A,Scheraga JD, Woodward A, editors. Climate change and human he Risks and responses. Geneva, Switzerland: World Health Organization; 2003. 79-102.
[6] Morgan O, Ahern M, Cairncross S. Revisiting the Tsunami: Health consequences of flooding. PLoS Med 2005; 2 : 491-3.
[7] Sur D, Dutta P, Nair G, Bhattacharya S. Severe cholera outbreak following floods in a northern district of West Bengal. Indian J Med Res 2000; 112 : 178-82.
[8] Siddique AK, Baqui AH, Eusof A, Zaman K. 1988 floods in Bangladesh: pattern of illness and causes of death. J Diarrhoeal Dis Res 1991; 9 : 310-4.
[9] Kunii O, Nakamura S, Abdur R, Wakai S. The impact on health and Risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. Public Health 2002; 116 : 6874.
[10] Mondal NC, Biswas R, Manna A. Risk factors of diarrhea among flood victims: a controlled epidemiological study. Indian J Public Health 2001; 45 122-7.