Socio-economic Implications of Climate Change: A Study on Vector Borne Diseases (Malaria) at Micro Level

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Abstract

Climate change has become a major global concern in the recent years mainly because of accumulating greenhouse gases, particularly CO_2 in the atmosphere. The increased pressure of CO_2 in the atmosphere has led to an alarming increase in the global temperatures. Infact records over the last 100 years show an increasing trend in surface temperature by 0.6^0 C resulting in extreme fluctuations in the spatial patterns of rainfall, local weather patterns and besides causing floods, droughts, cyclones. Further, there has been a growing concern about the changing pattern of diseases over the years throughout India in view of the climate change effects. Malaria is a vector borne disease and indicative of climate change. Studies conducted by the Ministry of Environment and Forest (MoEF) in India with respect to climate change issues address the incidence of malaria in detail. The main focus of this paper is to understand the likely influence of climate change on vector production and the transmission of malaria at the micro level in Raichur district, Karnataka, India. The study area, K. Irebgera (village) belongs to the semi arid zone of Northern Karnataka. We have analyzed a vast body of secondary data with regards to temperature, rainfall, relative humidity and malaria available for over 2 decades. Monthly data collected from Primary Health Centres, District Health Office and Meteorology Department has been used. Primary information was collected through conducting interview with officials and focused group discussions at Irebgera village, in addition to interactions with entomologists and malarial specialist and regional doctors. We have found that a 0.48^0 C rise in temperatures, result in variations of rainfall and relative humidity. A rapid malarial spread (about 28 per cent) has

been reported for the year 2007, due to variations in the climatic factors. Among malarial spread 13.25 per cent are affected by P. *falciparum* (P f).

Key Words: Climate Change, Vector borne diseases, P. *falciparum*, P. *vivax*

Introduction

Malaria continues to remain among the top three infectious organisms (Malaria, TB and HIV) affecting billions of people globally (Nirbhay, K., 2007). As a result, there has been a growing concern about the changing pattern of some of the diseases over the years, across India, directly influenced by variable climate. Malaria, a vector-borne disease, falls under this category (Sumana, B., et al., 2006) and it is the main indicator of climate change related diseases. Malaria occurs once in five or seven years as a natural phenomenon. Flooding can lead to the spread of infectious diseases and flood waters can become contaminated with substances including chemical waste, pesticides or inadequately treated human or animal sewage. Flooding also can affect the delivery of health services besides holding serious implications for mental health, including increased anxiety and depression.

Recently a study was conducted in India by Malaria Research Centre on the "Impact of climate change on malaria in India" under the National Communication Project of MoEF for studying vulnerability, assessment and adaptation measures in various sectors in view of climatic changes. Taking into account the present malaria situation in different parts of the country presenty the study envisages to identify: (i) areas vulnerable to climate change in India; and (ii) the future scenario of malaria with respect to global warming in 2050 and 2100, wherein a projection of rise in temperature and precipitation to the tune of 1.4 to 5.8^0C and 7% respectively has been made by Inter-Governmental Panel on Climate Change (IPCC,

2001., Jonathan, A. P., et all. 2005). There are four species of Plasmodium parasites that cause malaria in human beings, particularly *P. falciparum* induced malaria results in an estimated 1 million deaths per year, 90% of which in Africa alone, mostly children under the age of five (Nirbhay, K., 2007). Based on a detailed analysis of the relationship between malaria, meteorological parameters and socioeconomic conditions in few selected sites in Karnataka and Rajasthan, proactive adaptation measures would be suggested.

Identification of the Study Area and Objectives

The present study area K. Irebgera village is located under the Mosarkal Primary Health Centre (PHC) in Devadurga Taluk of Raichur District, Karnataka state, India (fig. 1). The selected village has 350 households with an average family size of 5.2 persons.(as of characterized 2007). It is surrounded by rain fed agricultural fields and a water body (tank), being used for various domestic purposes. Irebgera Village is 2 km off from the main road and 15 km from taluk head quarters, Deodurg. The present study concerns the occurrence of Malaria in the year 2007. Of a total of , 443 (28 percent) cases under vector borne disease malaria, 208 (13.12 percent) cases fall under *P. falciparum.*

The main objectives of this paper include 1) understanding the likely influence of climate change on vector production; 2) Malaria transmission and its impacts on human health, livelihoods and the local economy.

Fig.1: Study area

Methodology

The study follows standard methodologies for analyzing secondary variables such as temperature, rainfall and relative humdity. We visited the Primary Health Centre and discussed with doctors and laboratory officials about various issues related to malarial incidence in K Irebgera village. We collected secondary data from the Primary Health Centre, District Health Office (DHO) and India Meteorology Department (IMD) at Raichur. Primary information was collected through structured testimonials from selected households in the village and focused group discussions with senior village people and malaria affected people. Our personal observations of the village, malaria incidence and variations in climatic factors were documented besides cross checking the reports of blood samplings, frequency of sampling and malaria infection (spread). We also concurrently focused on studying the unhygienic conditions in and around the village. The annual minimum and maximum temperatures are correlated over the period 1994-2007. The average temperature increase has been estimated (Formula 1), and annual variations analyzed in graphical mode.

Formula 1. $AT_{rise}=A_{max.}T-T_{cur.yr}$

Where, AT_{rise} = Avereage Temperature rise

$A_{max.}T$ = Avereage Maximum Temperature

$T_{cur.yr}$ = Temperature current year

Rainfall variations have been measured on the basis of month wise actual rainfall recorded at a particular rain gauze station coming under K Irebgera village. The standard rainfall fluctuations (once in 12 years) have been considered. Relative Humidity (RH) has been recorded on mothwise basis and variations observed with an increase and decrease in maximum and minimum temperatures across months and years. At the same time we have compared the variations with respect to temperature and rainfall as well. Malarial incidence have been taken from the primary health centre with respect to the cases of malarial positive, postive of P. *falciparum* and P. v*ivax* after the laboratory tests conducted by the malarial specialist.

Household interviews were conducted for understanding the direct and indirect impacts of malaria on their livelihoods and health (as compared to international standards). We have also estimated the cost incurred per person per time for treating malaria cases (Formula 2). *Formula 2. Ci=Dc+Ic+Ge.* Focused group discussions were also held with malaria affected and not affected people.

Where, Ci=Cost incurred for curing malaria attack per time

Dc= Direct cost (includes hospital and transportation charges)

Ic= Indirect cost (includes income, wages, absence of work etc..)

Ge= Government expenditure (includes fumigation, laboratory, manpower etc.)

Results and Discussions

Rainfall

The amount of rainfall may be secondary when malaria is considered but the number of rainy days or degree of wetness that exists after a rain is considerable (Sumana, B. 2006). Rainfall also influences mosquito habitats and its size. An analysis of actual monthly rainfall over the period 1994 to 2007 shows variations (Table 1). But the rainfall in the year 2007 (between April and June) shows a drastic increase of 38 per cent as compared to the previous year 2006 (194.2 mm). There are fluctuations during rainy days also (Table 1). The coefficients between the rainfall and malarial incidence for the year 2007 bear a direct relation. The rainfall in the month of April creates a conducive environment for the growth of green cover and hence retains an optimum humidity which is required for mosquito breeding.

Table 1: Monthly wise rainfall in mm over the years

Months/year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
April	1.6	4.2	20.2	6	2	0	0	41.4	4.2	3	28.2	55.2	9	68
May	35.8	35.8	14.8	21.8	19.4	118.4	2	30.2	11.4	0	161.4	28.8	52.4	122
June	13.4	261.8	310.7	113.4	137.5	77.4	125.8	19.4	62.6	61	72.8	29.6	132.8	323.4
Total	50.8	301.8	345.7	141.2	158.9	195.8	127.8	91	78.2	64	262.4	113.6	194.2	513.4

Source: India Meteorology Department, Raichur

Rainfall will influences both temperature and humidity and provides favorable conditions for vectors growth and their breading (IPCC., Sumana, B., 2006). The study area is found to have affected by malaria in the same period. Further, increased temperature (0.48^0 C) has had an impact on climate resulting in increased rainfall in the corresponding year 2007.

Rainfall fluctuations occur due to seasonal or monsoon variations, but an increased rainfall from 501 mm to 928.9 mm in the year 2007 (Fig. 2) confirms that there is a climate change.

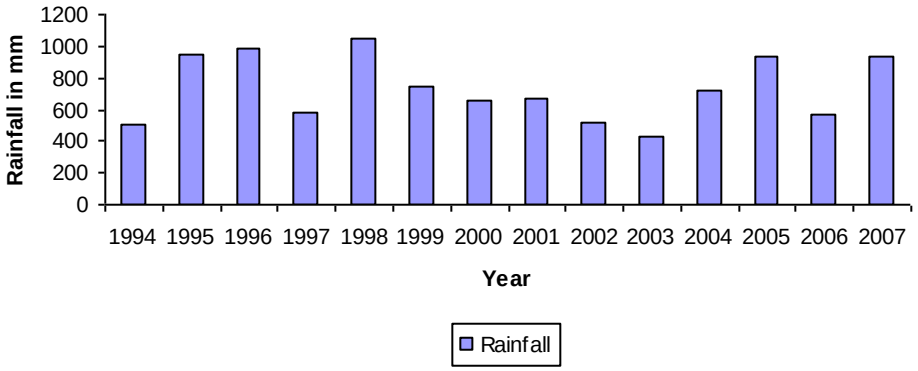

Fig.2: Annual actual Rainfall in mm from over a period

Temperature

Anopheles mosquito requires an optimal temperature between 20^0 C - 30^0 C for its growth. However, the transmission of *P. vivax (P v)* requires a minimum temperature of 15^0 C and *P. falciparum* (PF) requires 19^0 C. There are about 20 types of mosquitoes which spread malaria with Pf being one of them (as per doctor opine). Malaria is a disease caused by four species of parasites of genus *Plasmodium, P. falciparum, P. vivax, P. ovale* and *P. malariae*. Malaria is one of the major causes of mortality and morbidity worldwide, affecting nearly 40% of the world's population and accounting for about 3–5 million deaths and more than 500 million new cases annually (Chauhan, V. S., 2007). The transmission window in terms of the temperature range should extend over a period of time for completion of the progeny.. Continuation of Malaria is also dependent on time, i.e. wet or dry season (Sumana, B., et. al., 2006).

The temperature (minimum and maximum) has been analyzed over the years 1994-2008 and estimated a 0.48^0 C rise in the average maximum temperature for the year 2008 (0.6^0 C at the Global level in 2008). The average minimum and maximum temperature in the

study area ranges from 21.5^0 C to 34.5^0 C which is most suitable for vector growth and easy spread of malaria. It provides a conducive environment for both P. *vivax* and P. *falciparum* mosquitoes for their breading. The studies conducted by the United Nations Foundations observe that a little increase in temperature means that up to 181 million more people will be at risk. Malaria incidents recorded (28 per cent) for the year 2007 seem extremely produced especially during the month of April - June. Temperature during this period is seen ranging from a min. of 18 – 24.3^0 C to a max. of 33.7-36.3^0 C (Fig.3). It is superior for both P. *vivax* and P. f*alciferan* and it was directly and indirectly influenced the malarial growth in the village.

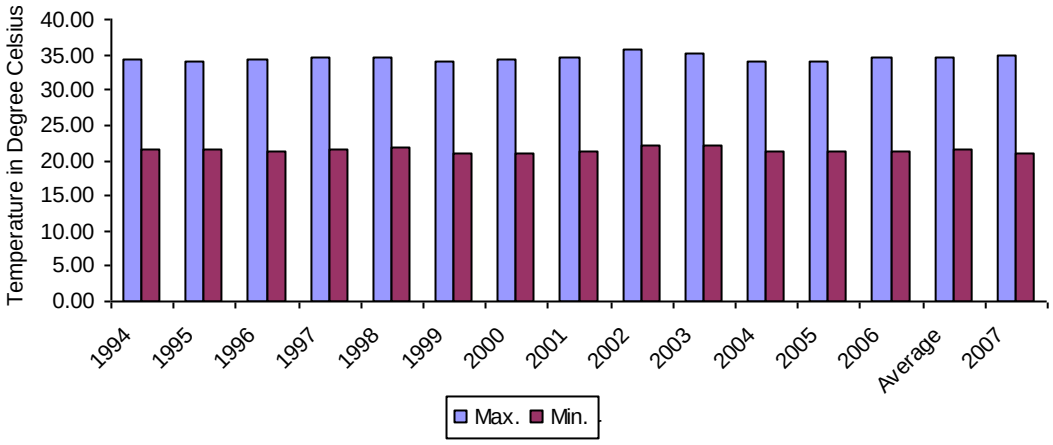

Fig.3: Annual temperature (Max and Min.) in Degree Celsius from 1994 to 2007

Relative Humidity (RH)

The RH estimation carried out over the years 1994-2007 shows that average RH varies from 42-78 per cent, where as the analysis considered for the months April to June, 2007 supports a conducive RH (40-75 per cent) for mosquito growth (Table 2). Mosquitos, especially P. *vivax* and P. *falciparum* survive under an average RH of 55 to 70 percent. If the

average relative humidity is either below 55 per cent or above 80 per cent, mosquito life span gets shortened, diminishing the scope for malaria transmission (Sumana, B., et. al., 2006).

The study area is observed to have recorded highest number of malaria cases during the months of April to June in the year 2007 (Fig. 4) with RH also simultaneously varying between 55 and 70 percent.(Table 2). This relationship shows that malarial incidence is directly proportional to RH and also that sudden rainfall influences both humidity and temperature, creating favorable weather condition for mosquito breeding.

Table 2: Relative Humidity (Max. & Min.) in percentage over the years

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
RH Max.(Av.)	74	79	76	84	77	74	75	76	75	71	74	76	77	78
RH Min.(Av.)	40	44	41	40	42	40	39	40	39	37	38	41	38	41

Source: India Meteorology Department, Raichur

Note: RH Max Av.= Average Relative Humidity Maximum

RH Min Av.= Average Relative Humidity Minimum

Malaria Incidence over Time

Malaria Incidences over the years have been recorded by the District Health Office (Malaria Division), Raichure, and the Primary Health Centre Mosarkal of Devadurga Taluk. Records show enormous malaria incidences for the year 2007 (28 per cent) especially during the months of April to June. Because, temperature and RH during this period supports vector growth. P.*falciparum* is one of the major observed to have seriously affected people's health. (13 per cent) (Table 3).

Table 3: Malaria Postive in the K. Erabgera village

Year	Population	Blood Smeared Examination		Positive		P f	
		Numbers	Percentage to Total population	Number	Percentage to Total population	Numbers	Percentage to Total population
2001	1418	322	22.71	7	0.49	3	0.21
2002	1443	301	20.86	3	0.21	0	0.00
2003	1482	328	22.13	23	1.55	10	0.67
2004	1482	277	18.69	22	1.48	8	0.54
2005	1515	575	37.95	7	0.46	4	0.26
2006	1548	1037	66.99	101	6.52	61	3.94
2007	1585	3501	220.88	443	27.95	208	13.12

Source: District Health Office, Raichur and Mosarkal PHC

Note:1) P f = P falciparum and

2) Positve denotes affected by both P vivax (Pv) and P falciparum (Pf)

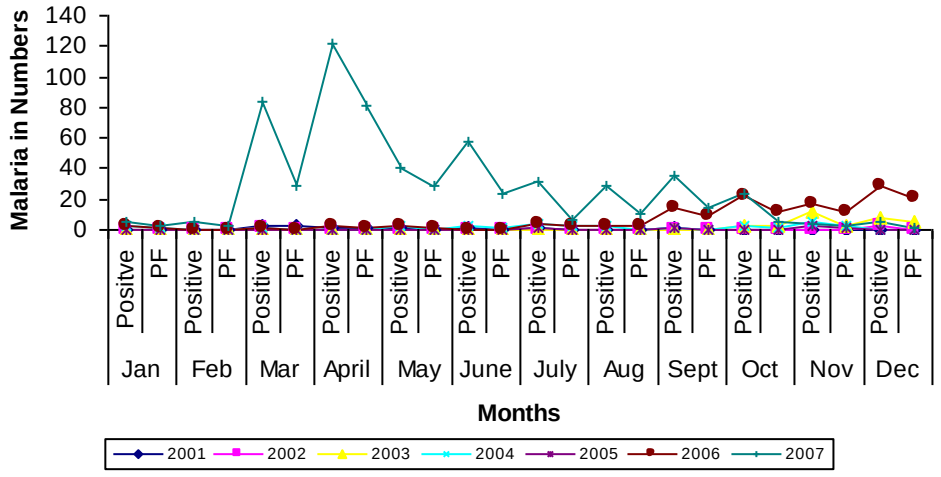

Fig.4: Malaria incidence over a period (monthlywise)

The analysis on malaria incidence over a period shows positive impacts on village people and is high during the months of Arpil to June, 2007 (Fig.4) mainly because a conducive environment provided by climatic variables such as temperature, rainfall and RH. This incidence has been formed massive with a lot of village people suffering physically and mentally. According to people's perceptions, this incidence remains unforgettable and unexpected. Our observations reveal that they have struggled a lot to recover malaria related

health problems with many poor people even experiencing economic losses. Ten people have been reported to have died due to this incidence.

Impacts

Direct Impacts

Malaria is one of the most severe public health issues worldwide. It is leading to deaths and sufferings in many developing countries, particularly young children and pregnant women. It is an acute disease that spreads to a large extent within a short period of three months. If malaria infects a person he will suffer from fever and severe cold. Personal interaction with the village people reveals that, malaria is a transformational disease which is spreads across within a short period of three months. It has also been observed that people suffer a lot because of frequent fevers, cold, vomiting and diarrhea. If not cured properly on ontime it can lead to Jaundice. Further, 50 percent of the people are observed to have suffered from severe mental and physical imbalance.

Indirect Impacts

Malaria is a blood rescue disease that will weaken a person, once he/she sick. Further, it can adversely affect the performance of people in their respective fields, their cognitive developments and children's school performance. Similarly labor quality cannot be assured and household expenditure might increase enormously. .

Malaria impacts on Socio-economic Conditions

Malaria can impose substantial costs on both the individuals and Governments.

Costs Include: purchase of drugs for treating malaria at home; expenses for travel and treatment at dispensaries and clinics; loss of work days; expenses for preventive measures; expenses for burial in case of deaths. Based on the perceptions of village people, malaria can cost up to Rs 4000 (US$ 90) per person for treatment in a private hospital. Although treatment is free in a Government hospital, the Government should spend at least Rs.100 (US$ 2.2) per person for laboratory tests and medicine (as doctor say). The Government provides compensation of Rs.10,000 (US$ 223) per person in the event of his/her death due to malaria. At the same time the Government should concentrate on the maintenance of health facilities such as purchase of drugs and supplies, public health interventions against malaria, such as spraying insecticides, distribution of bed nets etc. Further, the Government should compensate for the loss of work days and ensure income for individuals and opportunities for joint economic ventures and tourism.

Adaptive Measures for Controlling Malaria

Adaptation to climate change is a key concern now, considering the fact that the climate change projections and the anticipated changes in the existing disease conditions are highly uncertain. And capacities to adapt to adverse impacts of climate change may not be sufficient when malaria attacks. It is not only a function of climate determinants, but also prevailing socio-economic conditions. Therefore, adaptation measures should encompass these aspects. A few measures can be envisaged at this juncture which can help reduce the vulnerability to malaria under climate change conditions. Our observations reveal that the study area has been unaware of prevention and precautionary measures. A few people use bed nets at night and some do not because of high temperatures (summer season). The following are a few better suggestions for adaptation.

1. Health education (also called Information-Education-Communication, IEC), where in the communities are informed of what they can do for prevention and treatment of malaria.
2. Training and supervision of health workers, so as to ensure that they carry out their tasks correctly.
3. Allowing health workers and the communities to carry out interventions.

Mitigation for Malaria Control

The prevention of malaria in malaria-endemic areas is the prime objective under the mitigation programme by using the locally available resources taking into account the health priorities. A malaria control option does not eliminate malaria totally. A complete elimination of malaria parasite (and thus the disease) might help prevent the occurrence of malaria Although eradication is more desirable, it is not currently a realistic goal for most of the countries where malaria is endemic. In the study area also mitigation options have been provided but they are not effective and not monitored frequently. It would be better if the Government and individuals follow the suggestions given here.

1. Prevention of infection through vector control
2. Health department should provide bed nets to all the houses in the village
3. Regular spraying and fogging of vector controller
4. Regular use of larva controller
5. It is necessary to introduce biological malaria control fishes to the nearby water body (tank)
6. Prevention of disease by administration of antimalarial drugs to particularly vulnerable population groups such as pregnant women and infants should be ensured

7. Effective awareness exercises about malaria impacts are absolutely essential.

Costs of Mitigation

The cost incurred by the Government for malaria mitigation is huge as it was to provide basic health infrastructures such as medicines, doctors, etc. According to the Government (Health Department) it has spent Rs.100 (US$ 2.2) per person for mitigating malaria effects in the village. As per the record of Malaria Office at Raichur, it has spent Rs.150,000 (Rs.100 x 1500 people) (US $ 3334) in K. Irabgera village for the year 2007. It includes spraying, fogging, laboratory, medicine, intervention of biological controller, bed nets and awareness programmes costs.

Apart from the Government, individuals also spend a lot on malaria controllers such as, DDT, fogging and their travel to health centers. Each household on an average, is observed to have spent Rs.50-100 (US$ 1.1-2.2) for overcoming malaria. As per discussions held with doctors it took four months to control malaria with about 60-70 percent of the cases cured.

Collective Action

There are no formal and informal collective actions observed in the village. In the earlier days, few societies used to work for village needs, however, currently they are not functioning due to improper management. If something happens in the village, individuals themselves have to go to health centres for treatment.

In the year 2007, the staff from the primary health care centres stayed in the village for regular spraying, monitoring and treatment of malaria. None of the Non Government Organisations (NGOs) participated in controlling malaria in the village.

Awareness and Empowerment on Climate Change

Based on the discussions with the village people and our observations it is clear that none of them seems informed about climate change and its impacts on malaria. Most of the respondents in the village have stated that the outbreak of malaria is mainly to the introduction of irrigation in the rainfed areas rather than climate change. But fluctuations in climatic factors such as temperature, rainfall and humidity during the prevalence of malaria confirmed that there is climate change. According to them rainfall was unexpected during the period in the village.

Conclusions

Based on the analysis of data on malaria incidence, temperature, relative humidity and rainfall it is confirmed that malaria breaks out due to changes in climatic varibles. Fluctuations in the variables provide favorable weather conditions for vector survival and growth. An increase of about 0.48^0C in temperatures affects on the spatial rainfall pattern. Further, unexpected rainfall provides a conducive environment for vector growth around the tank, and agriculture fields. The lack of awareness with respect to mitigation and adaptation of malaria control and the insufficient medicare facilities are major cause for the spread of malaria. The improvements in the treatment facilities may have reduced the household expenditures. On time treatment and monitoring through sophisticated instruments will further cut down the burden. Awareness about climate change and its impacts on livelihood is

essential. Integrated research on malaria at the micro level is required (existing at the national and international levels as of now). Proper education and sanitation are required. Better public transportation facility from the village to the primary health centre is also needed.

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