Heat waves, Human Health and Adaptation : An Empirical Study in West Bengal, India

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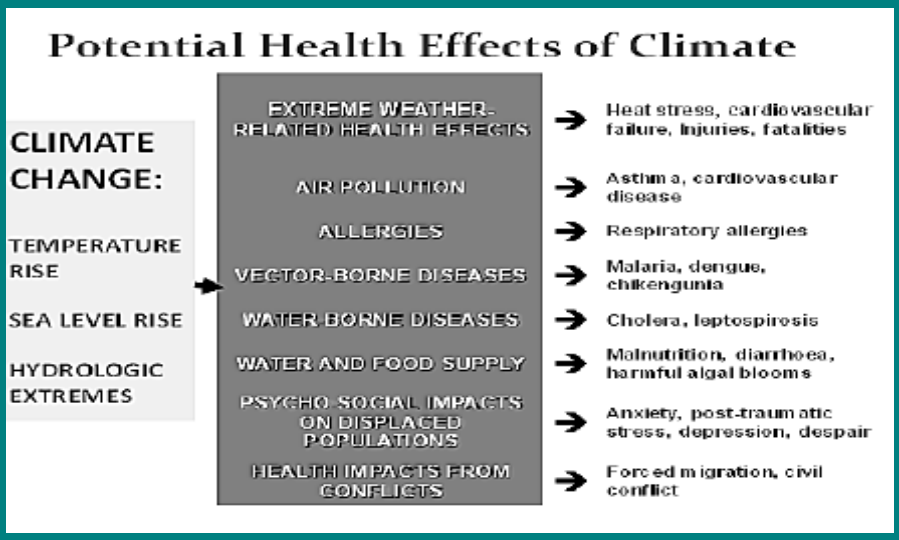
Back ground of the study

- The Third Assessment Report of IPCC has predicted that by 2100 the global temperature would increase by 1.8 °C–4 °C and which has effect on increased heat-related mortality and morbidity.
- The Fourth Assessment Report of IPCC (2007) has also highlighted the possible increase in vector-borne diseases spatially and temporally due to rise in temperature and precipitation.
- The past heat waves that killed about 70,000 people in Europe in 2003 showed that the high-income countries are not free from vulnerable.

- The occurrence of heat waves affects the distribution of disease vectors like malaria, dengue and the incidence of diarrhea.
- Vector-borne diseases are spreading across the Eastern Europe and Central Asia and South Asia.
- In India heat-wave caused 22562 deaths since 1992 to 2015 at various states.

Health Effect of Climate Change



Health outcomes for South Asian regions

Health Outcome	Bangladesh	Bhutan	Nepal	India
Heat waves	+	-	+	+
Malaria	+	+	M	+
Japanese encephalitis	+	-	+	+
Kala azar	-	-	+	+
Dengue	+	+	-	+
Water-borne diseases	+	M	M	M
Drought-related food Insecurity	+	-	-	M

Source: WHO, 2005

Objectives of the study

- First, to examine the impact of heat waves on human mortality in India.
- Second, to examine the effect of precipitation on malaria death in India.
- Third , to examine how climate change affects the distribution of disease vectors in the coastal and drought regions of West Bengal.
- Lastly, to identify the adaptation options of the households to reduce the risk of climate change.

Definition of Heat wave in India

India's Meteorological Department (IMD) has defined heat wave under three categories.

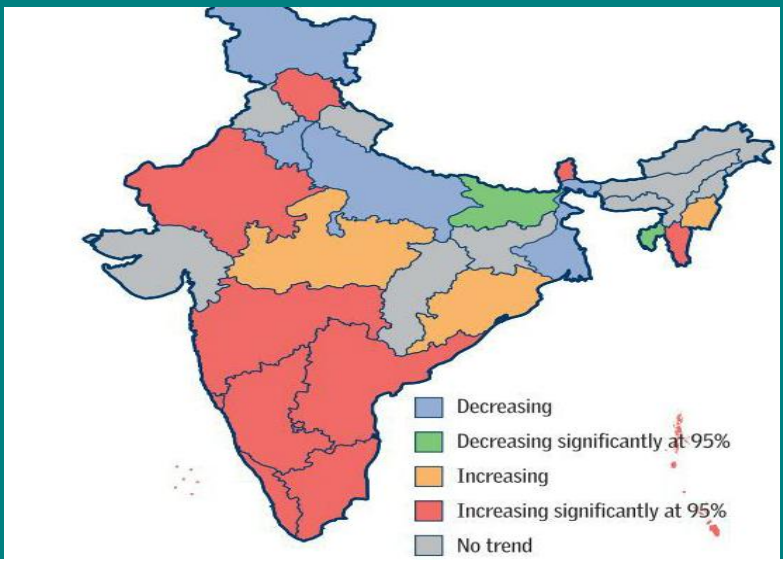
- The first category includes places where the normal maximum temperature is more than 40°C. If the day temperature exceeds by 3 to 4°C above the normal, it is said to be affected by a heat wave.
- The second category considers the regions where the normal maximum temperature is 40°C or less. In these areas, if the day temperature is 5–6°C above the normal, then the place is said to be affected by a moderate heat wave.
- A severe heat wave condition exists when the day temperature exceeds the normal maximum temperature over the place, by 6°C .

Heat Index in India

Relative Humidity %	Temperature °C																
	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
40	27	28	29	30	31	32	34	35	37	39	41	43	46	48	51	54	57
45	27	28	29	30	32	33	35	37	39	41	43	46	49	51	54	57	
50	27	28	30	31	33	35	36	38	41	43	46	49	52	55	58		
55	28	29	30	32	34	36	38	40	43	46	48	52	54	58			
60	28	29	31	33	35	37	40	42	45	48	51	55	59				
65	28	30	32	34	36	39	41	44	48	51	55	59					
70	29	31	33	35	38	40	43	47	50	54	58						
75	29	31	34	36	39	42	46	49	53	58							
80	30	32	35	38	41	44	48	52	57								
85	30	33	36	39	43	47	51	55									
90	31	34	37	41	45	49	54										
95	31	35	38	42	47	51	57										
100	32	36	40	44	49	56											

Caution | Extreme Caution | Danger | Extreme Danger

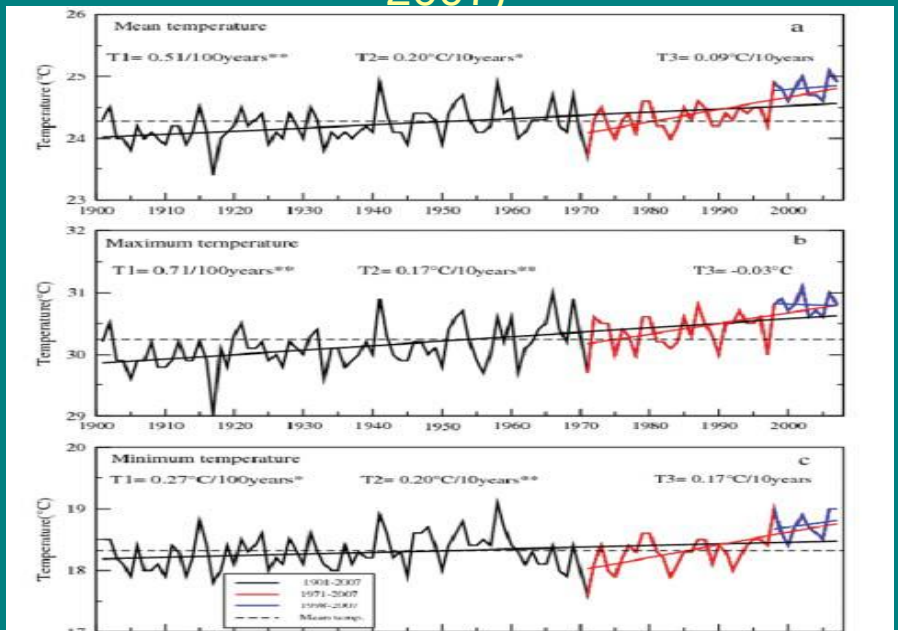
Mean Maximum Temperature Trends for 1951-2010 (Summer)



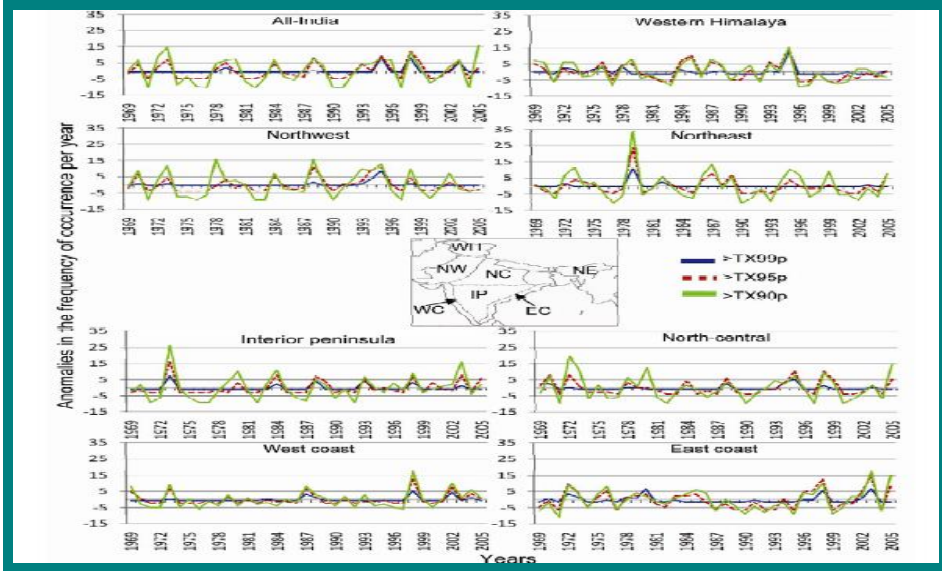
Heat wave in India from April to May 2015

State	Month	*Mean Daily Maximum Temperature (°C)	**Recorded Maximum Temperature (°C)
1	2	3	4
Andhra Pradesh	15 April to 30 May 15 Hyderabad,	39.9	46
Telangana	15 April to 30 May 15 Khammam	40.0	48
Odisha	21 May 15 Jharsuguda,	41.4	45.4
	10 June 15 Bhubaneswa,	37.2	44
Uttar Pradesh	24 May 15 Allahabad	41.8	47.7
	8 June 15 Allahabad,	39.8	47.8
Delhi	25 May 15 Delhi	40.5	46.4
Chattisgarh	25 May 15 Jashpur	41.9	44.5
West Bengal	28 May 15 Kolkata	35.5	44.5
Gujarat	29 May 15 Ahmadabad	41.4	43.2
Madhya Pradesh	29 May 15 Harda	39.7	43.5

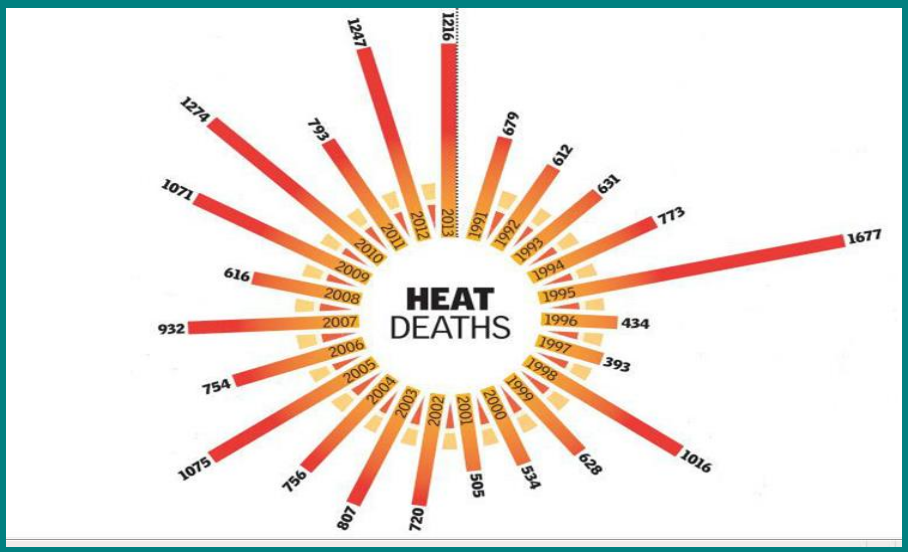
Annual Trends in temperature (1900-2007)



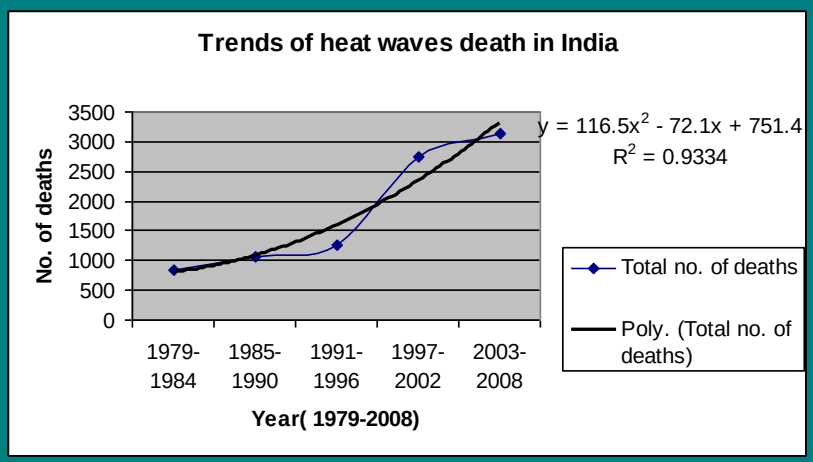
Anomalies of frequency of warm days from 1969to 2005



Heat Deaths in India



Trends of Heat Waves Death in India



Relation between temperature and heat wave human deaths in India

- Dependent Variable : The number of deaths D_t (where t= 1978, 1979, ------2008)
- Independent Variable : The maximum temperature T_t (where t= 1978, 1979, ------ 2008).
- We have worked out unit root test of two time series variables by ADF test statistic.
- After conforming the stationarity of the variables we have applied regression analysis.

Unit Root Test

- The model is given by
- $Y_t = a_1 Y_{t-1} + \varepsilon_t$ ---------- (1)

$\Delta Y_t = \gamma Y_{t-1} + \varepsilon_t$ Where $\gamma = a_1 - 1$ ----------(2)

- In the presence of trend of drift the Dickey and Fuller equation can be written as

$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=1} c_i \Delta Y_{t-i} + \varepsilon_t$ ------(3)

- Where a_0 and t represent the drift and time trend component respectively.
- Null hypothesis
- H 0 : $\gamma = 0$ (Non stationary)
- Against alternative hypothesis
- H 1 : $\gamma < 0$ (Stationary)

Unit root test by ADF test Statistic

Variable	ADF value at level	1% critical value
Number of death	5.315	3.71
Maximum temperature	4.16	3.71

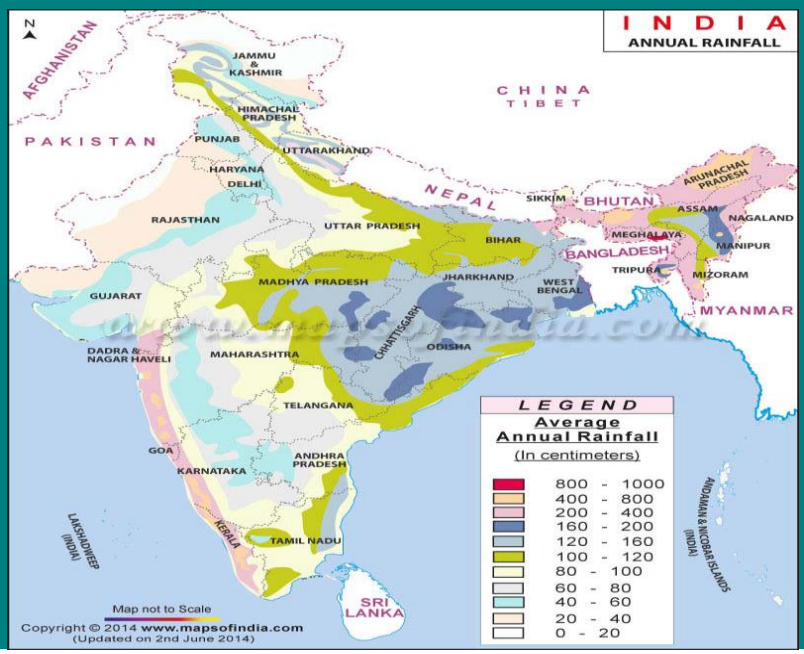
Results of Regression Analysis

Dependent variable	Co-efficient	T value	F value	Adjusted R square
D_t	367.27	3.38	19.49*	0.39

Season wise rainfall statistics for All India and homogeneous regions (mm/month)

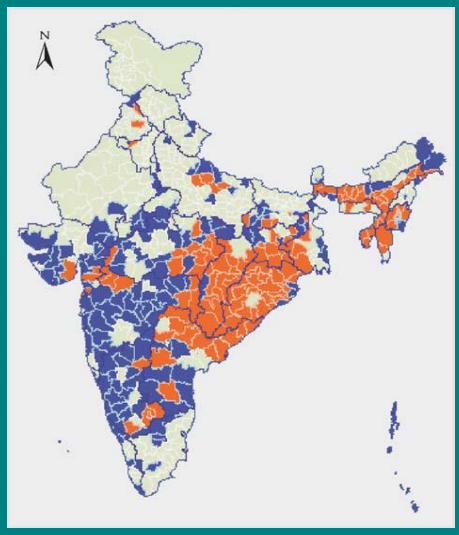
Salient Statistics for all India and homogeneous regions (mm. /month)								
	Mean				Std.dev			
Regions	Winter season	Pre. Monsoon	South-west monsoon	Post monsoon	Winter season	Pre. Monsoon	South-west monsoon	Post monsoon
ALLIND	120.89	312.24	2145.01	395.71	61.87	68.49	247.69	123.99
CORIND	81.77	93.25	2193.75	206.92	60.86	57.92	353.69	139.96
NWIND	72.71	68.94	1227.36	68.12	51.39	53.2	330.89	73.35
WCIND	95.52	144.58	2302.41	283.15	73.4	72.36	308.22	145.45
CNEIND	172.11	247.16	2504.1	304.99	106.12	108.56	290.24	170.62
NEIND	218.61	1430.37	3492.41	593.57	118.02	341.25	390.34	238.87
PENIND	104.17	457.7	1654.56	1149.08	98.93	155.07	248.02	303.34

Notes: ALLIND means All India; CORIND means Core India, NWIND means North West India; WCIND means west central India; CNEIND means Central North east India; NEIND stands for North east India and PENIND stands for peninsular India.

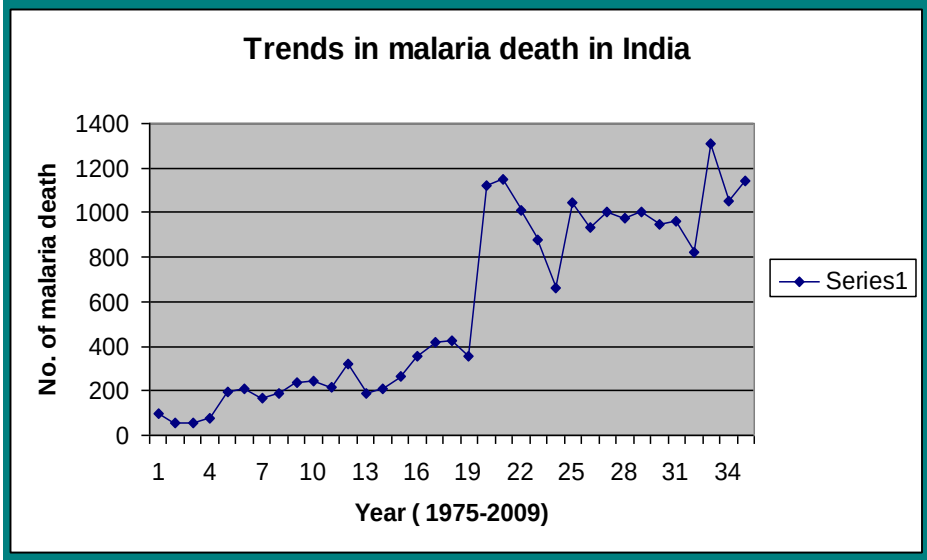


Malaria prone Regions of India

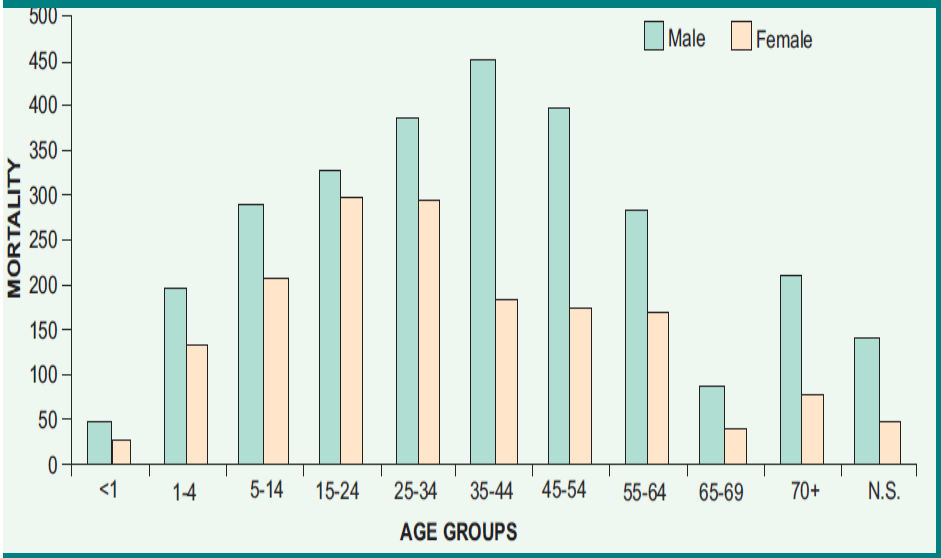
The red colour regions are malaria prone



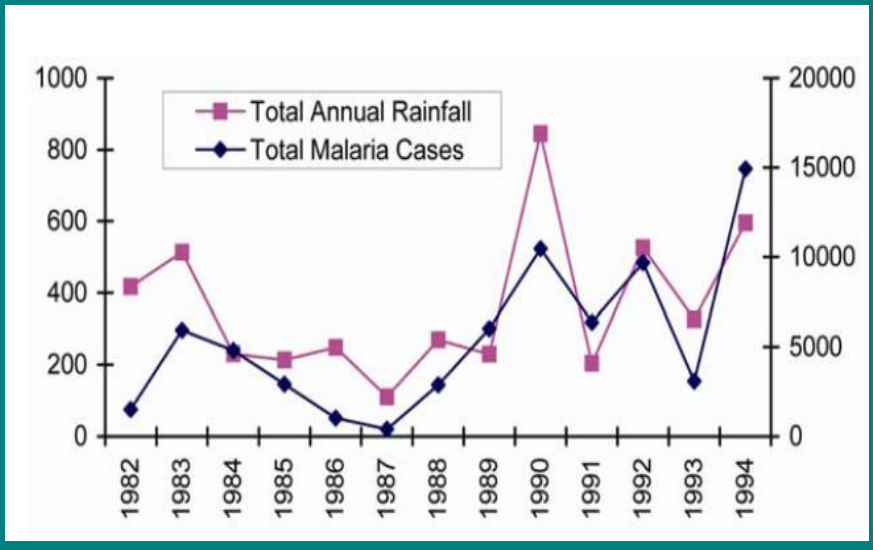
Trends in Malaria Death in India



Gender wise Malaria Deaths



Rainfall and Malaria cases



Impact of precipitation on malaria death in India

- Dependent Variable : The number of deaths due to malaria (MD_t) (where t= 1984, 1985, ------ 2010)
- Independent Variable : Precipitation (R_t) (where t= 1984, 1985, ------2010)
- We have worked out unit root test of two time series variables by ADF test statistic.
- After conforming the stationarity of the variables we have regressed dearth rate due to malaria on precipitation.

- The regression equation is given by

Log Kt = b Log Z t

Where Kt = Log MDt - Log MD t-1

Zt = Log MRt - Log R t-1

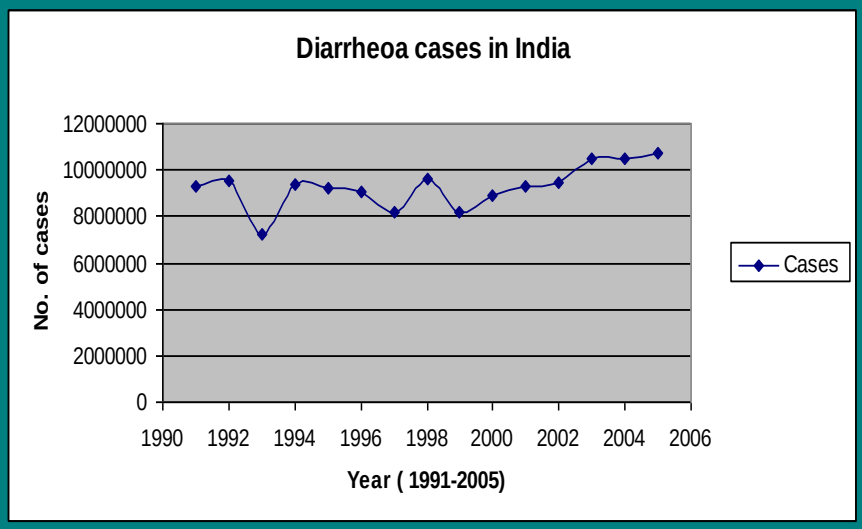
Unit Root Test by ADF Test statistic

Variable	ADF test statistic (at level)	ADF test statistic (at first difference)	Critical value at 1% level
Log MDt	1.36	6.11	3.75
Log MRt	4.64	7.67	3.75

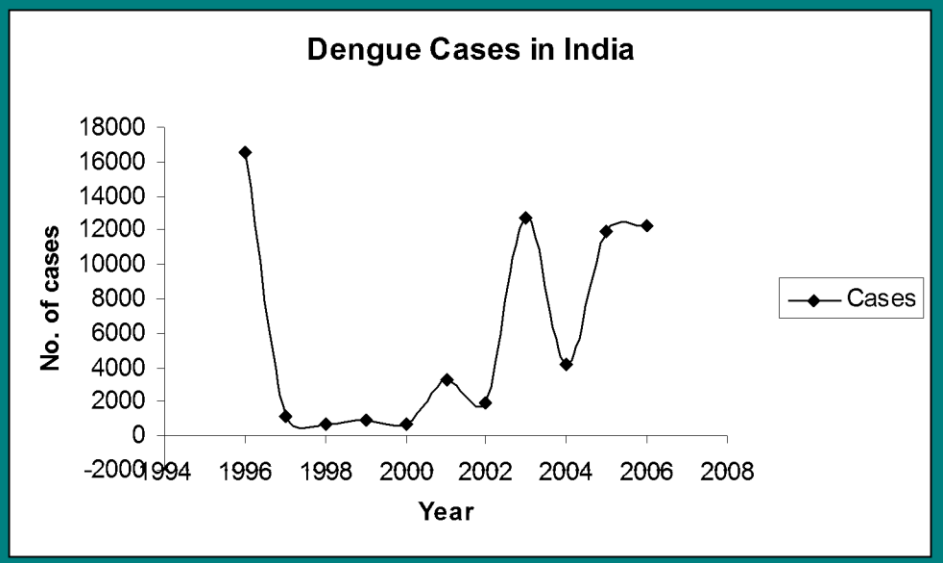
Results of Regression Analysis

Dependent variable	Co-efficient	T - value	F value	Adjusted R square
Log Kt	0.947	52.82	2790.41	0.99

Trends in Diarrheoa cases in India



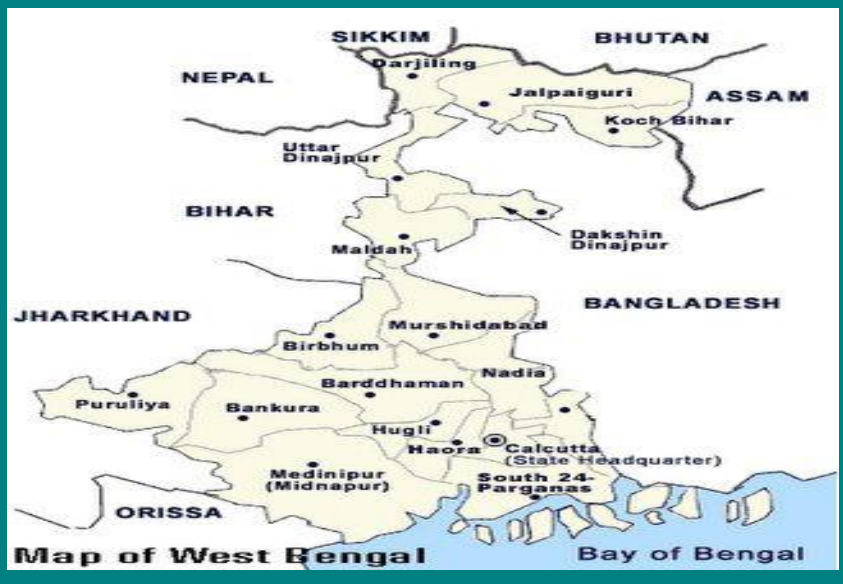
Trends in Dengue cases in India



Pattern of disease vector in the coastal area and drought prone area of West Bengal

- **Data and Methodology**
- The study was conducted in two villages of Gossaba block namely Jamespur and Chargheri in Indian coastal Sunderbans in 2011. The study selects 30% random sample households from each village. Total number of sample households in coastal Sunderbans was 202 .
- Similar study was conducted in the two other villages namely namely Junsura and Baskula under Sonamukhi forest area in the district of Bankura, one of the drought prone districts of West Bengal in 2011. In this area total sample household was 120.

West Bengal , India



Disease vector in Coastal Sunderban

Disease	Jamespur(% of hhs)	Chargeri (% of hhs)
Malaria	50.00	65.00
Diarrheoa	19.2	11.00
Vision problems	9.6	10.00
Skin disease	9.6	6.00
Others(heart related disease)	11.5	4.00

Disease vector in Drought prone Areas of Bankura District

Disease	Junsura (% of hhs)	Baskula(% of hhs)
Diarrheoa	65.00	70.00
Malaria	25.00	16.7
Vision problem	6.7	11.7
Others(skin disease)	3.3	1.6

Adaptation options by the Households in Coastal Areas of Sunderban

Adaptation strategy	Jamespur(% of hhs)	Chargeri (%of hhs)
Use of net from mosquito	20.00	11.00
Use of sanitation	100.00*	100.00*
Migration	73.00	85.00
Formation of Self-help Group (SHGs),	77.9	90
Borrowing from money lender	87.6	82.7
Livestock rearing	78.8	70.00
Boiling of water for drinking purposes	8.00	15.00

Adaptation options by the Households in Drought prone Areas of Bankura district

Adaptation strategy	Junsura (% of hhs)	Baskula(% of hhs)
Use of net from mosquito	30.00	27.00
Use of sanitation	35.00	41.67
Migration	56.67	76.67
Formation of Self-help Group (SHGs),	38.33	11.67
Borrowing from money lender	65.00	95.00
Livestock rearing	100.00	98.33

Key Strategies

- ***Establish Early Warning System and Inter-Agency Coordination*** to alert residents on predicted high and extreme temperatures.
- ***Capacity building / training programme*** for health care professionals at local level to recognize and respond to heat-related illnesses, particularly during extreme heat events.
- ***Public Awareness and community outreach*** Disseminating public awareness messages on how to protect against the extreme heat-wave through print, electronic and social media and Information, Education and Communication (IEC) materials such as pamphlets, posters and advertisements and Television Commercials (TVCs)

Continued

- ***Collaboration with non government and civil society*****:** Collaboration with non-governmental organizations and civil society organizations to improve bus stands, building temporary shelters, wherever necessary, improved water delivery systems in public areas and other innovative measures to tackle Heat wave conditions.
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Conclusions

- First, there is a positive and significant relation between the number of heat wave deaths and temperature rise in India. As temperature rises there is an increase in number of heat wave deaths and vice versa.
- Second, there is a positive and significant relation between precipitation and death rate due to malaria. The higher is the precipitation and higher is the death rate due to malaria.

- Third, in the coastal area of Sunderban and drought prone areas the common climate related diseases are malaria, diarrhea, low vision problems, skin diseases and other heart related diseases.
- Fourth, use of net from mosquito, use of sanitation, migration, formation of self help groups, borrowing of loan from money lenders, live stock rearing and boiling of water for drinking purposes are the possible adaptation strategies of the households.

- Thank you for your attention!