CLIMATE CHANGE AND VECTOR BORNE DISEASES

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Overview of presentation

- Evidence of climate change
- Impact of health and VBDs.
- Temp thresholds for transmission.
- Projected impact on Transmission Windows of Malaria and Dengue using PRECIS model by 2030.
- Emerging chikungunya and Kala-azar need detailed studies
- Possible adaptation measures.
- CONCLUSION

Changes in Climate

CLIMATE has always been changing and this Change is NATURAL. EARTH has witnessed ice ages in past which are examples of Change in Climate.

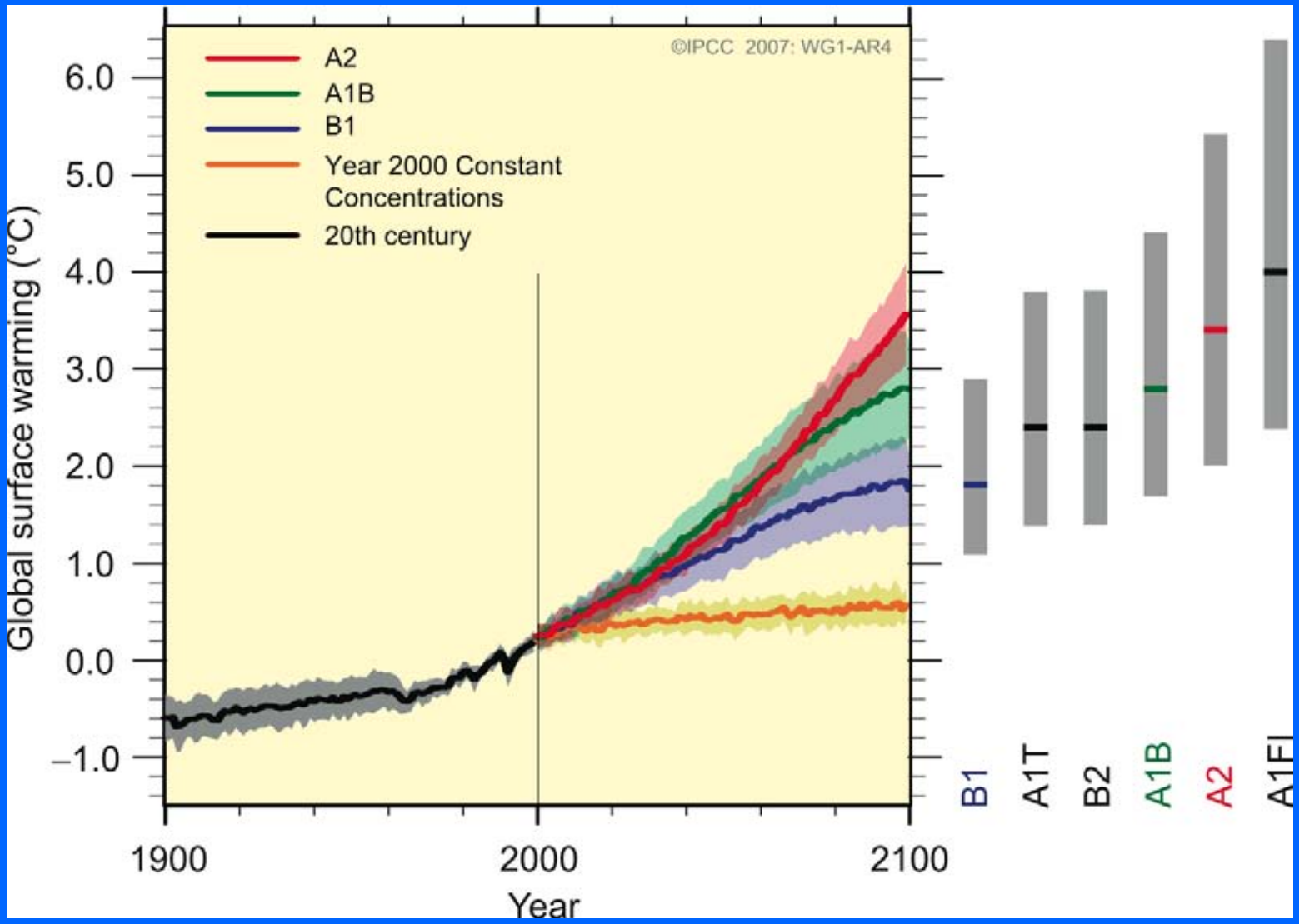
Naturally occurring Greenhouse Gases include WATER VAPOUR, CARBON DIOXIDE, OZONE, METHANE, CLOROFLURO CARBON (CFC) and NITROUS OXIDE, AND TOGETHER CREATE A NATURAL GREENHOUSE EFFECT.

However, Human activities are causing Greenhouse Gas levels in the atmosphere to increase and thus Causing in GLOBAL TEMPERATURE. This increase in mean Global Temperature is called GLOBAL WARMING.

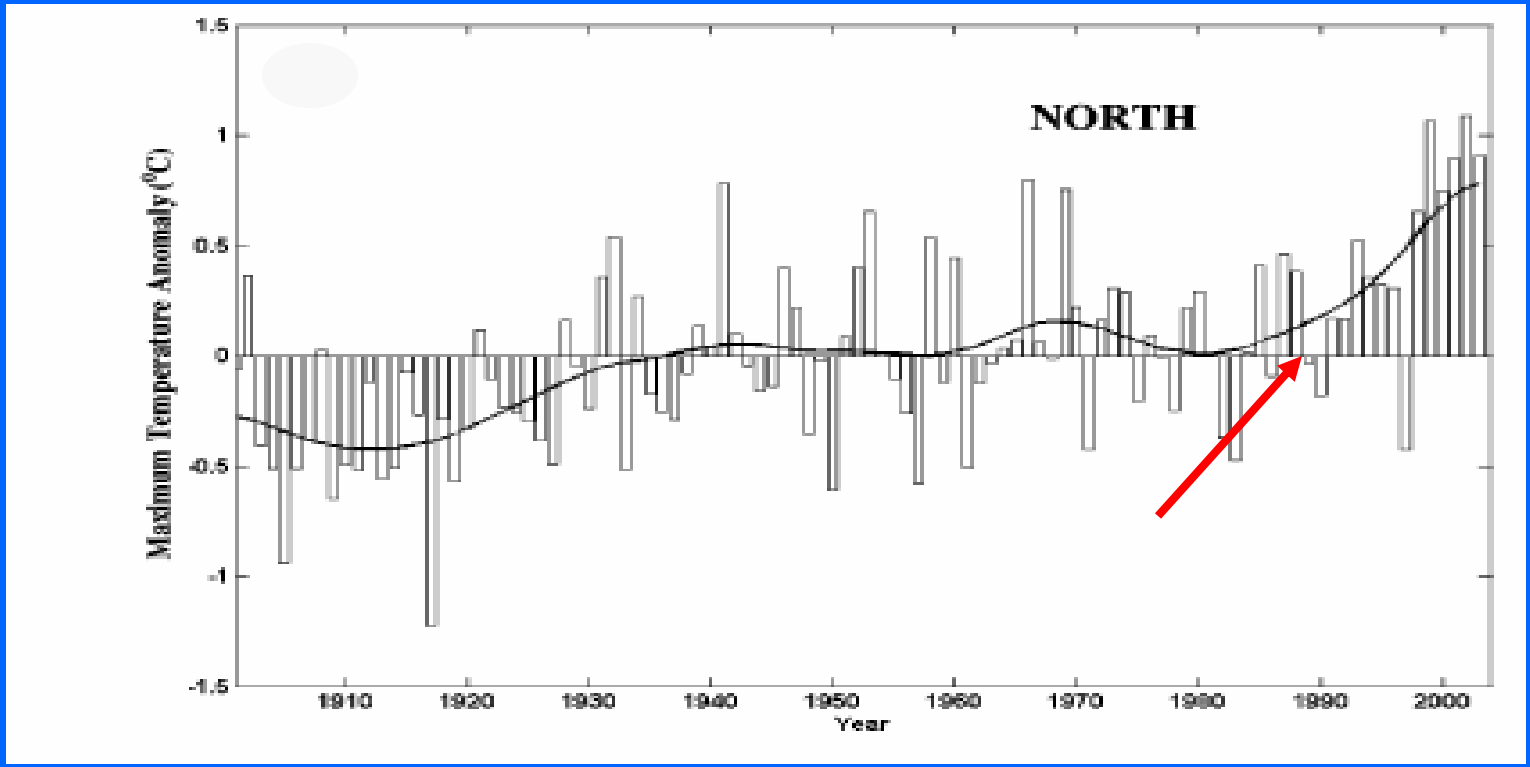
What is Climate Change?

Climate change refers to any change in *climate over time,* whether due to natural variability or as a result of human activity (IPCC,2007).

Projected Global Climate Change (IPCC, 2007)



Anomalies of average land surface maximum temperatures (°C) (1901–2003)



There is appreciable increase in Temp after 1990. Re-emergence of Chikungunya in 2006 needs analysis

Potential Impacts of Climate Change on Health (WHO)

Climate Change

- Temperature
- Precipitation (rainfall)
- Sea Level

Weather related mortality	**Heat Strokes** **Skin Diseases** **Eye Diseases** **Floods , Storms leading to deaths, Injury ,Psychological distress** **Loss of PH infrastructure**
Infectious diseases	**Geographic range and incidence of Vector Borne diseases,** **Changed incidence of Diarrhoeal Diseases**
Altered food productivity & associated pest and diseases	**Malnutrition , Hunger , Impaired child growth and development**
Air quality respiratory illnesses	**Asthma & Respiratory diseases**

Summary of 4th Assessment Report of IPCC (2007)

- Anthropogenic warming has had a discernible influence on many physical and biological systems.
- Impacts of CC will vary regionally, they are likely to impose net annual costs which will increase over time.
- Adaptation will be necessary to address impacts from warming which is unavoidable
- Future vulnerability due to CC depends not only due to CC but also on development pathway.
- Sustainable development can reduce vulnerability;CC can impede sustainable devlopment.
- Many impacts can be avoided, reduced or delayed.

Malaria: Epidemiological Triangle

- Analogy: Applicable to all vector borne diseases
- Development of vectors and pathogens in insect vectors is affected by climatic conditions

Major Vector Borne Diseases in India (2010)

Diseases	Cases/annum	Deaths
Malaria	1.59 million	1023
Filariasis	600 million (total burden)	-
Kala-azar	28941	105
Dengue	28292	110
Chikungunya	59535 (23.26% confirmed)*	-
Japanese Encephalitis	5149	677

***Reported cases in 2007**

Source : NVBDCP

Temperature thresholds (0C) for pathogens and vectors of major vector borne diseases

Disease	Pathogen	Minimum Temp	Maximum temp	Vector	Minimum temp for vector
Malaria	*Plasmodium falciparum*	16–19 C	33–39	*Anopheles*	8–10 (biological activity)
	Plasmodium vivax	14.5–15 C	33–39	*Anopheles*	8–10 (biological activity)
Dengue	Dengue virus	11.9	not known	Aedes	6–10
Chagas disease	*Trypanosoma cruzi*	18	38	Triatomine bugs	2–6 (survival) 20 (biological activity)
Schistosomiasis	Cercaria	14.2	>37	Snails (*Bulinus* and others)	5(biological activity) 25±2(optimum range)
Lyme disease	*Borrelia burdorferi*	Not yet determined	Not yet determined	Ixodes ticks	5–8

IPCC,2001

Relationship of Temp. & RH with Malaria Parasite and Mosquito Development

	Minimum temp. for parasite development	Optimum temp.	Maximum temp. for mosquito survival
10 11 12 13	14 15 16 17 18 19	25 26 27	40 ^{o} +

Relative Humidity 40 60 70 80+

Minimum T required for transmission

***P vivax*: 14.5-16^{0} C** ***P falciparum*:16-18^{0} C**

(Adapted from :Bruce chwatt ,1980 and Martens et al 1995

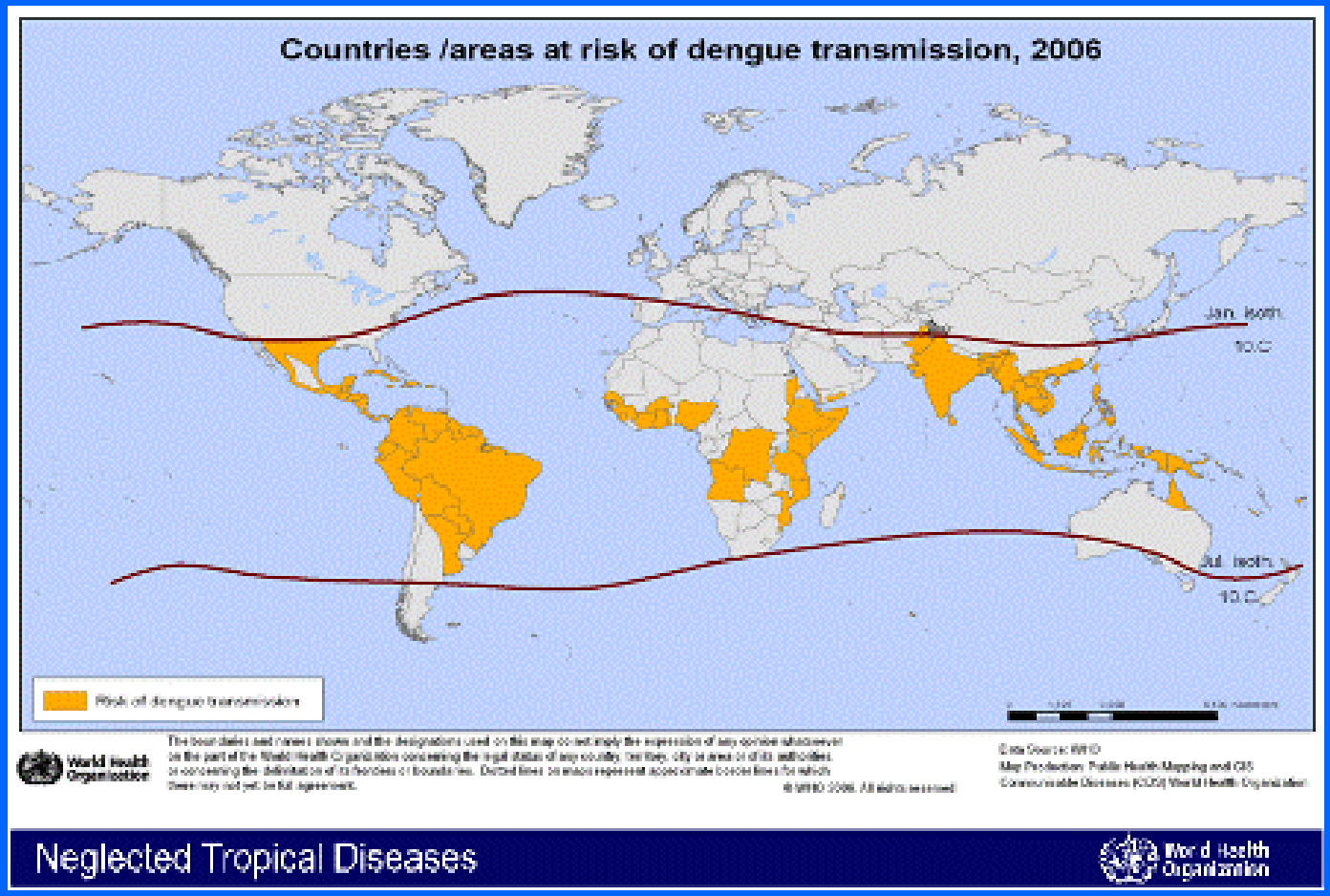
Impact Assessments made

Projected impacts of climate Change (Source: IPCC,2007)

Disease-Region	Results
Malaria-Global	>220-400 m additional pop at risk with A2 scenario by 2020 to 2080;reduced if >3 consecutive months are considered.
Malaria-Africa	16-28% increase in person-months of exposure(including 5-7% increase in altitudinal by 2020-2080. Limited latitudinal expansion.
Malaria-Zimbabwe	Highlands become more suitable for transmission with 1.4 to 4.5^0 C increase.
Malaria- Britain	Increase in risk of local malaria transmission 8-15% with 1-2.5 ^{0}C avg T rise by 2050. Indigenous transmission unlikely.
Malaria-Portugal	Increase in No of days suitable for survival of malaria vector. Risk is very low if no vector

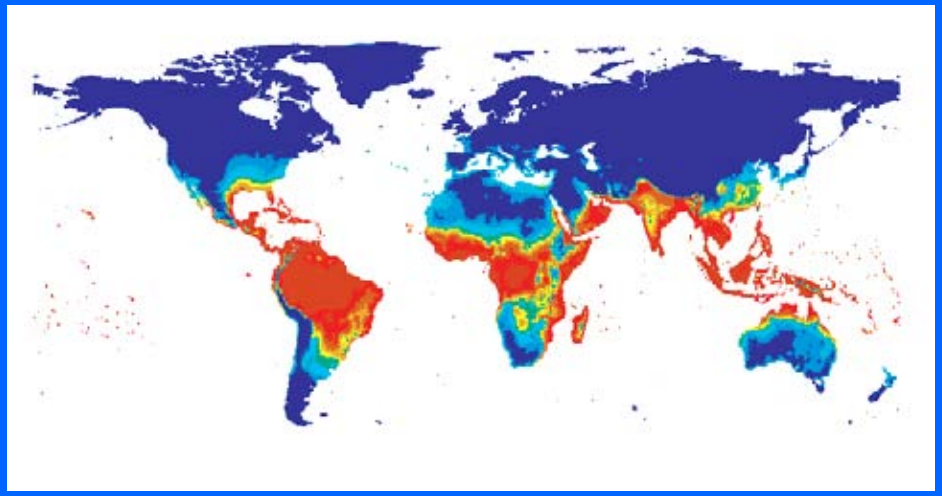
Projected impacts of climate Change

Disease-Region	Result
Malaria-Australia	Receptive zone expands southward by 2050. Absolute risk of reintroduction very low
Malaria-India	Projected shift to southwaest and northern states. TWs widen in northern and wetsern states; shorten in southern states by 2050.
Dengue-Global	Global Poln at risk 3.5 billion with CC; 5-6 billion with popln. growth & CC(baseline 1.5 billion)
Dengue-N.Z'land	Potential Risk of outbreaks in more regions
Dengue-Australia	Climate suitability increase southwards with 1.8 to 2.8 ^{0}C increase.
Lyme disease-Canada	Northward expansion; tick abundance increase 30-100% by 2020
Tick borne Encep.	Pushed towards northeast under low to high degree of CC by 2050

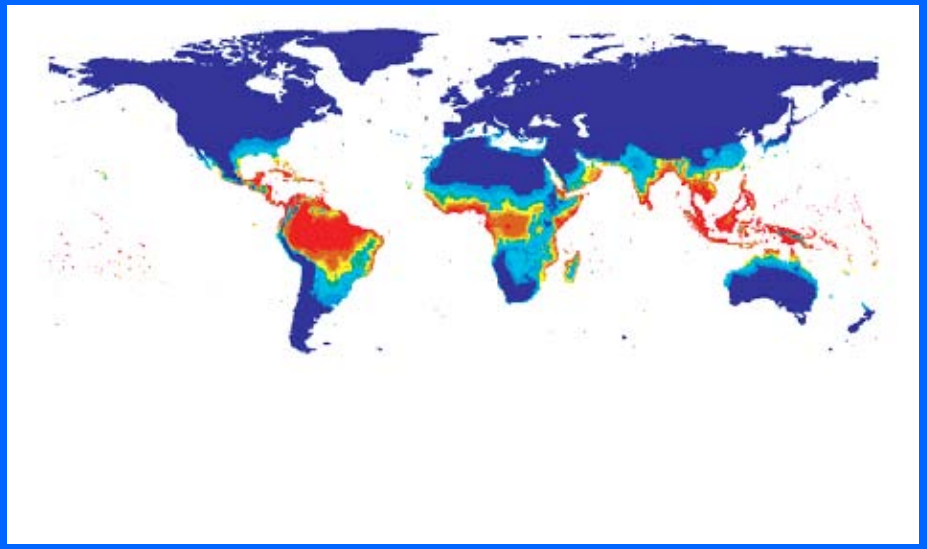


(source: WPRO,WHO website (courtesy of Dr. Michael B. Nathan, Department of Control of Neglected Tropical Diseases, WHO Geneva)

Estimated baseline population at risk of Dengue



Estimated population at risk in 2085



in 1990

Source: Hales et al 2002

Activities & Methodology

- Analysis of baseline and projected climatic parameters for malaria/dengue at national level using A2 and A1B scenario of PRECIS model
- Detailed analysis for Himalayan region, Northeastern,Western Ghats and Coastal areas

Methodology

- Monthly temperature, RH and rainfall (January 1961 to December 1990) extracted from PRECIS (Providing Regional Climate for Impact Studies) were used as baseline.
- Projected scenario (A2 scenario) for 2071,2081,2091 and 2100) of PRECIS were used.
- 18^0C and 32^0C T and 55-90% RH were taken as lower and upper limits for malaria parasite development in mosquito.
- For dengue 12^0 C T was taken as lower limit while 32^0C as upper cut off temperature.

Contd.

- Maps of monthly open Transmission Windows (TW) for malaria transmission based on Temperature, and T & RH at each grid (0.44 X 0.44 deg. Pixel, roughly 50 X50 Km) were prepared for baseline and projected scenario.

- Based on the number of months TW is open, pixels were grouped into 5 classes i.e.

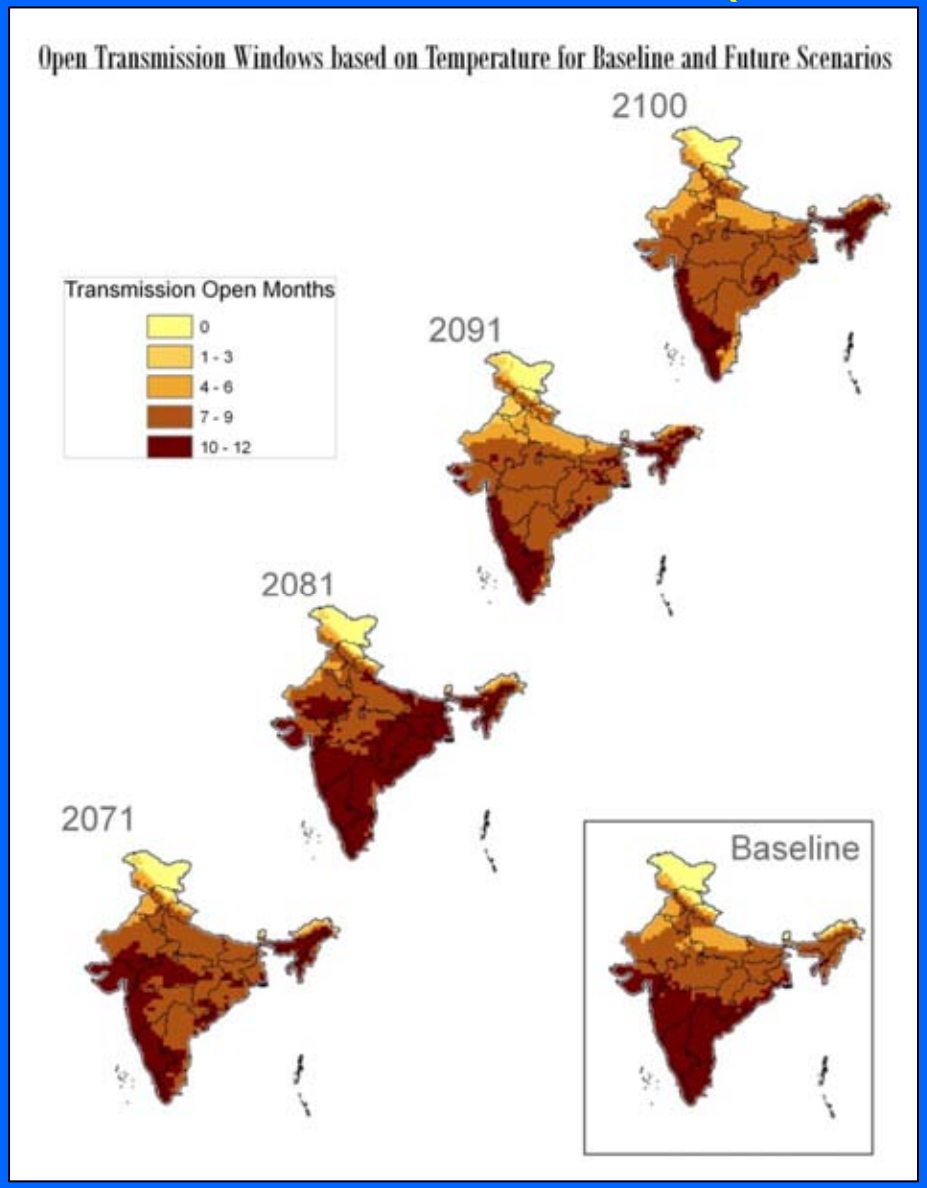
- Class - 1, Closed for 12 months;
- Class – 2, open for 1-3 months;
- Class – 3 open for 4-6;
- Class - 4 open for 7-9 and
- Class – 5 open for 10-12 months.

Contd. Criteria of Determining Transmission Windows

- Temperature 18-32 C and RH 55% or more: OPEN FOR TRANSMISSION
- Consecutive opening of TWS for 3 months: INDIGENOUS TRANSMISSION
- Suitability of transmission for >6 months: STABLE MALARIA

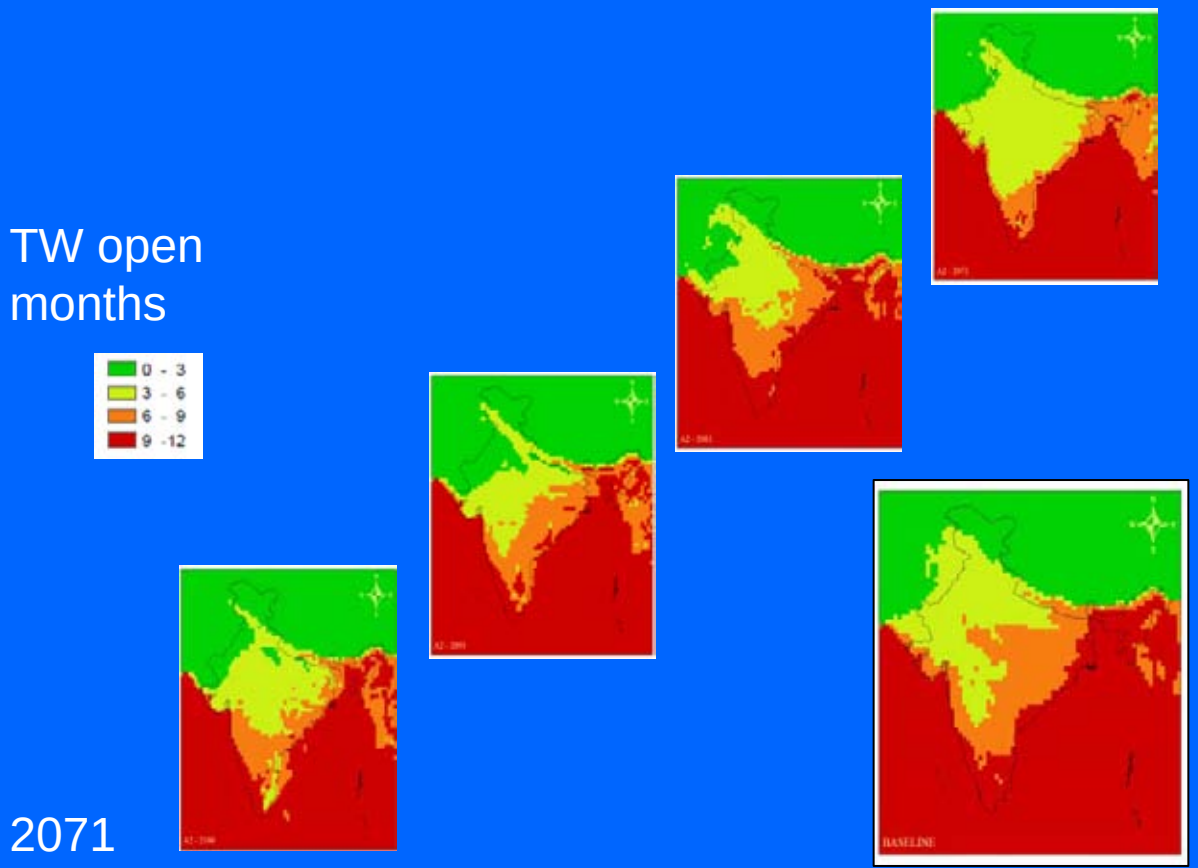
Scenario used A1B (1961-1990 for baseline and 2030 for projection)

Baseline and projected Transmission windows of malaria (A2 Scenario)



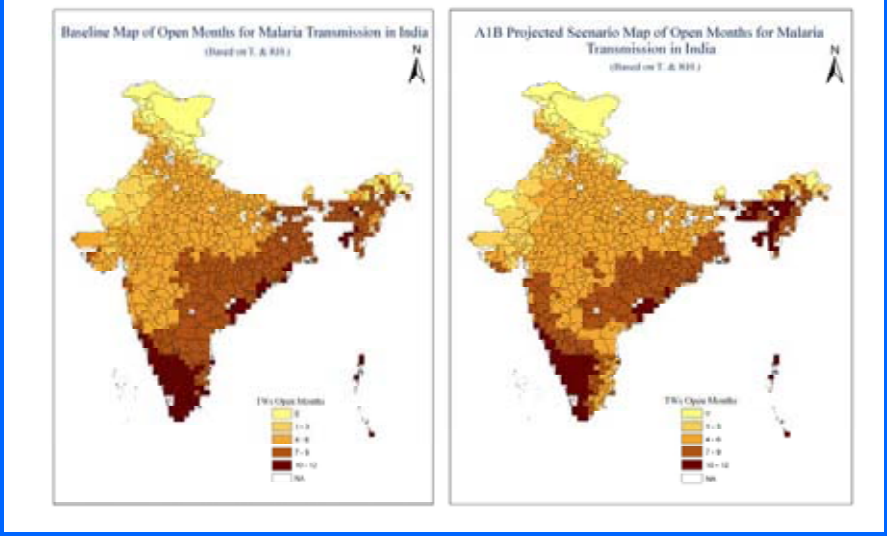
- In 3-9 months TW open categories, appreciable increase in months of TWs is expected leading towards stable malaria.
- In baseline 128 pixels show NO transmission which may reduce to 90 pixels by 2091
- Baseline TWs in 10-12 months(546) are likely to be reduced to 322 by the year 2091.

Transmission Windows of malaria in baseline and projected temperature and RH scenario (A2)

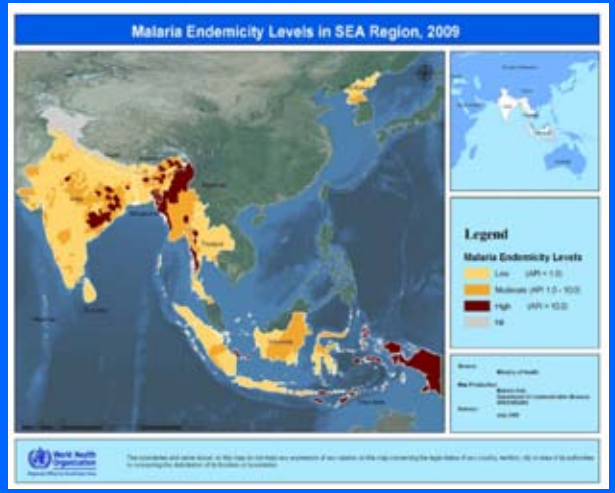


Reduction in 9-12 month open category; increase in 3-6 month TW open

TWs of malaria based on T & RH (A1B Scenario, by 2030) Dhiman et al 2011



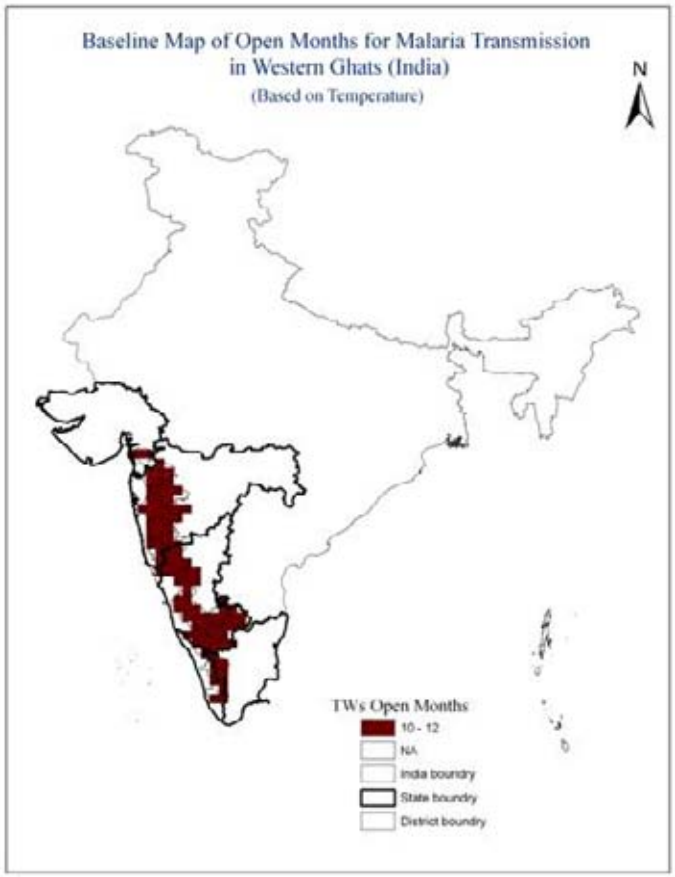
a. Baseline and b. by 2030s

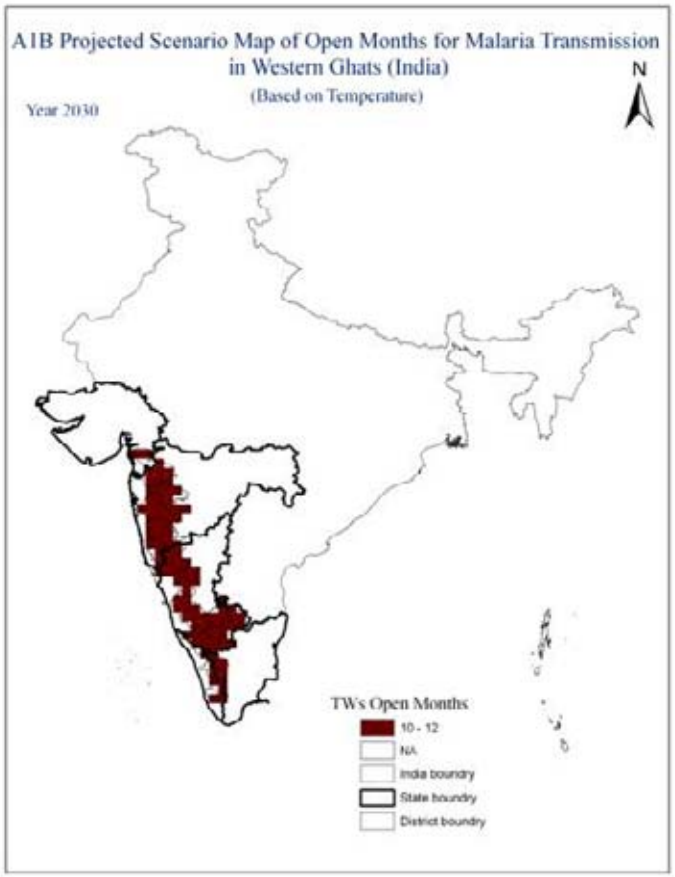


In 2009

Scenario	Category (0)	II (1 - 3)	III (4-6)	IV (7-9)	V (10-12)	Remarks (NA)
Baseline	160	118	593	456	126	42
Projection (by 2030)	155	152	652	363	131	42

Baseline and A1B Scenario Projected Map of Open Months for Malaria Transmission in Western Ghats (India)
(Based on Temperature)

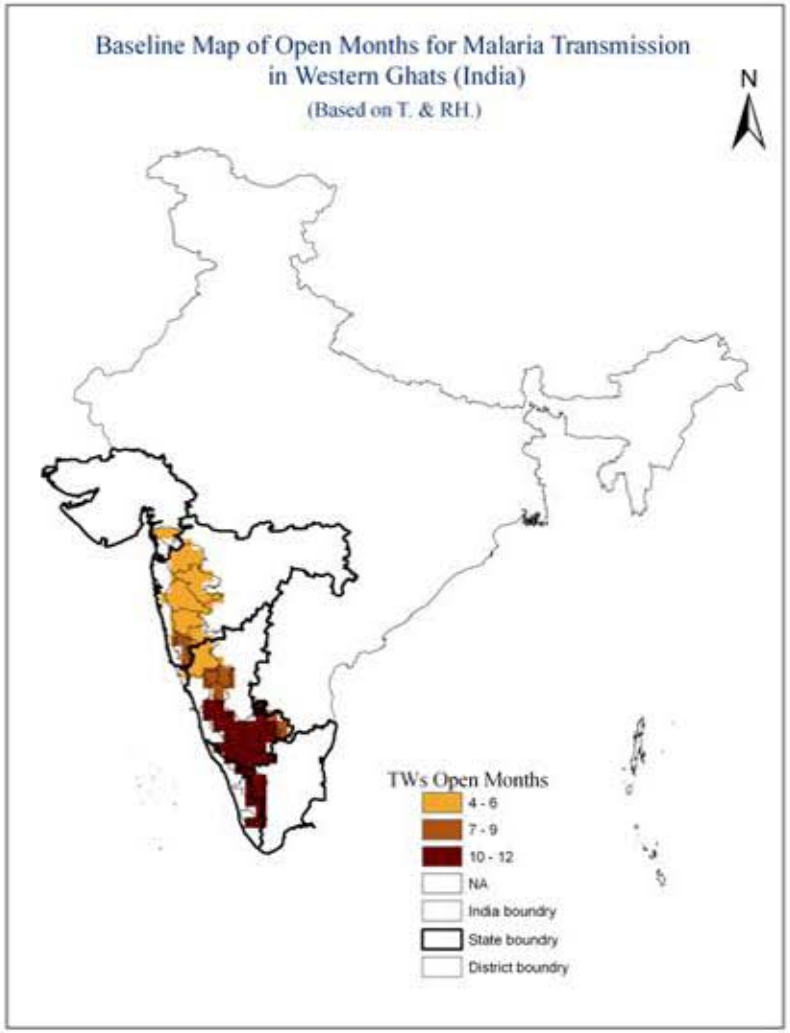


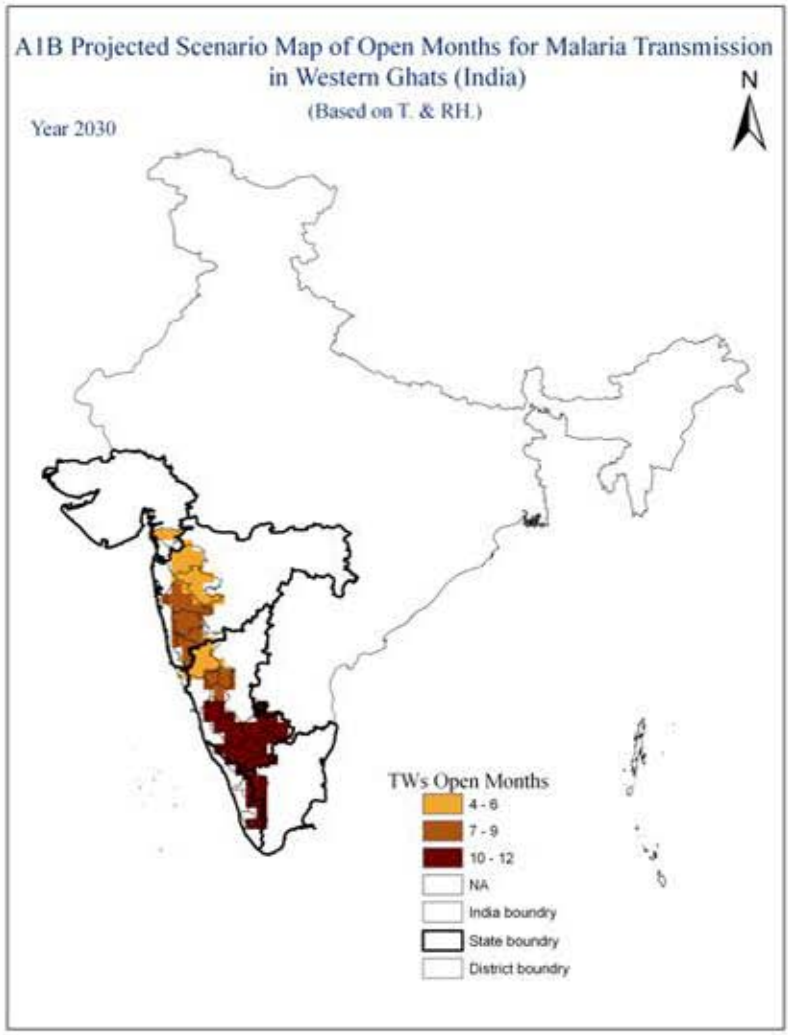


Projection of TWs of malaria in Western Ghats by 2030
(based on Temperature of A1B scenario)

State	No. of Districts	No. of months open for Malaria Transmission							
			0	1-2	3	4-6	7-9	10-12	Data not available
Gujarat	2	Baseline	0	0	0	0	0	1	1
		Projection	0	0	0	0	0	1	1
Maharsthra	6	Baseline	0	0	0	0	0	6	0
		Projection	0	0	0	0	0	6	0
Karnataka	15	Baseline	0	0	0	0	0	15	0
		Projection	0	0	0	0	0	15	0
Kerala	5	Baseline	0	0	0	0	0	4	1
		Projection	0	0	0	0	0	4	1
Tamil Nadu	2	Baseline	0	0	0	0	0	2	0
		Projection	0	0	0	0	0	2	0
5	**30**	**Baseline**	**0**	**0**	**0**	**0**	**0**	**28**	**2**
		Projection	**0**	**0**	**0**	**0**	**0**	**28**	**2**

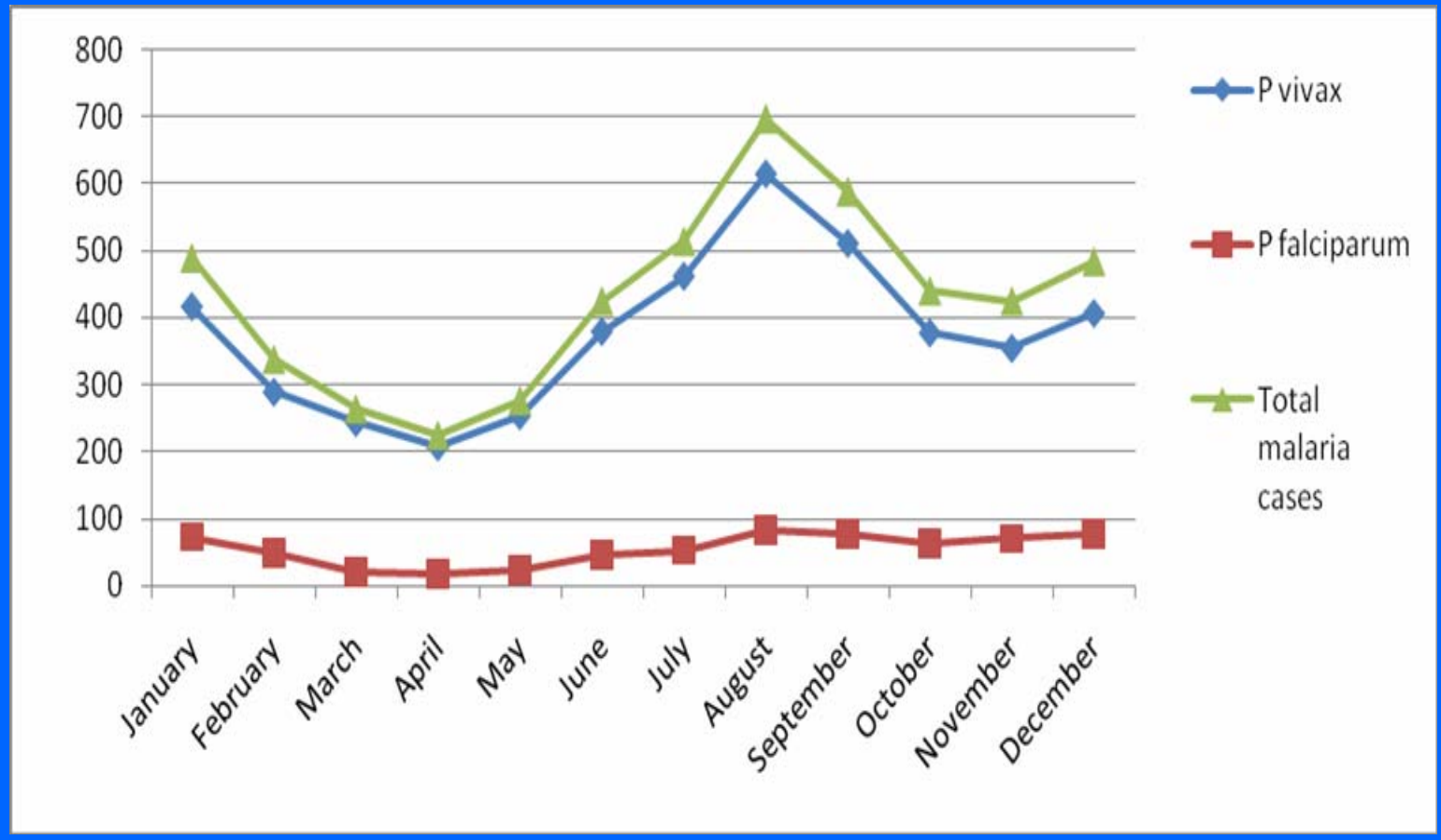
Baseline and A1B Scenario Projected Map of Open Months for Malaria Transmission in Western Ghats (India)
(Based on T. & RH.)



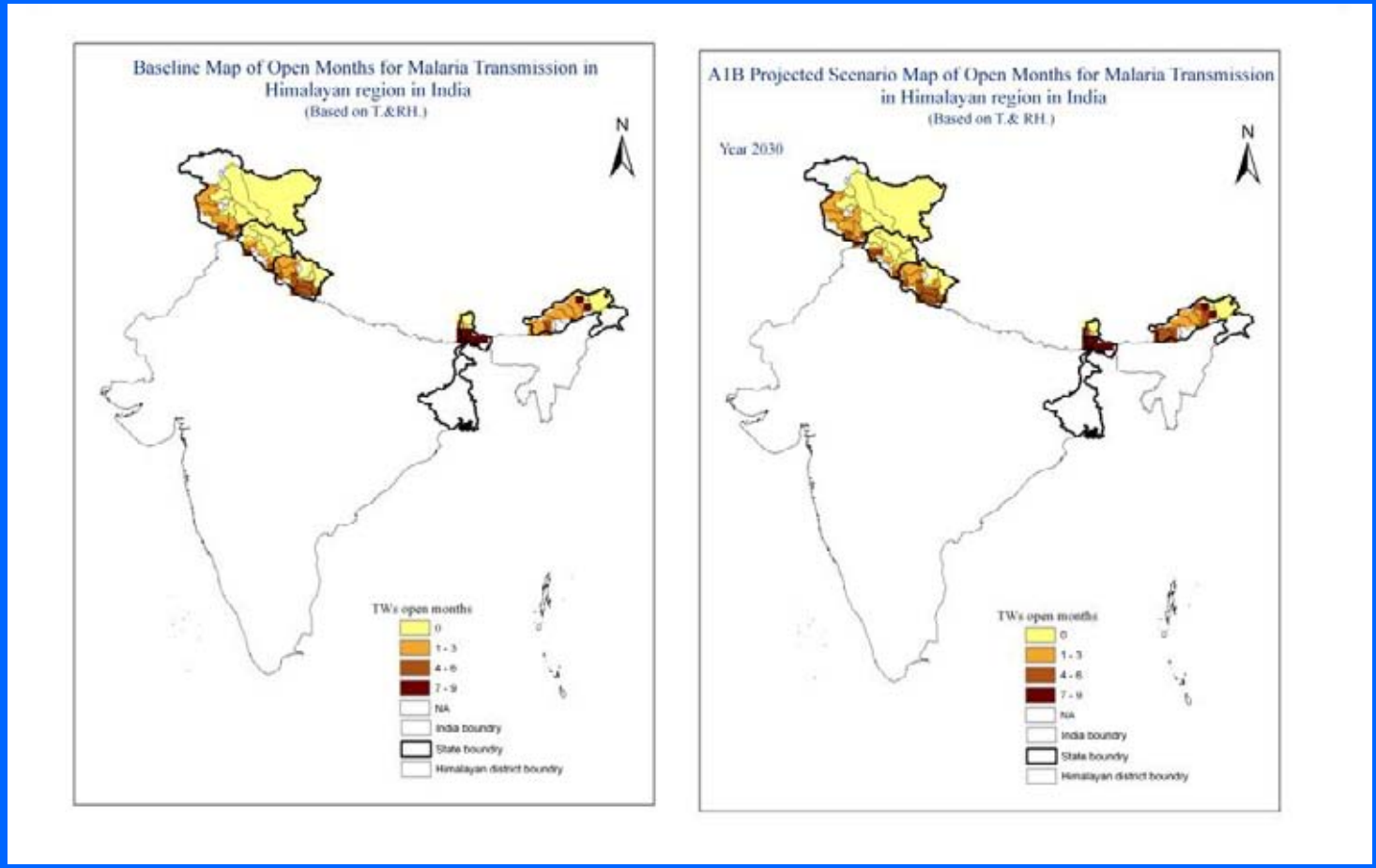


Seasonality of malaria in Mangalore

(Source: Office of DMO, Mangalore)



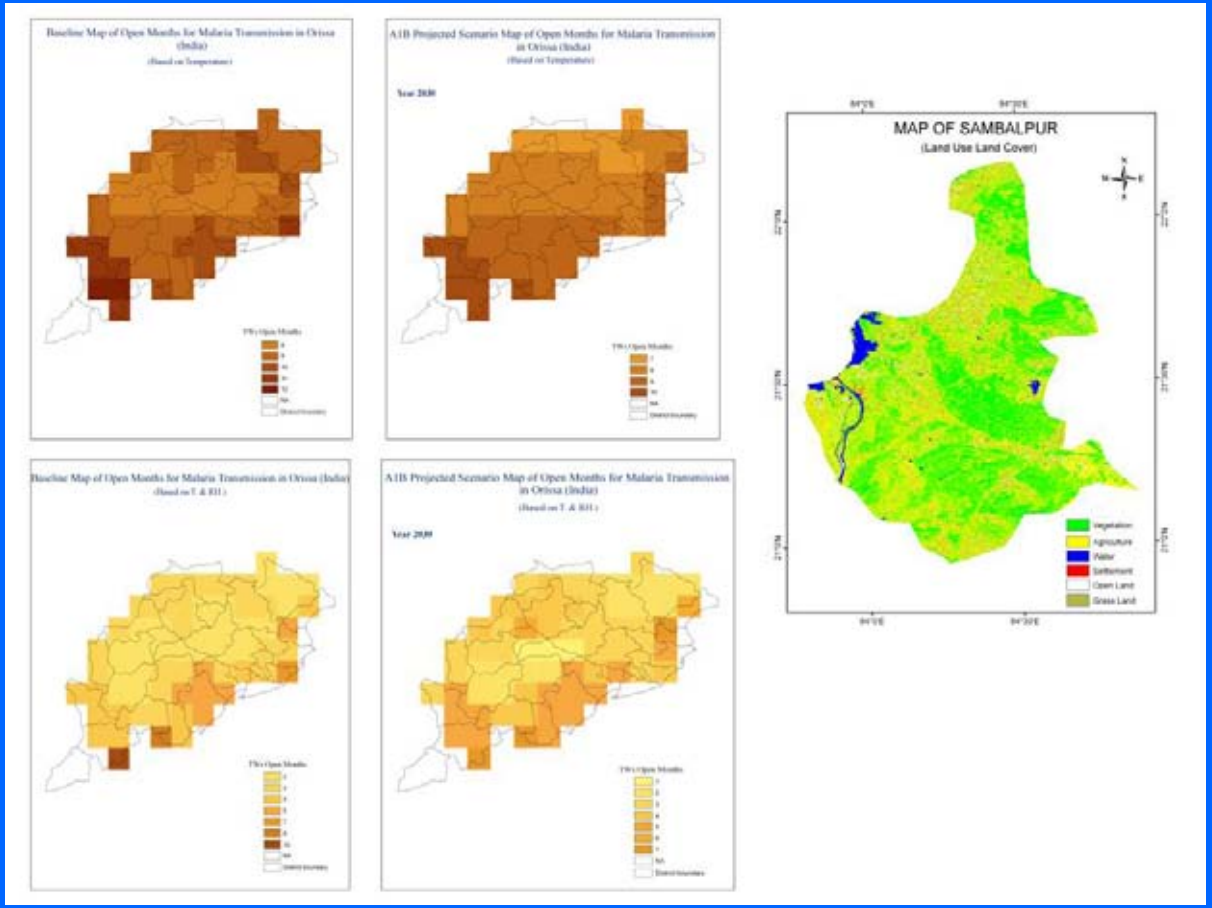
TWs of malaria in Himalayan region based on minimum required T and RH under (a) baseline and (b) projected scenario



Impact of CC in Himalayan region (based on T & RH)

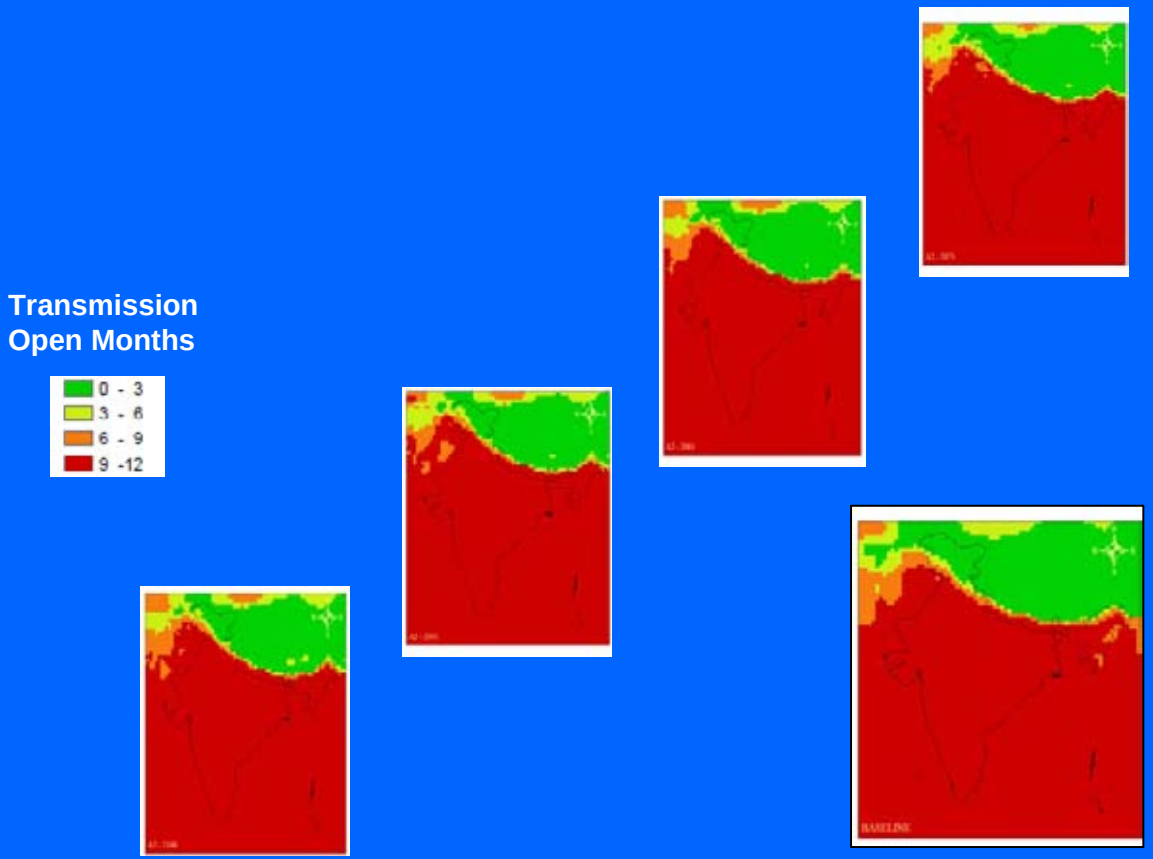
State	District	Baseline TWs	Projected	Additional months Open
Arunachal Pradesh	East Kameng (Seppa)	5	6	October
	Upper Subansiri(Dap.)	1	2	Aug.
	Upper Subansiri(Ziro)	2	3	September
	West Kameng (Bomdila)	3	4	September
	West Siang	3	4	September
Himachal Pradesh	Hamirpur	4	5	April, May
	Kangra	3	4	May
	Sirmaur	4	5	May, Oct
	Una	4	6	March, May
Jammu & kashmir	Anantnag	0	2	**July, Aug.**
	Jammu	4	6	March, May
	Udhampur	3	2	June
Sikkim	East District	4	5	September
	West District	3	4	September
Uttarakhand	Almora	4	5	May
	Bageshwar	0	1	June
	Garhwal	5	4	June
	U S Nagar	4	5	November
	Uttarkashi	1	2	**July, Aug.**
West Bengal	Darjeeling	7	9	Mar, Nov.
	Jalpaiguri	8	9	November

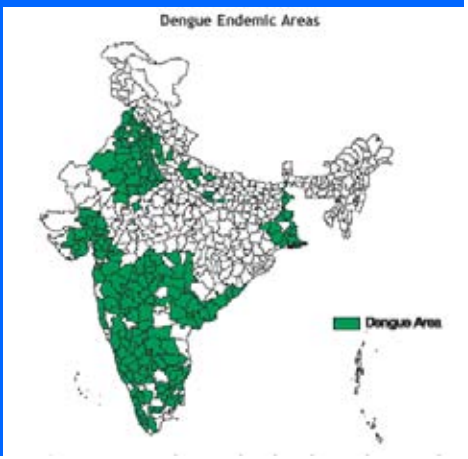
Projected impact of Climate Change on malaria in Sambalpur district (Odisha)



Projected reduction in TW by one month will not be affected as vegetation cover is present over endemic area.

Transmission Windows of dengue in baseline and projected temperature scenario (A2)

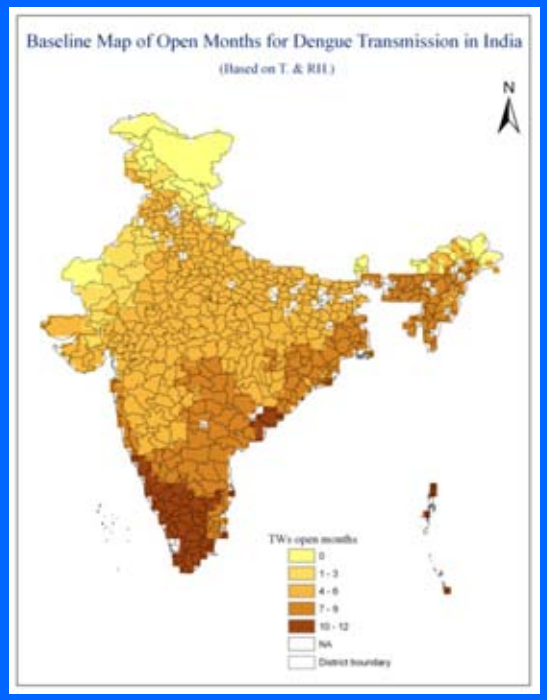


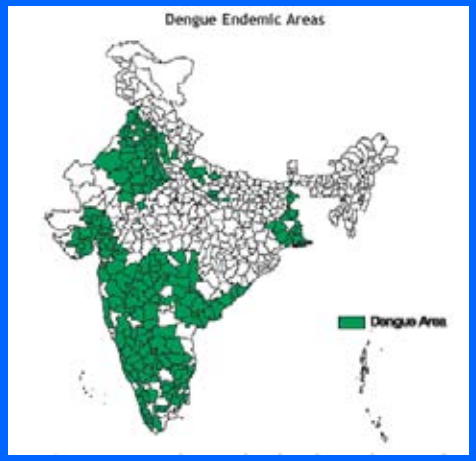


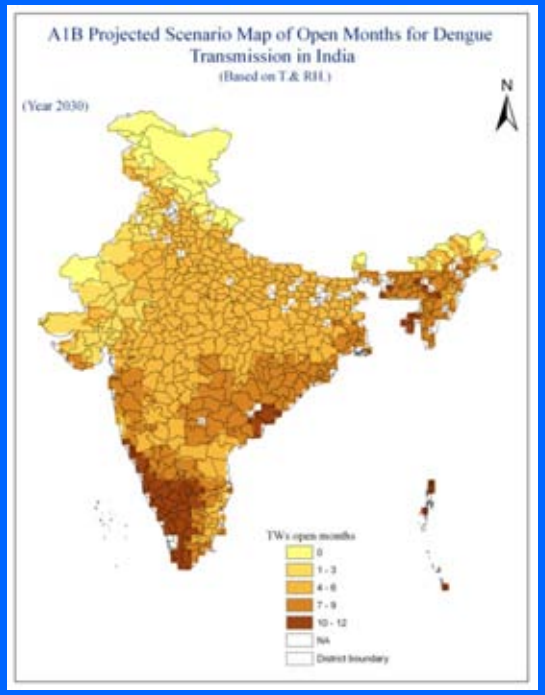
Climatically almost whole country is suitable; water availability and life style are major determinants.

TW Criteria : 12 to 40 C

Transmission Windows of dengue (A1B Scenario)







Projected by 2030

Baseline TW criteria: 12-32 C

Inconclusive, no matching with current distribution

Conclusion

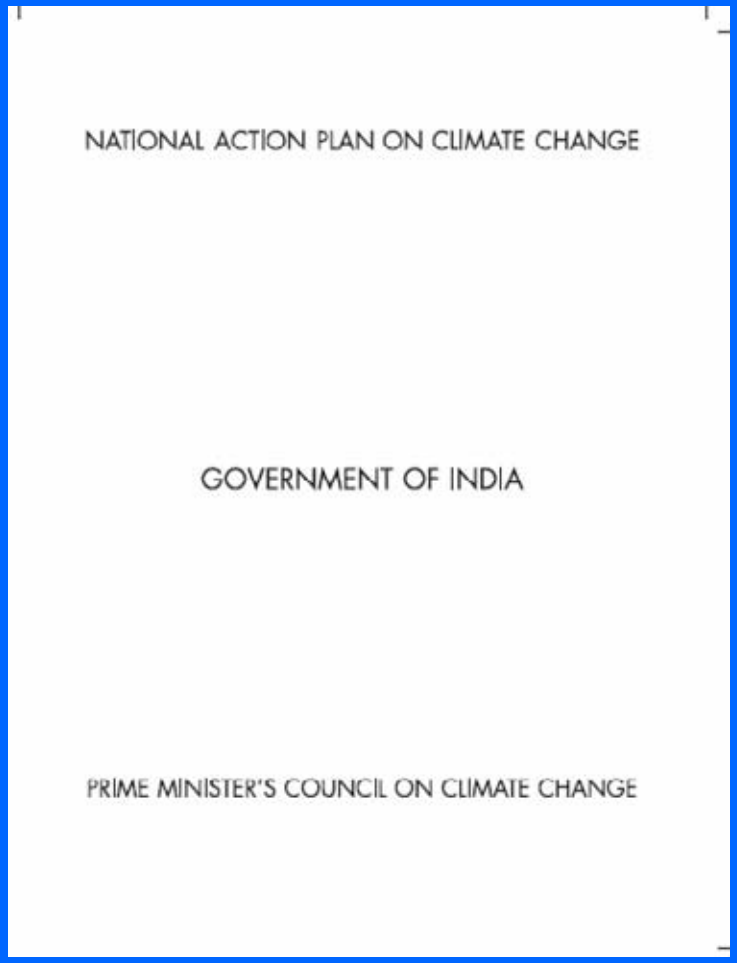
- Malaria is endemic in most of the districts of India. Projections based on temperature reveal introduction of new foci in Jammu & Kashmir and Uttarakhand.
- Increase in opening of more transmission months in districts of Himalayan region.
- North-eastern states are projected to rise in transmission intensity.
- Districts under Western Ghats are not likely to experience any change in TWs when determined based on temperature alone. But TWs based on T and RH show reduced intensity but increase in months of transmission.
- East coastal areas are projected to experience reduction in number of months open for transmission (but may not).

Limitations

- Since transmission dynamics of VBDs is affected by agricultural practices, deforestation, urbanization, socioeconomic conditions and intervention measures, projections may be viewed as plausible guidelines and not with certainty.

Adaptation measures required

National Action Plan on Climate Change



- **Provision of enhanced public health care service**
- **Assessment of increased burden of disease due to climate change.**
- **Providing high-resolution weather and climate data to study the regional pattern of disease**
- **Development of a high-resolution health impact model at the state level**
- **GIS mapping of access routes to health facilities in areas prone to climatic extremes**
- **Prioritization of geographic areas based on epidemiological data and the extent of vulnerability to adverse impacts of climate change**
- **Ecological study of air pollutants and pollen (as the triggers of asthma and respiratory diseases) and how they are affected by climate change.**
- **Studies on the response of disease vectors to climate change**
- **Enhanced provision of primary, secondary and tertiary health care facilities and implementation of public health measures, including vector control, sanitation, and clean drinking water supply.supply.**

www.pmindia.nic.in

Possible adaptation measures

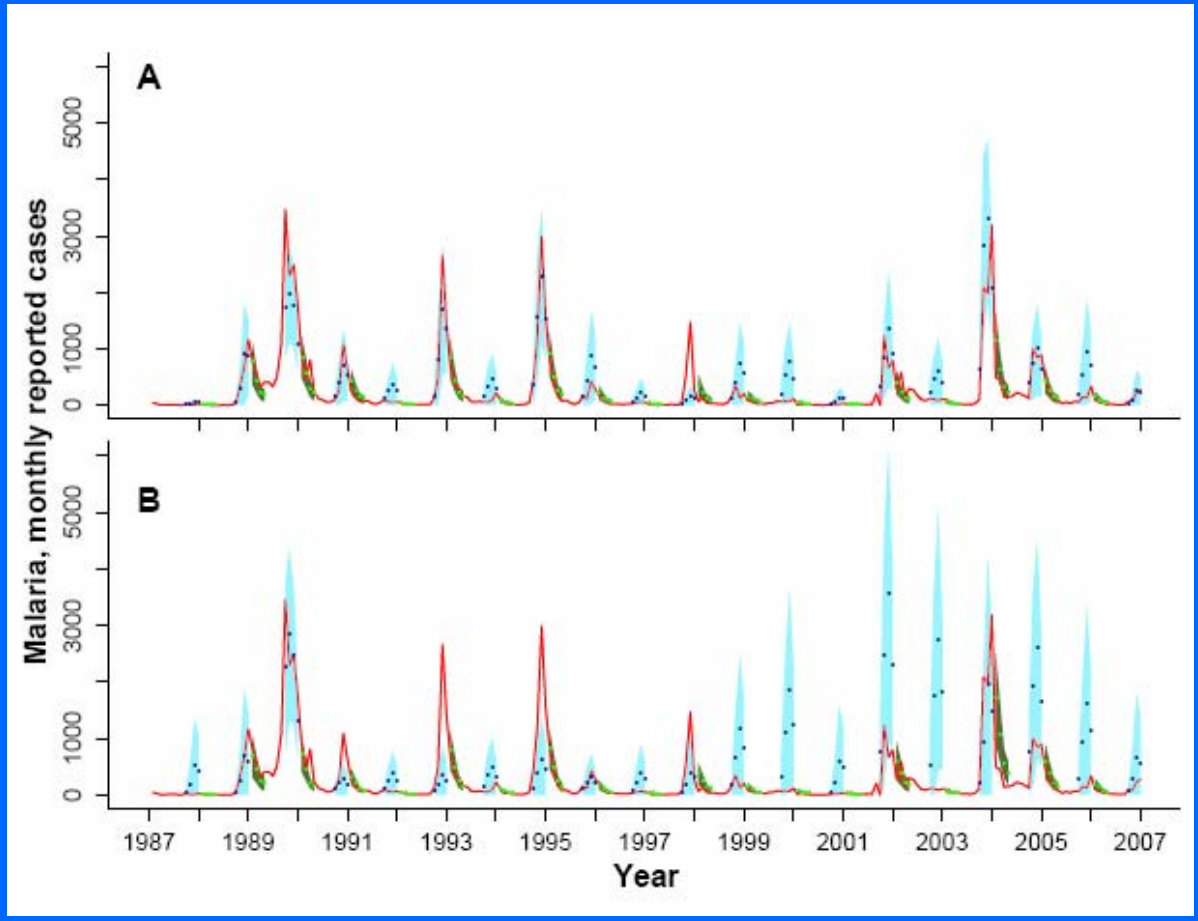
Researchable issues:

- Situation analysis for current strategies in vulnerable areas and in general.
- Assessment of impact of climatic factors on different species of disease vectors.
- Development of risk maps of Vector Borne Diseases
- Development of Early warning system

Strengthening of Health system & intervention strategies

- Shift in time of indoor residual spray and number of rounds
- Assessment of adaptive capacity of communities in vulnerable areas
- Health education to communities about prevention and control of VBDs
- Development of health infrastructure.

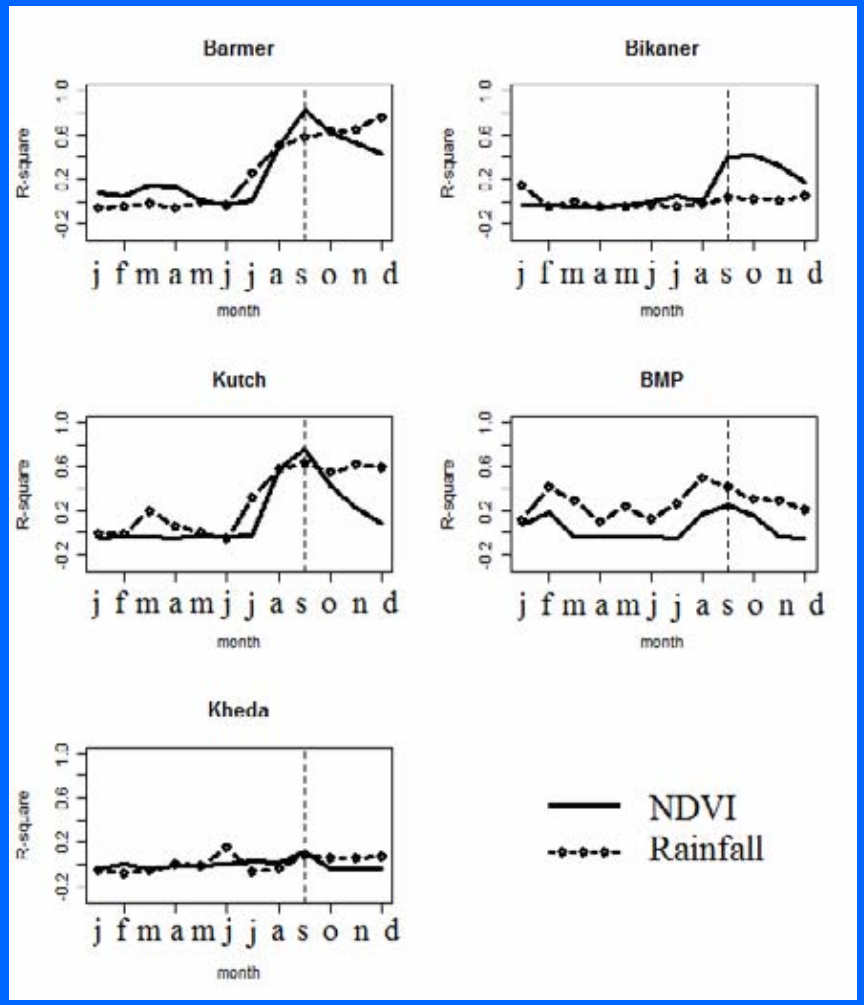
Prediction for the Epidemics of malaria in Kutch(India)



Accumulated rainfall from May to Aug. (blue dots) could predict malaria cases in Sept. to December (green dots) using VSEIRS model.

(Laneri et al PLoS Com. Biol. 2010)

Predictability power of NDVI v/s rainfall



The picture shows that NDVI is a better predictor than rainfall one month prior (September; dashed line) to the epidemic season (Oct-Nov-Dec) for Barmer, Bikaner and Kutch.

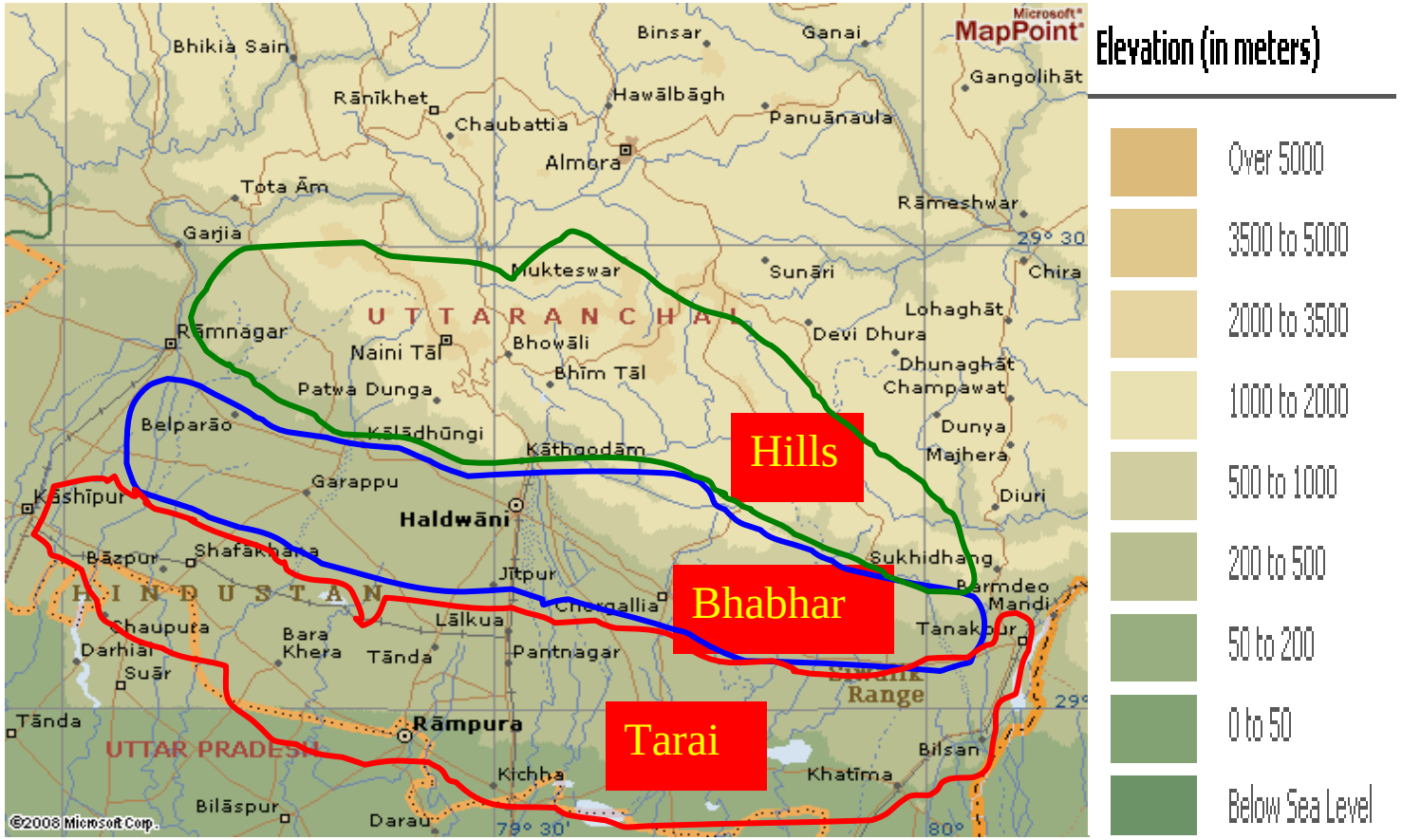
For BMP, rainfall from Banaskantha is a better predictor.

For Kheda, neither NDVI nor rainfall is a good predictor for the epidemics.

Baeza et al 2011)

Current observations

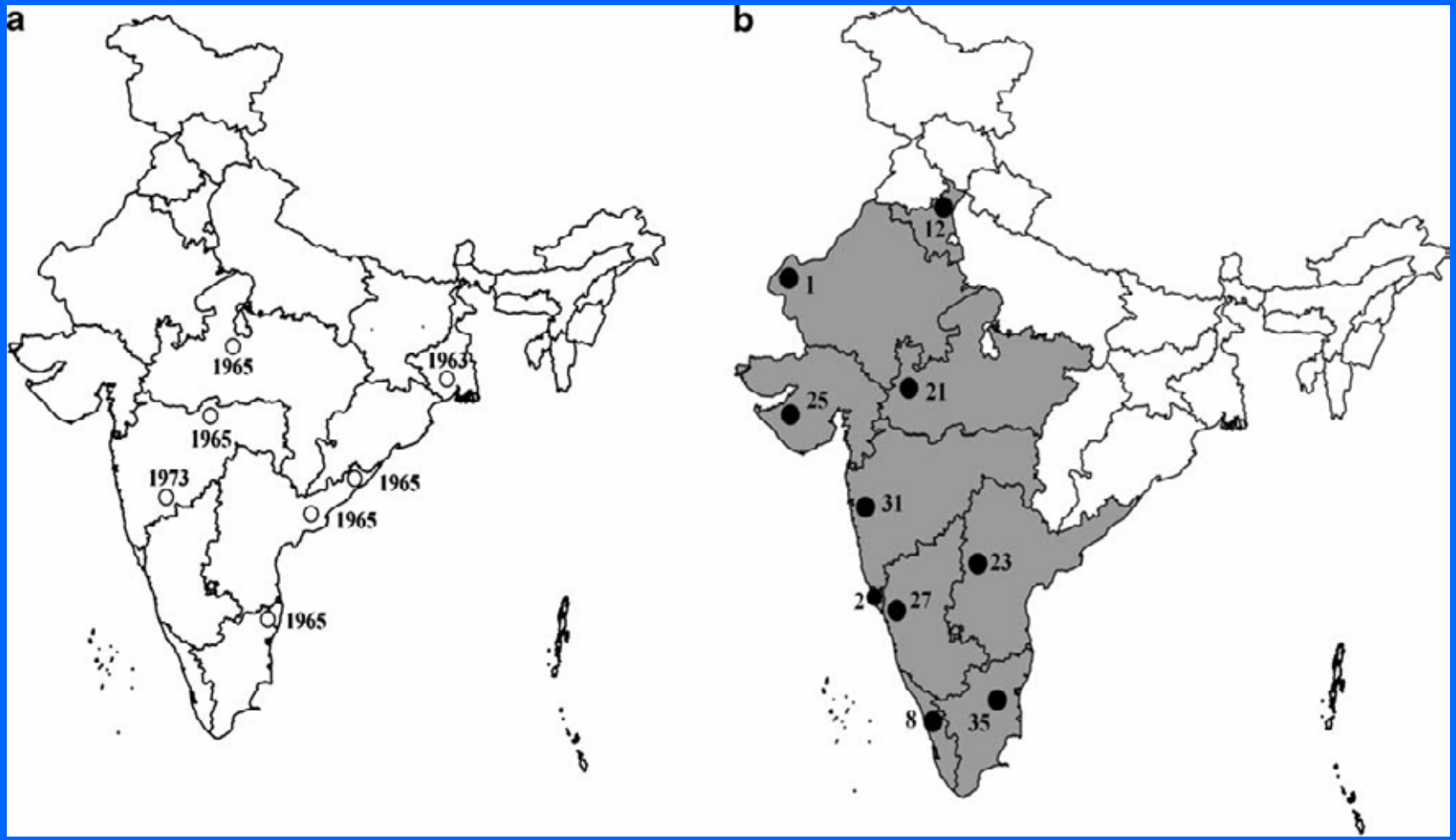
Distinct Physiography and malaria endemicity in District Nainital



API in 2007: Hills- 0 ; Bhabhar- 0.43 ; Tarai- 0.41

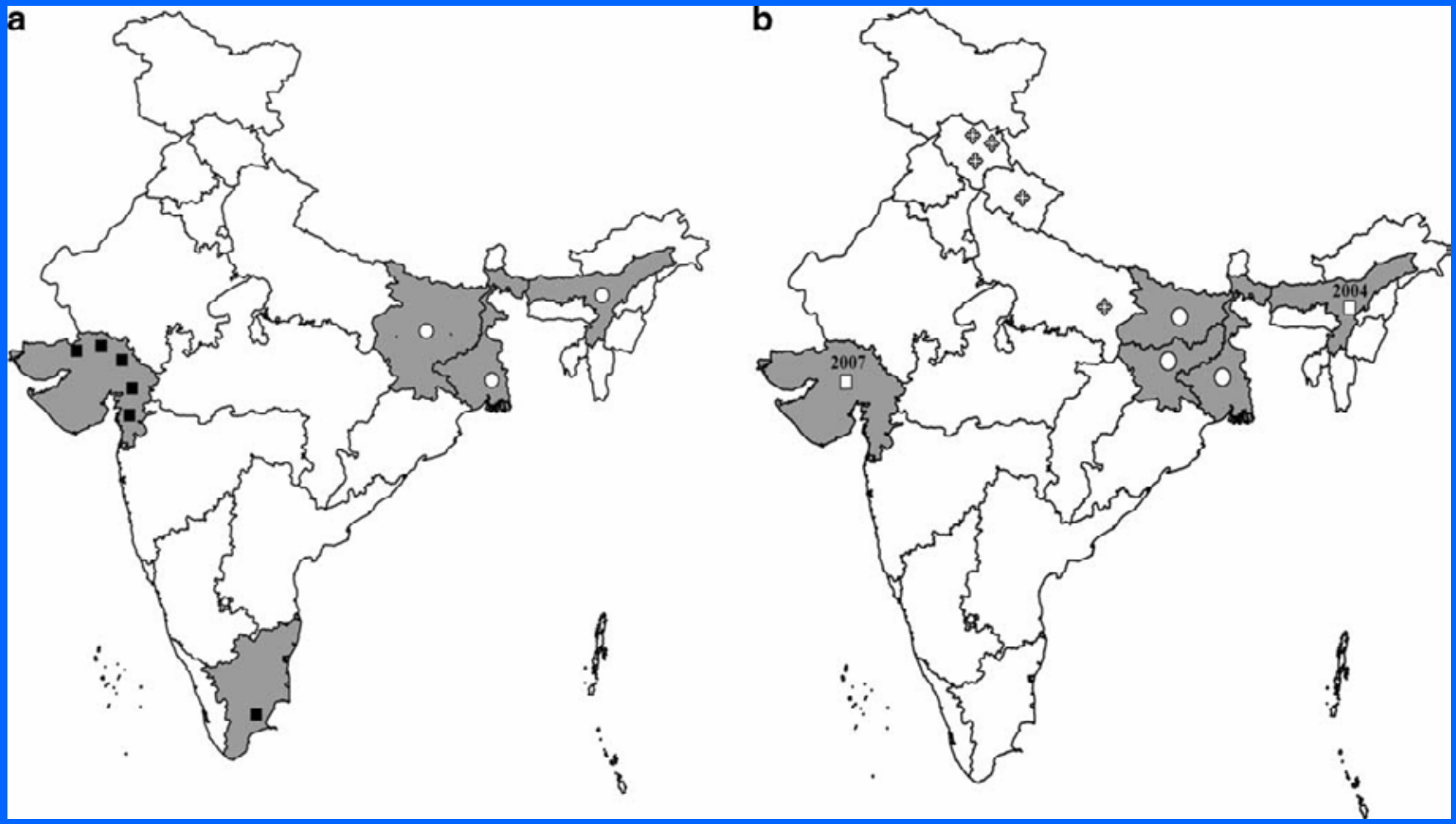
Cases reported from Hilly area also

Chikungunya in India



a Circles indicate old foci of chikungunya (till 1973) b. Filled circles indicate new foci of chikungunya (2005 onwards); figures indicate number of districts affected

Re-emergence of kala-azar in India

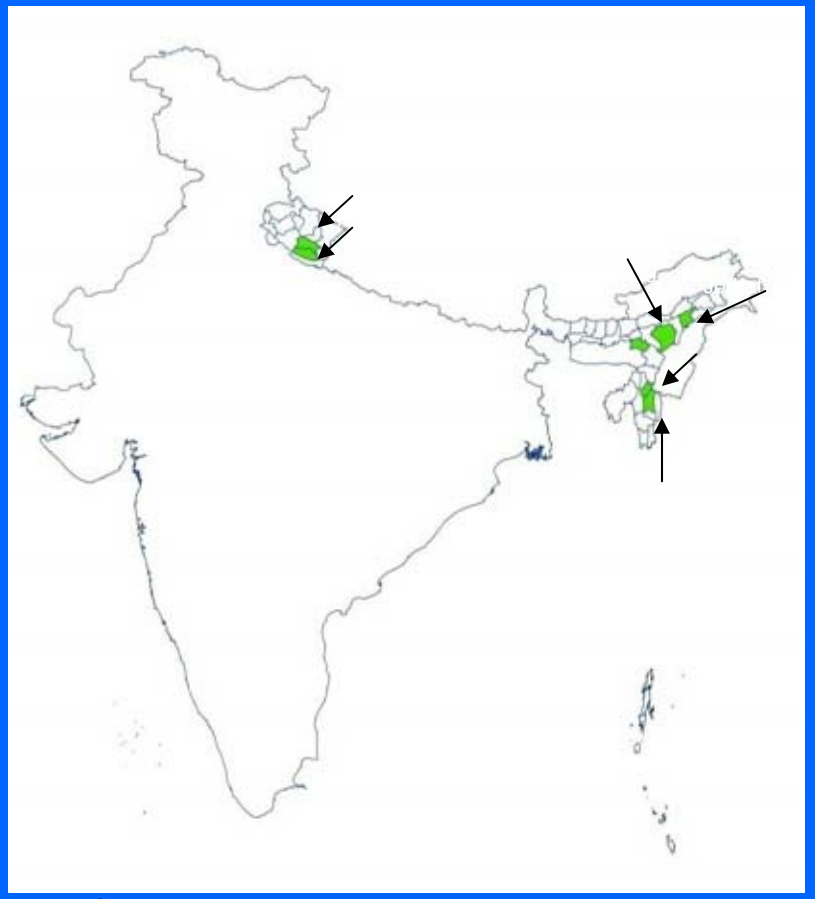


Circles indicate old foci of kala-azar; filled squares indicate kala-azar cases that occurred till 1982; squares indicate re-emergence of cases; rhombus indicate new foci of kala-azar after 1982

Dhiman et al 2010

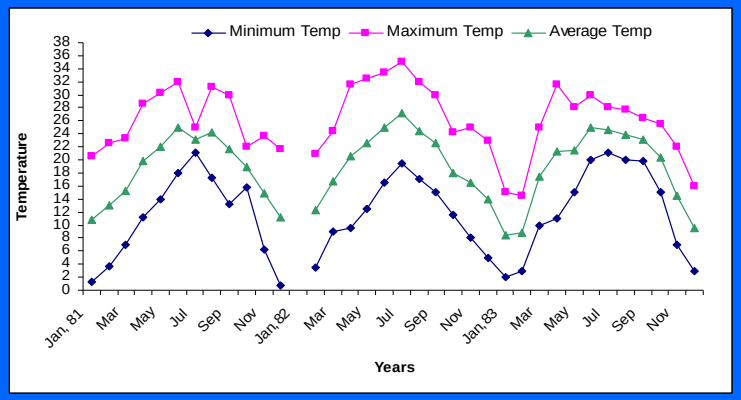
ICMR sponsored project

- Evidence based assessment of biophysical determinants of malaria in the north-eastern states of India and development of framework for adaptation measures for malaria control under climate change scenario

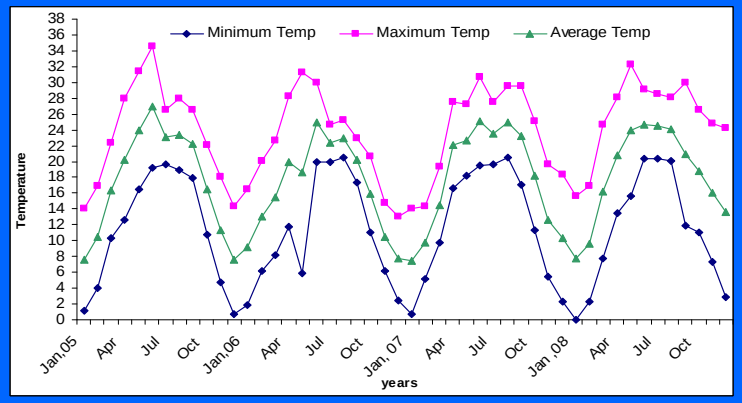


RC Dhiman: PI

Temperature of Bhimtal
(a. from 1981 to1983; b. from 2005 to 2008)



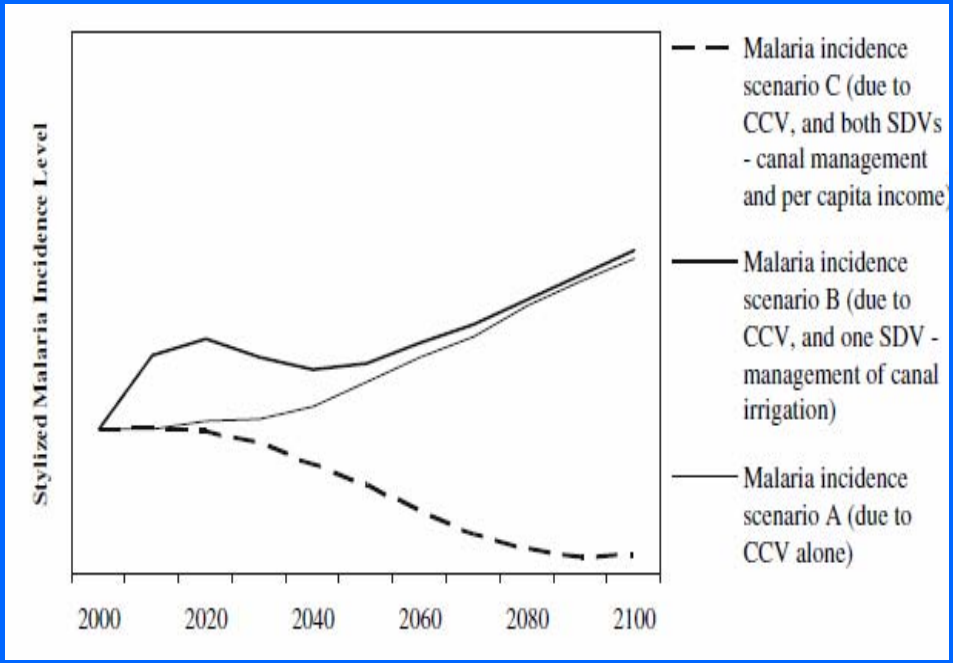
a



b

- Rise in minimum temperature in the month of March and April (up to 3.27^0C)
- Reduction in minimum temperature during winter months

Development and Malaria



- Sustainable development variables may sometimes reduce the adverse impacts on the system due to climate change alone, while it may sometimes also aggravate these impacts if the development variables are not managed well.
- Well crafted and well managed developmental policies could result in enhanced resilience of communities and systems, and lower health impacts due to climate change.,

(Garg, A, Dhiman, RC, Bhattacharya S(2009). Environ Management 43:779:789 DOI10.1007/s00267-008-9242-z52)

Way forward

- Refined assessments using min/max, diurnal/night temp and outdoor/indoor temp are required.
- Dengue and Chikungunya are resurging fast. Need understanding the relationship between climate and diseases and impact assessment.
- Leishmaniasis, JE and leptospirosis also need to be evaluated in the context of climate change.
- Plenty of scope for research.
- ICMR's Global Environmental Change and Health,MoEF &DST support research proposals.

Acknowledgement

- Manoj Pant
- Laxman Chavan
- Sharmila Pahwa
- MoEF and
- IITM Pune

Thanks for your kind attention