Environmental Factors: Vector Borne Diseases

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Outline or Presentation

- Basic definitions
- Burden of Vector Borne Diseases (VBDs)
- Epidemiological triad
- Environmental factors related to VBDs
- Climate change

What is environment?

- All that is external to the individual human host
- Environment provides the food people eat, the water they drink, the air they breathe, the energy they command, the plague and pests they combat and the mountain, seas, lakes, streams, plants and animals that they enjoy and depend upon
- Physical, biological, social, cultural and other dimensions of the environment commonly interact and influence the health status of individuals and populations

(Definition: Dictionary of Epidemiology, IEA)

Vector

- An insect or any living carrier that transports an infectious agent from an infected individual or its wastes to an susceptible individual
- The organism may or may not pass developmental cycle within the vector

Vector Borne Diseases

- Human illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice



Vector borne diseases

- Mosquitoes
  - Aedes: Chikungunya, Dengue fever, Rift Valley fever, Yellow fever, Zika
  - Anopheles: Malaria, Lymphatic filariasis
  - Culex: Japanese encephalitis, Lymphatic filariasis, West Nile fever
- Sandflies:
  - Leishmaniasis, Sandfly fever (phelebotomus fever)

Vector borne Diseases…

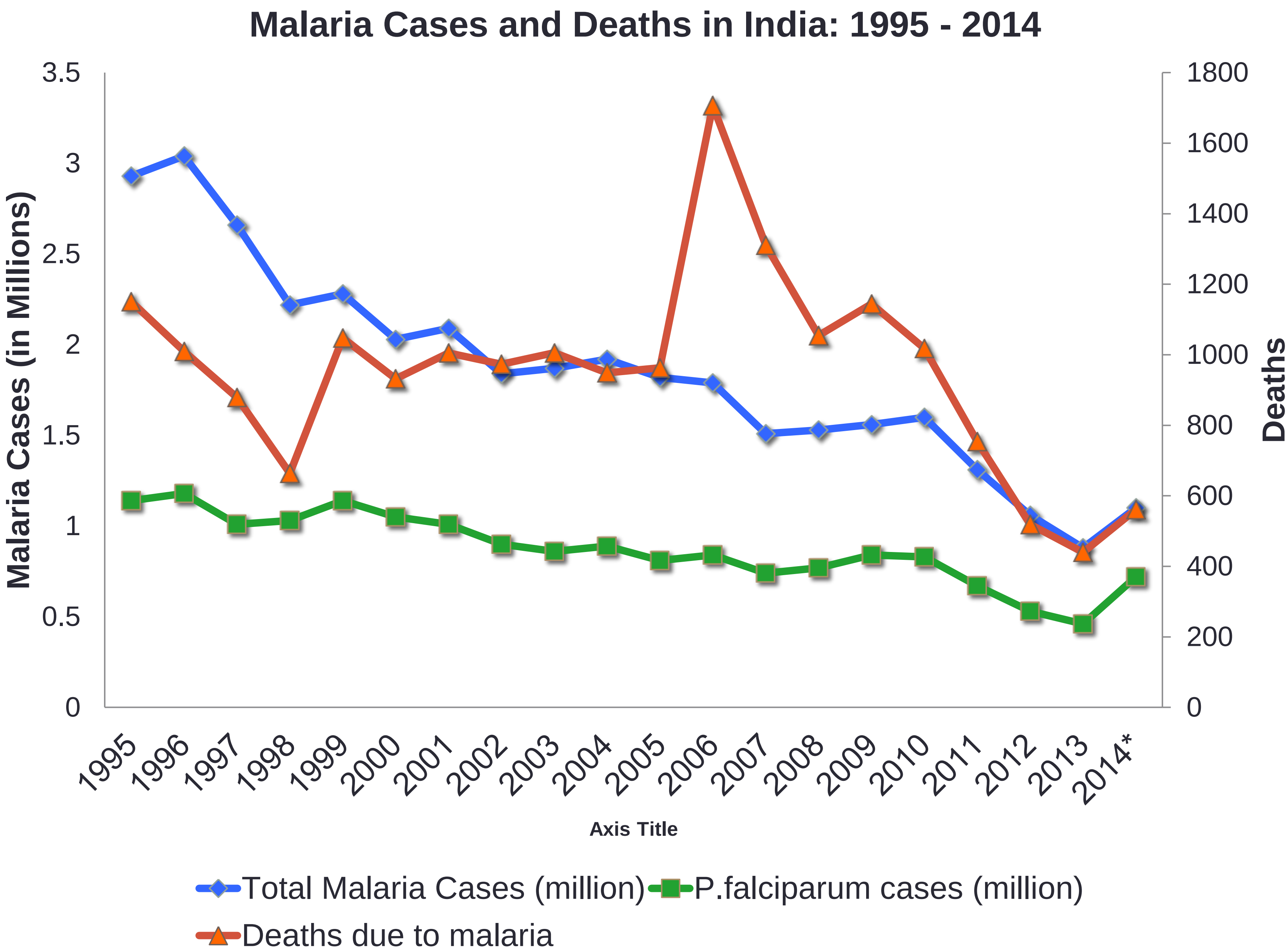
- Ticks:
  - Crimean-Congo haemorrhagic fever, Lyme disease, Relapsing fever (borreliosis), Rickettsial diseases (spotted fever and Q fever), Tick-borne encephalitis, Tularaemia,
- Fleas:
  - Plague (transmitted by fleas from rats to humans), Rickettsiosis
- Lice:
  - Typhus and louse-borne relapsing fever

Vector Borne Diseases…

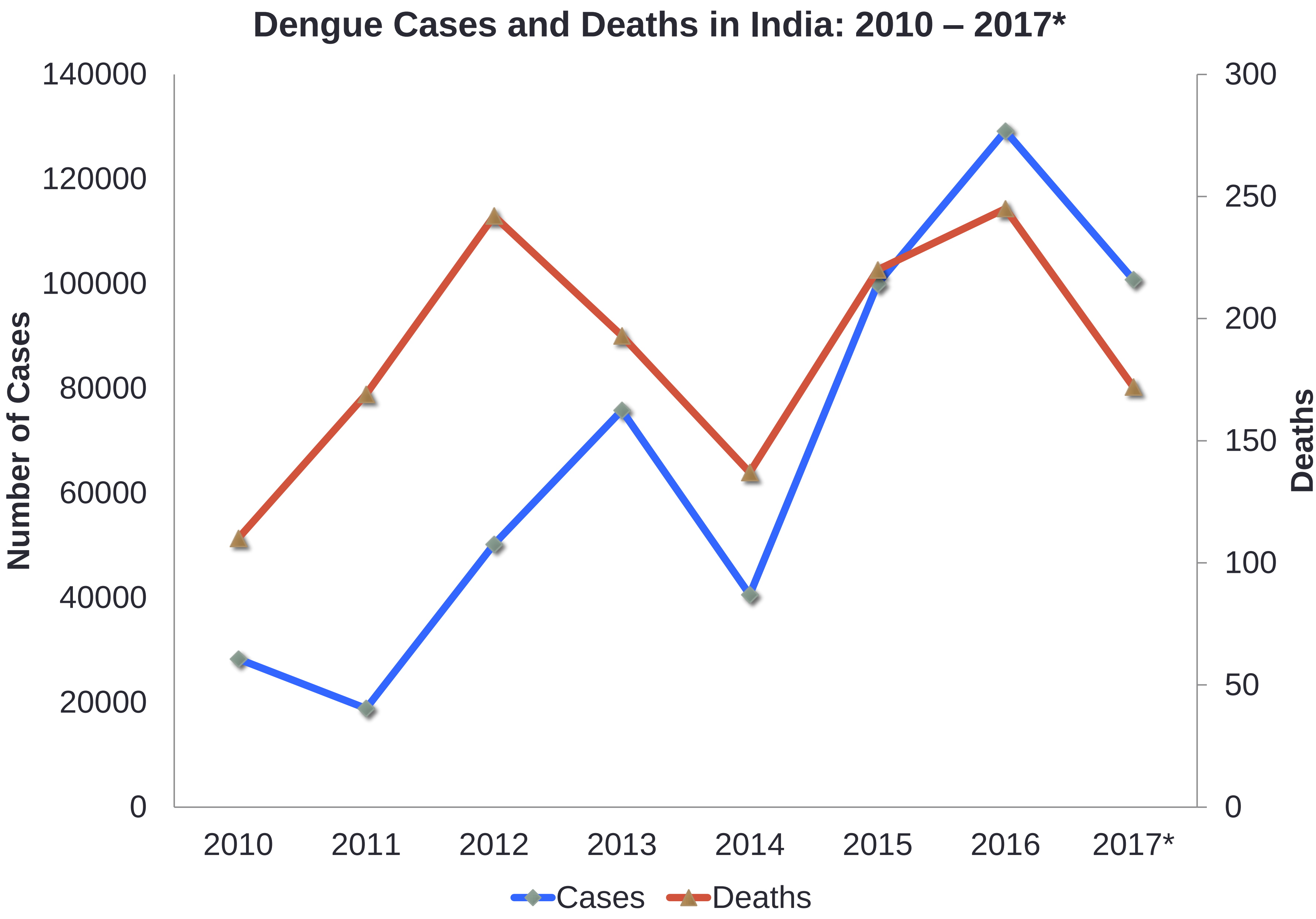
- Triatomine bugs:
  - Chagas disease (American trypanosomiasis)
- Tsetse flies:
  - Sleeping sickness (African trypanosomiasis)
- Black flies:
  - Onchocerciasis (river blindness)
- Aquatic snails:
  - Schistosomiasis (bilharziasis)

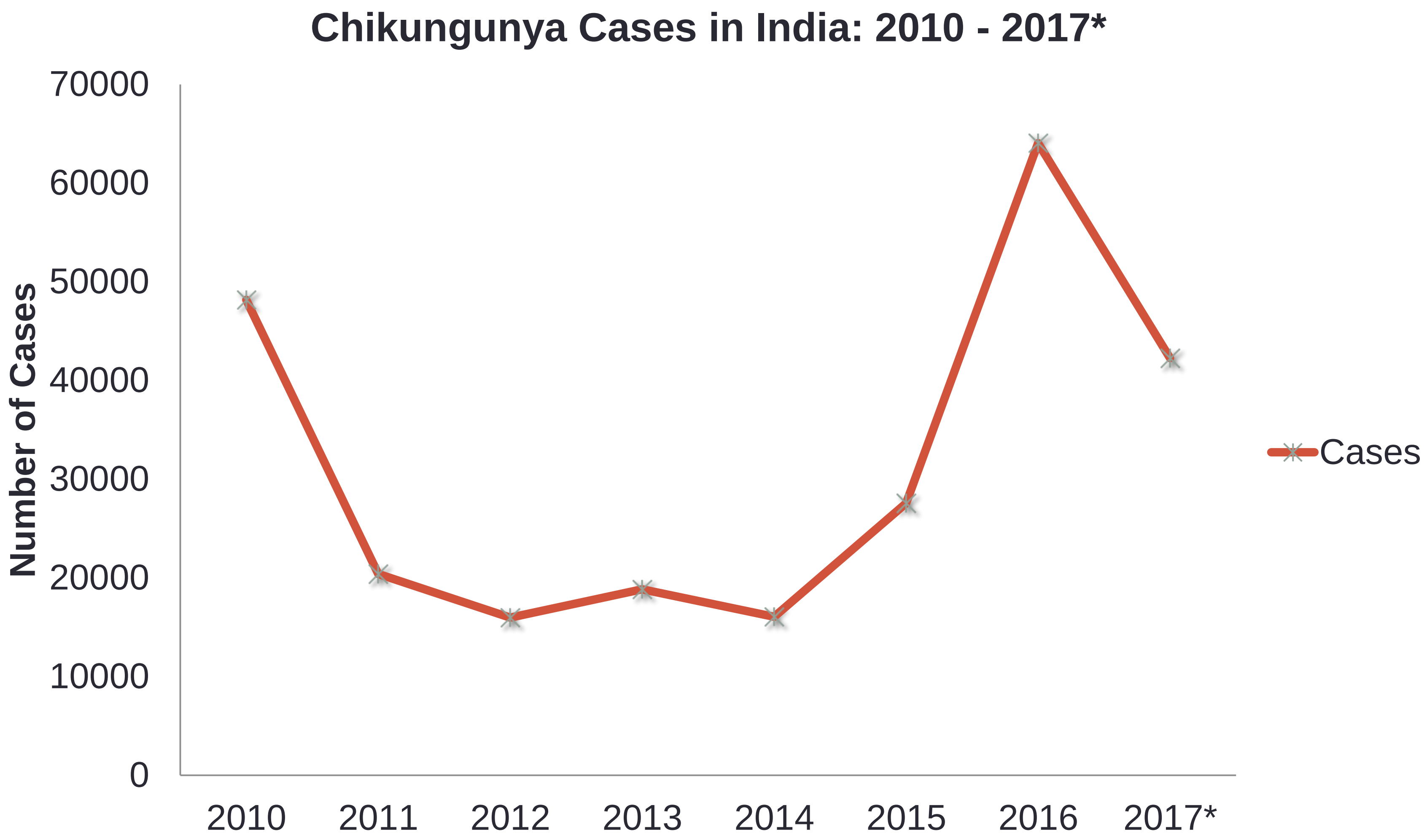
Burden of VBDs

- Vector-borne diseases account for more than 17% of all infectious diseases, causing more than 7,00,000 deaths annually.
- More than 3.9 billion people in over 128 countries are at risk of contracting dengue, with 96 million cases estimated per year.
- Malaria causes more than 4,00,000 deaths every year globally, most of them children under 5 years of age.
- Other diseases such as Chagas disease, leishmaniasis and schistosomiasis affect hundreds of millions of people worldwide

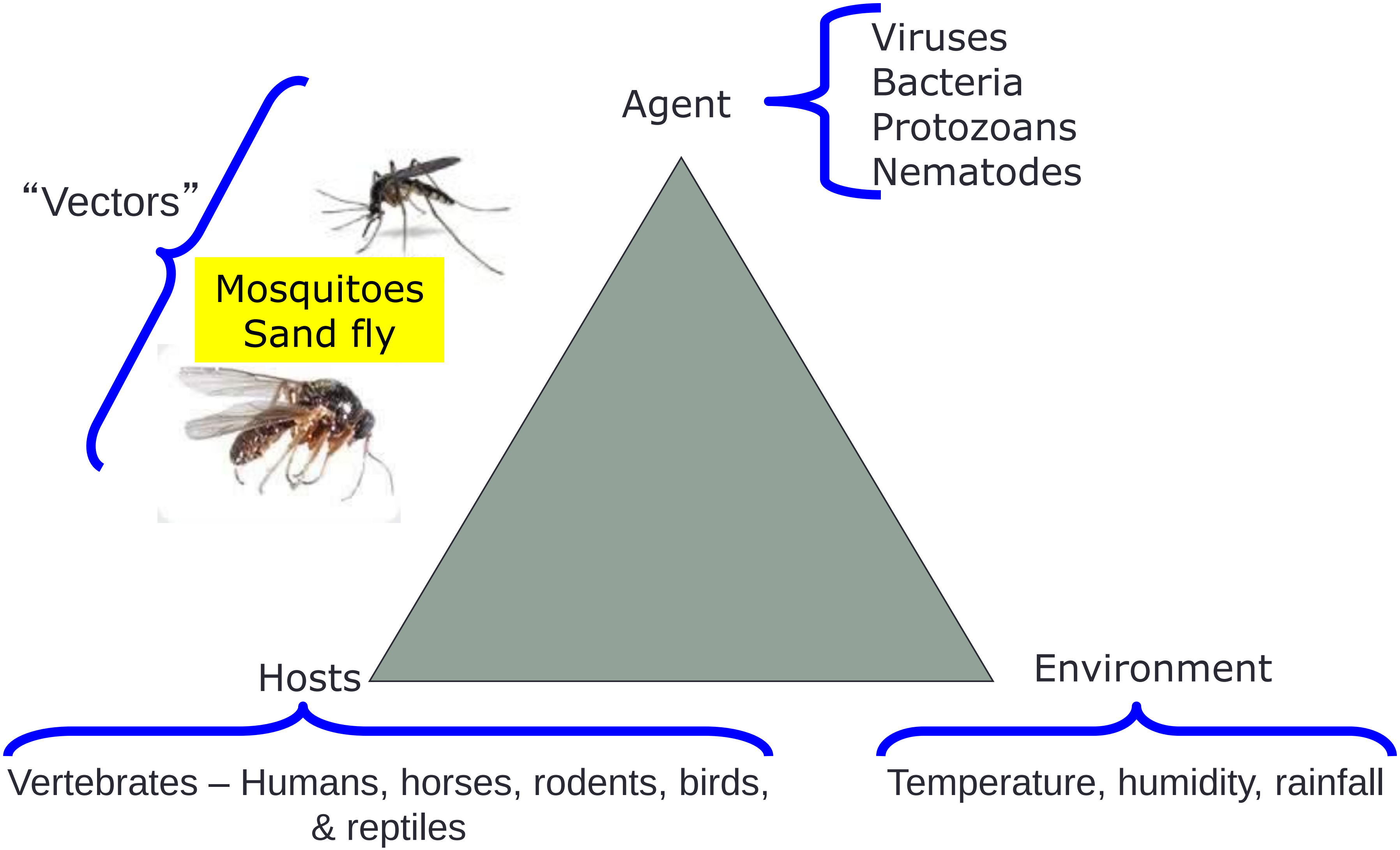


Malaria Cases and Deaths in India: 1995 - 2014
Malaria Cases (in Millions)
3.5
3
2.5
2
1.5
1
0.5
0
1800
1600
1400
1200
1000
800
600
400
200
0
Deaths
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014*
Axis Title
Total Malaria Cases (million)
P.falciparum cases (million)
Deaths due to malaria


Dengue Cases and Deaths in India: 2010 – 2017*
140000
120000
100000
80000
60000
40000
20000
0
Number of Cases
300
250
200
150
100
50
0
Deaths
2010
2011
2012
2013
2014
2015
2016
2017*
Cases
Deaths


Chikungunya Cases in India: 2010 - 2017*
Number of Cases
70000
60000
50000
40000
30000
20000
10000
0
2010
2011
2012
2013
2014
2015
2016
2017*
Cases

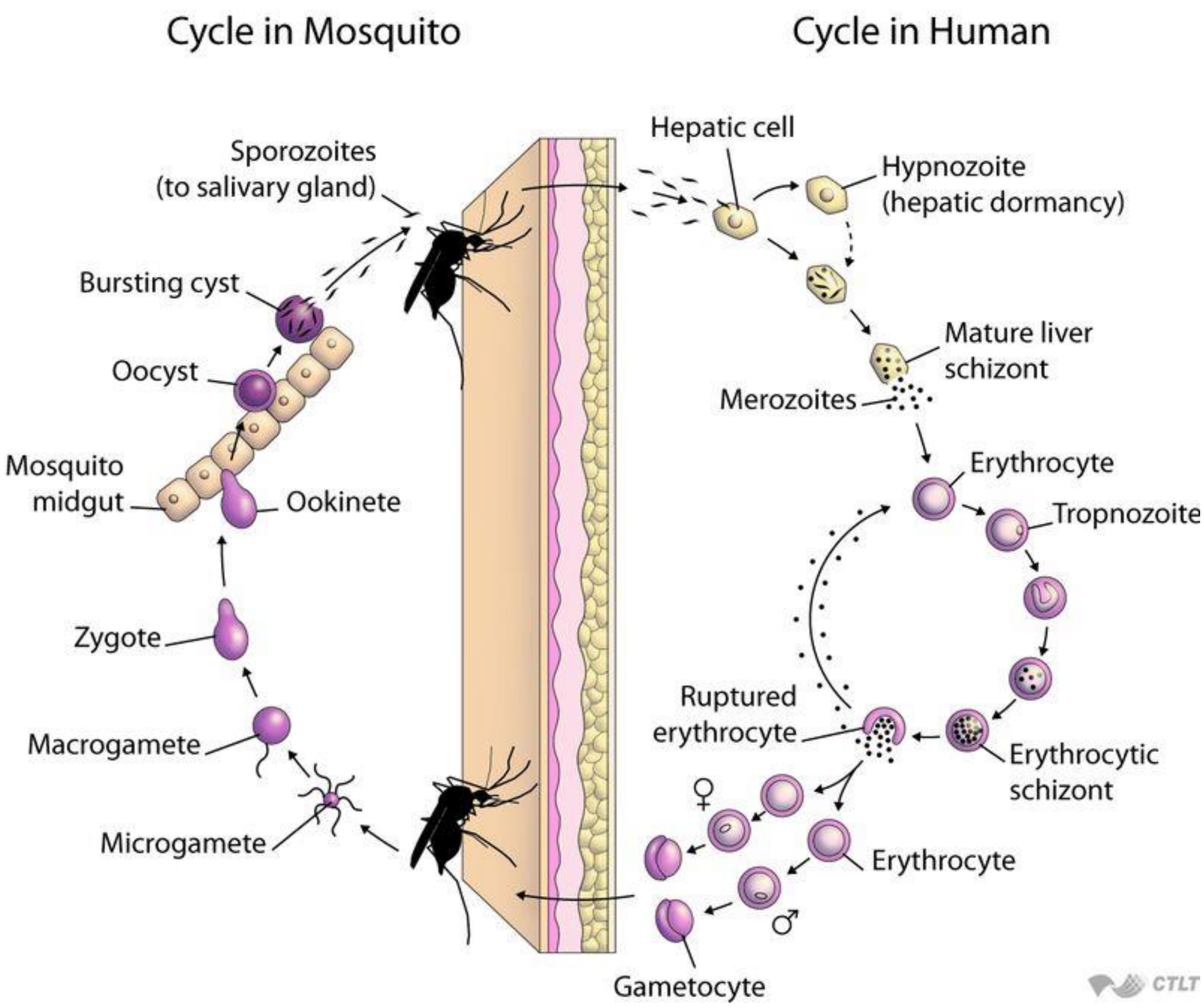
Epidemiological Triad



Vectorial Capacity

- The potential for a population of mosquitoes to transmit of a vector borne disease like malaria (Vectorial Capacity) is determined by :
    - ratio of mosquitoes : humans
    - mosquito bites /day
    - daily mosquito survival probability
    - parasite extrinsic incubation period
    - vector competence

Life Cycle of Plasmodium



Environmental Factors in VBDs

- Importance of ecological factors in the emergence of VBDs: Early 1935
- *"need to have a thorough knowledge of breeding places and habits and to apply the most suitable methods to the situation"* – Klinger

Environmental Factors related to VBDs

1. Deforestation
2. Agriculture and animal husbandry
3. Water control projects
4. Urbanization
5. Loss of biodiversity
6. Introduction of alien species
7. Climate change

Deforestation

- Altered vegetation
- Introduction of livestock
- Development of human settlements
- Loss of biodiversity
- Forest related activities: Exposure to vectors of Malaria, Yellow fever, Leishmaniasis

Deforestation

- Creation of ecological niches favourable for vector proliferation
  - Water puddles in deforested land have lower acidity and salinity favourable for breeding of certain species of Anopheles
  - Increased Malaria transmission in deforested areas due to altered biting habits of Anopheles spp: Amazon
  - Black fly vectors of Savannah cause severe form than black fly vectors of forest region

Agriculture and Animal husbandry

- Availability of farm animals
  - Additional feeding options leading to growth of vector population and in turn increased frequency of frequent feeding on humans
  - Potential reservoir hosts resulting in wide spread disease
  - Eg: Transmission of JE in SE Asia and western Pacific

Rice fields: Environmental Niche for Japanese Encephalitis

Agricultural and Animal Husbandry

- Changes in land cover effects micro climates
  - Eg: Replacement of swamp vegetation by agricultural land causes raise in temperatures leading to increased risk of Malaria

Water Control Projects

- Dams and Canals: Breeding sites for mosquitoes
  - Eg: Emergence of Plasmodium falciparum malaria in the Thar Desert of India coincided with the construction of irrigation canals
  - Outbreak of schistosomiasis affecting thousands of people occurred after the construction of the Diama Dam on the Senegal River
- Settlers can inadvertently bring infection to the community who might have had little or no immunity

Urbanisation

- Direct effects by conversion of natural habitat into human settlements
- Indirect effects by waste generation
- Expanding cities encroaching upon neighboring environments may increase exposure to some vectors and nonhuman hosts of vector borne diseases. Eg: Yellow fever, trypanosomiasis, and Kyasanur Forest disease

Urbanisation

- Migrants to new areas may lack immunity to the prevalent endemic vector borne diseases
- Migrants may introduce new pathogens and vectors to their resettled locations
- Inadequate clearance of standing water collected in used containers and tires etc, facilitating mosquito vector reproduction. Eg: Dengue, yellow fever
- Eg: Spread of visceral Leishmaniasis from rural to urban areas in Brazil

Loss of Biodiversity

- The threats to biodiversity from human activities include stratospheric ozone depletion; pollution; introduction of invasive species; global warming; and most important, habitat degradation
- Reduction in global biodiversity is likely to contribute to vector borne disease transmission
  - Biodiversity protects against VBDs because of dilution effect
  - Eg: Low incidence of Lyme disease in areas with high biodiversity

Introduction of Alien Species

- Introduction of non indigenous species because of air and sea travel
- Eg: Aedes albopictus in America
- A.albopictus was implicated as a vector of the chikungunya virus on several Indian Ocean islands involved in a 2006 chikungunya fever outbreak

Climatic Factors Influencing VBDs

- Temperature
- Relative Humidity
- Rainfall

El Nino Phenomenon

- The El Nino phenomenon, cycling with a frequency of every 2-7 years
- Strongest driver of weather variability in many regions of the world
- Resulting in drought in some regions of the world and flooding in others
- El Nino- Triggers natural disasters & related outbreaks of infectious diseases (Malaria, Cholera)

Climate Change

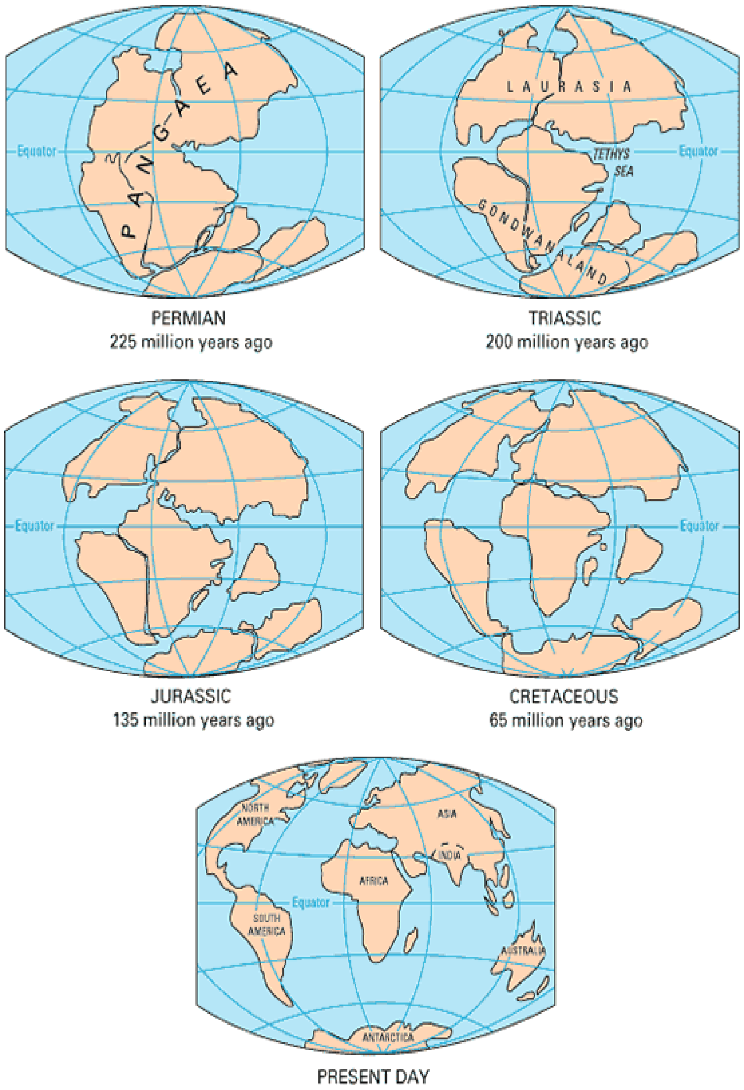
- A statistically significant difference noted either in the mean state of the climate or in its variability, persisting for an extended period (decades or longer)

- Natural factors contributing to climate change:

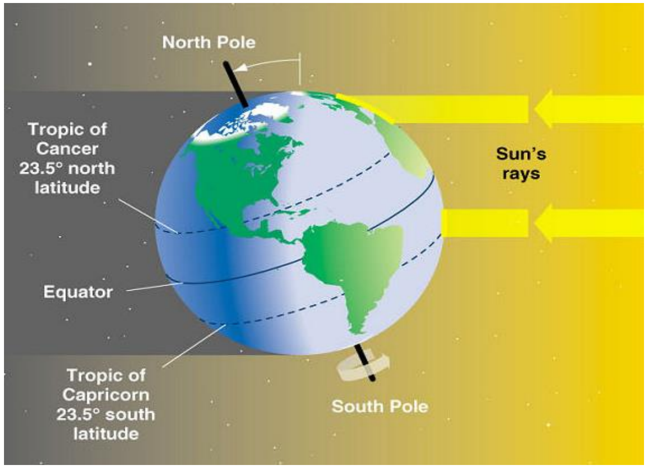
- Glaciation

A schematic of modern thermohaline circulation

- Volcanoes

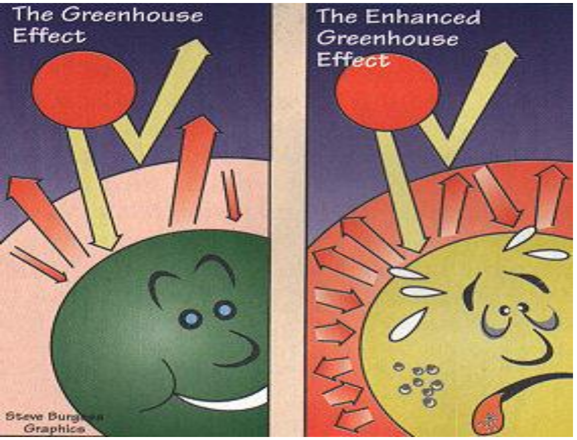


- Continental drift



- The Earth's Tilt

Anthropogenic factors driving climate change:



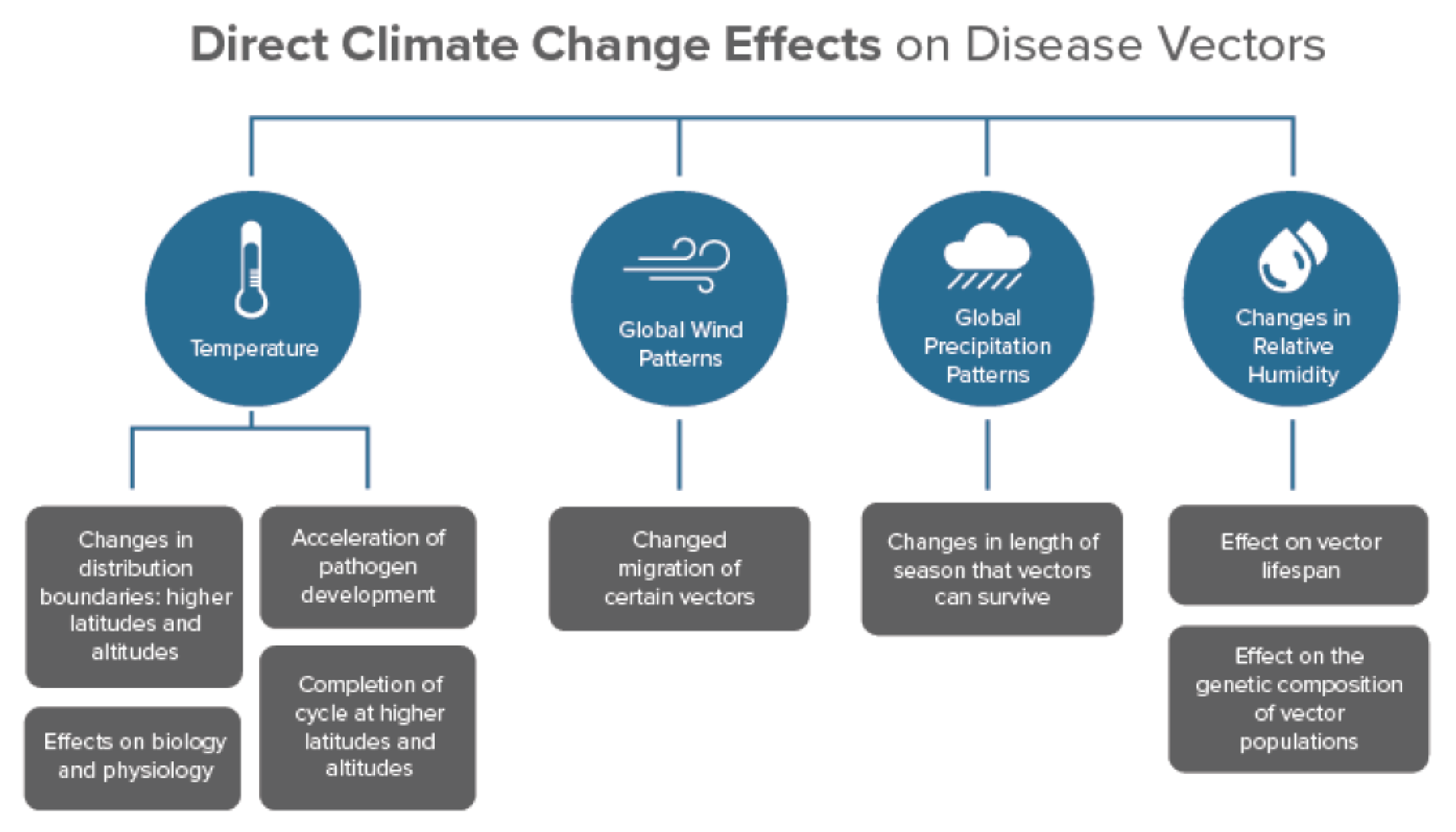
Greenhouse effect

Deforestation

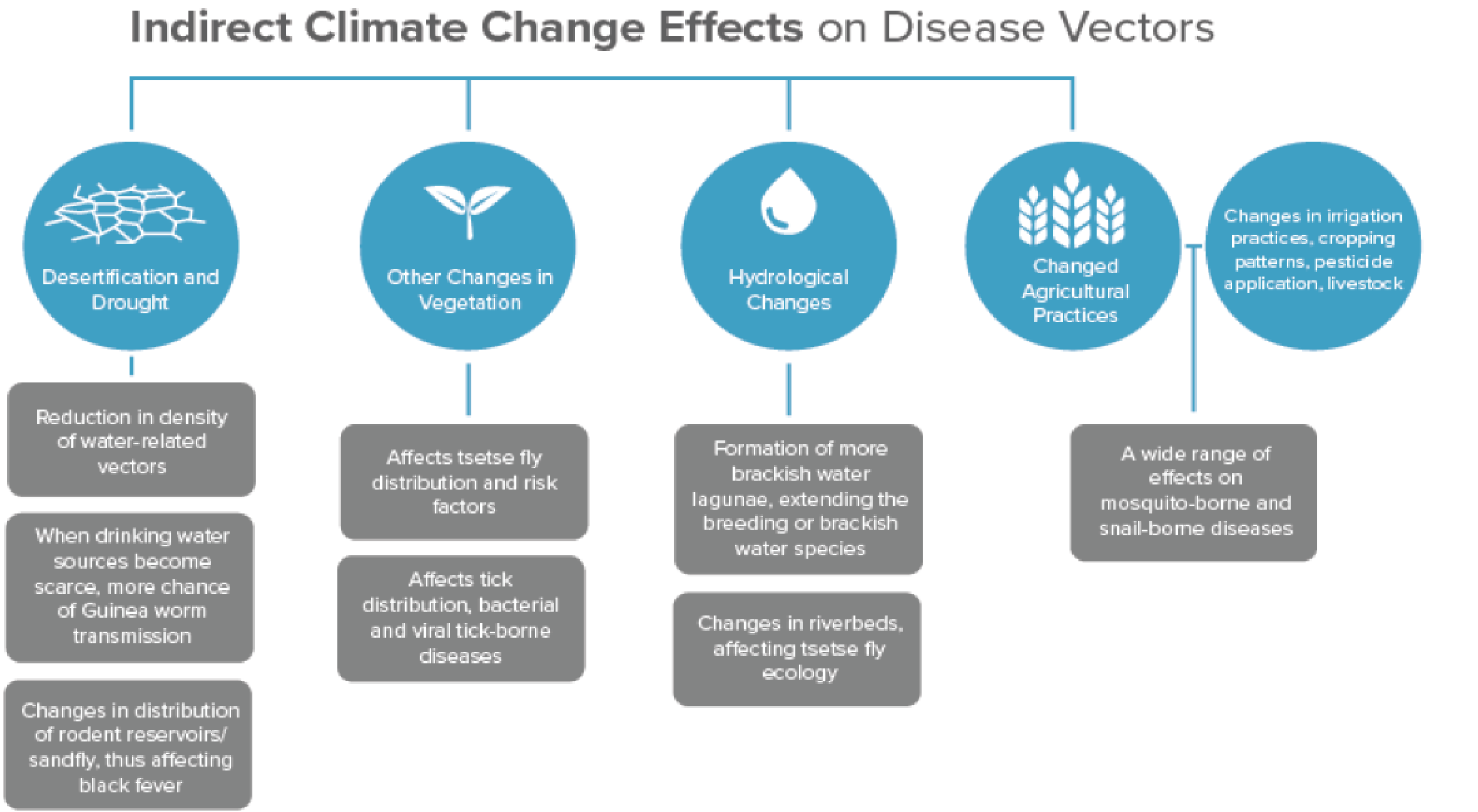
Land use

Livestock

Aerosols



http://climatenexus.org/climate-issues/health/climate-change-and-vector-borne-diseases/



http://climatenexus.org/climate-issues/health/climate-change-and-vector-borne-diseases/

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

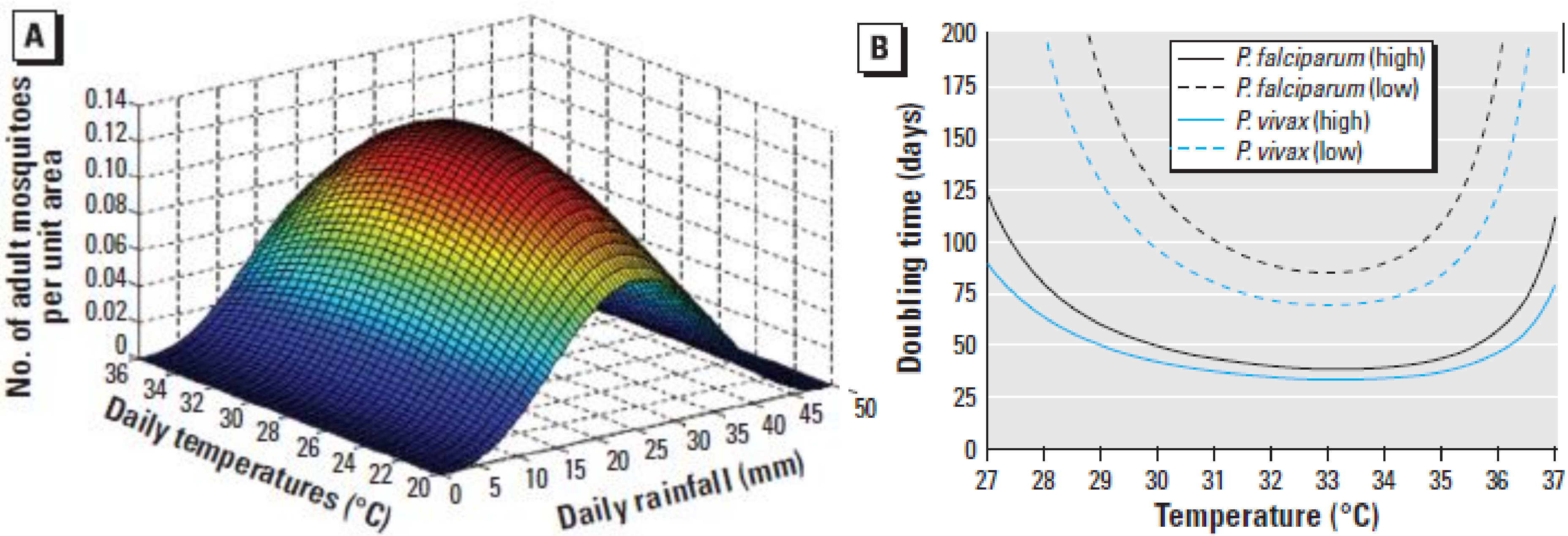
Climate Change and VBDs

- For many diseases minimum tempartures lie in the range 14–18º C at the lower end and 35–40º C at the upper end
- Warming in the lower range has a significant and non-linear impact on the extrinsic incubation periodand consequently disease transmission, while, at the upper end, transmission could cease
- At around 30–32 º C, vectorial capacity can increase owing to a reduction in the extrinsic incubation period, despite a reduction in the vector's survival rate.

Climate change and VBDs

- Increased precipitation has the potential to increase the number and quality of breeding sites for vectors such as mosquitoes, ticks and snails, and the density of vegetation, affecting the availability of resting sites
- Small change in larval diet leads to **45-fold difference in transmission potential**

Effect of temperature and rainfall on mosquito population and *Plasmodium species dynamics*



Effect of temperature and rainfall on mosquito population and *Plasmodium species dynamics. (A) The mean number of mosquitoes per unit area as a function of temperature and rainfall. (B) Estimated doubling times of P. falciparum and P. vivax; high and low refer to vector density values*

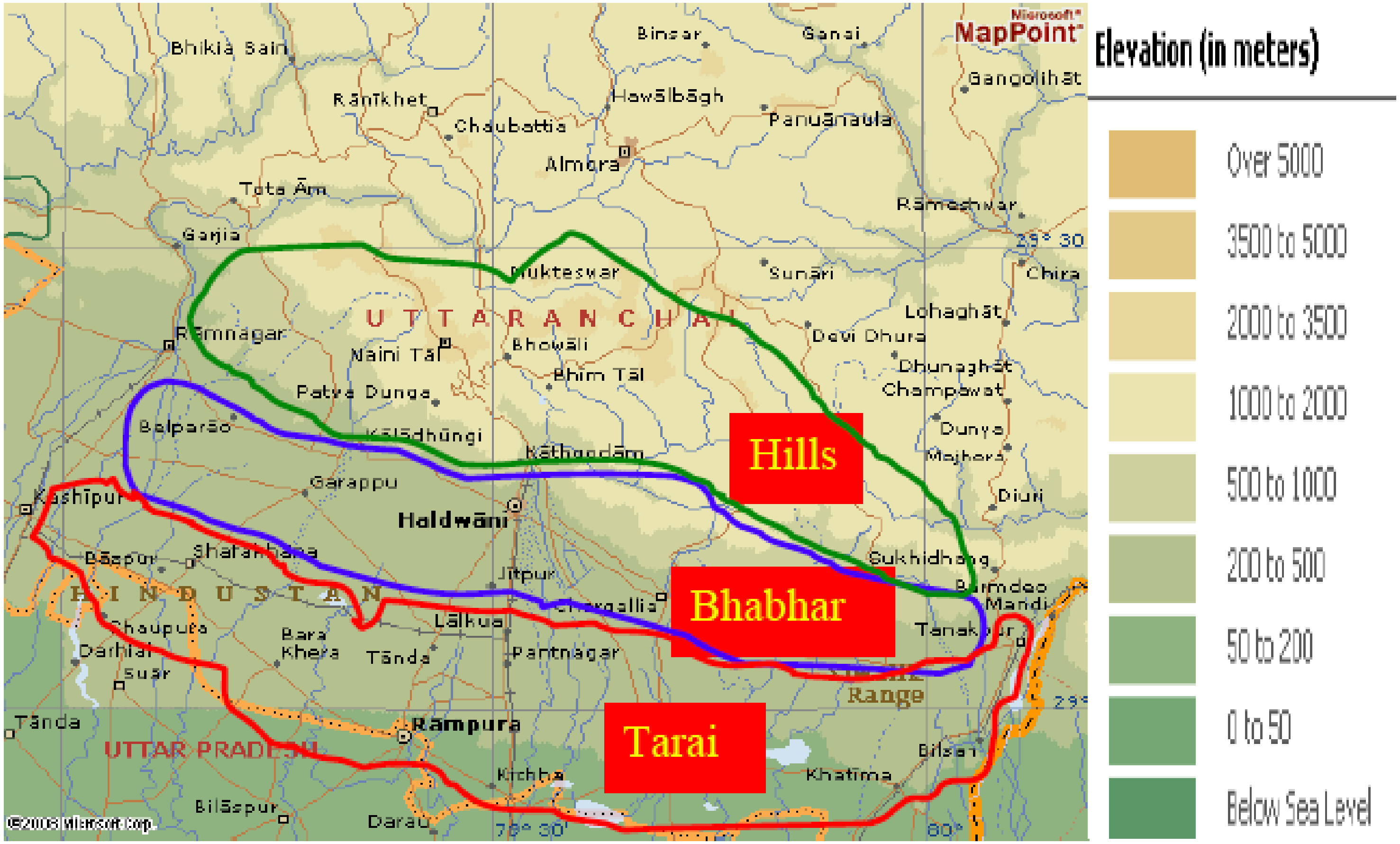
Source: Parham and Michael (2010) Environmental Health Perspectives 118: 620-627

EFFECT OF CLIMATE CHANGE ON VBDS IN INDIA

Source: Climate Change and Vector

Borne Diseases: Dr. R C Dhiman, NIMR

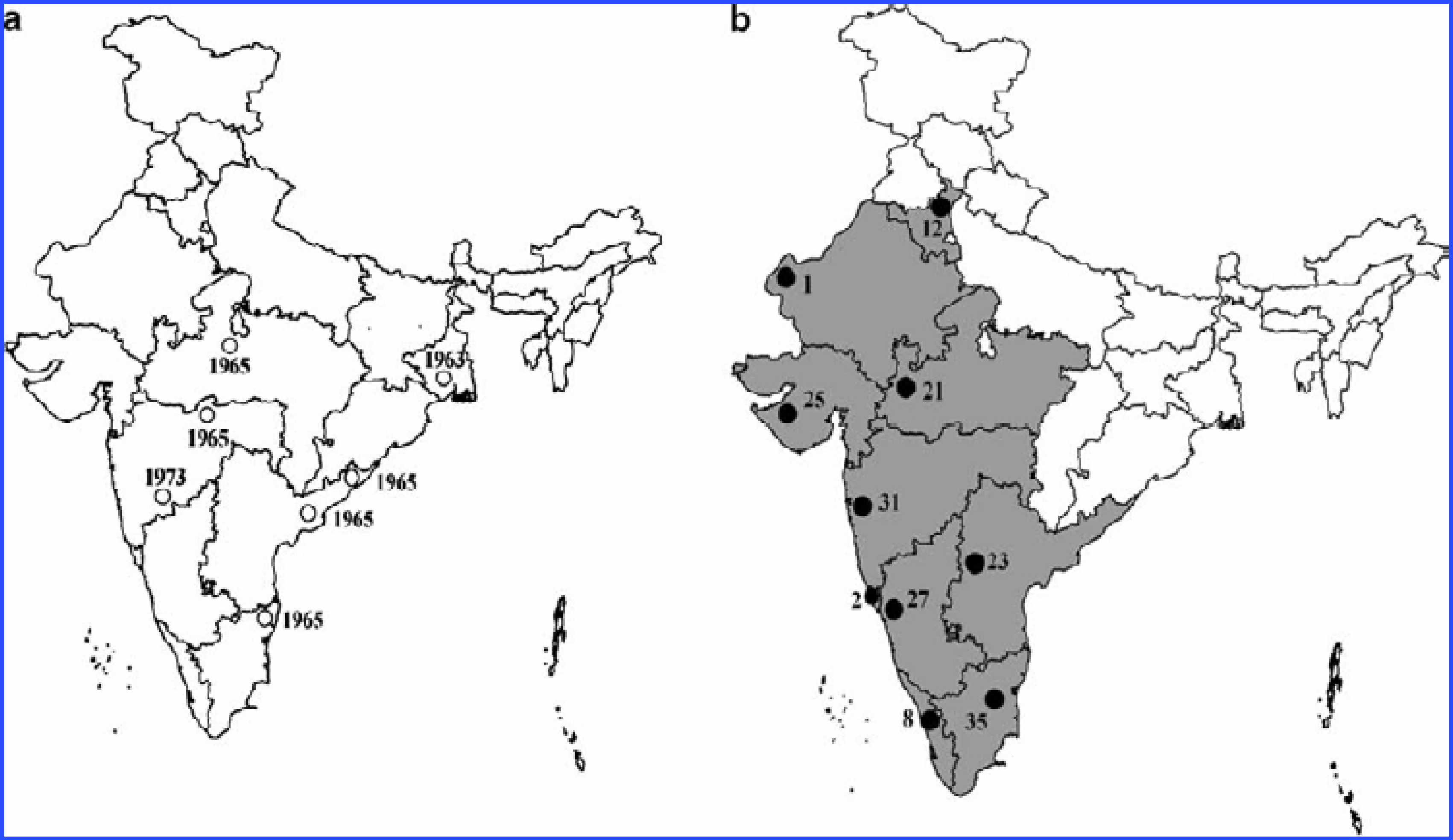
Distinct Physiography and malaria endemicity in District Nainital



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

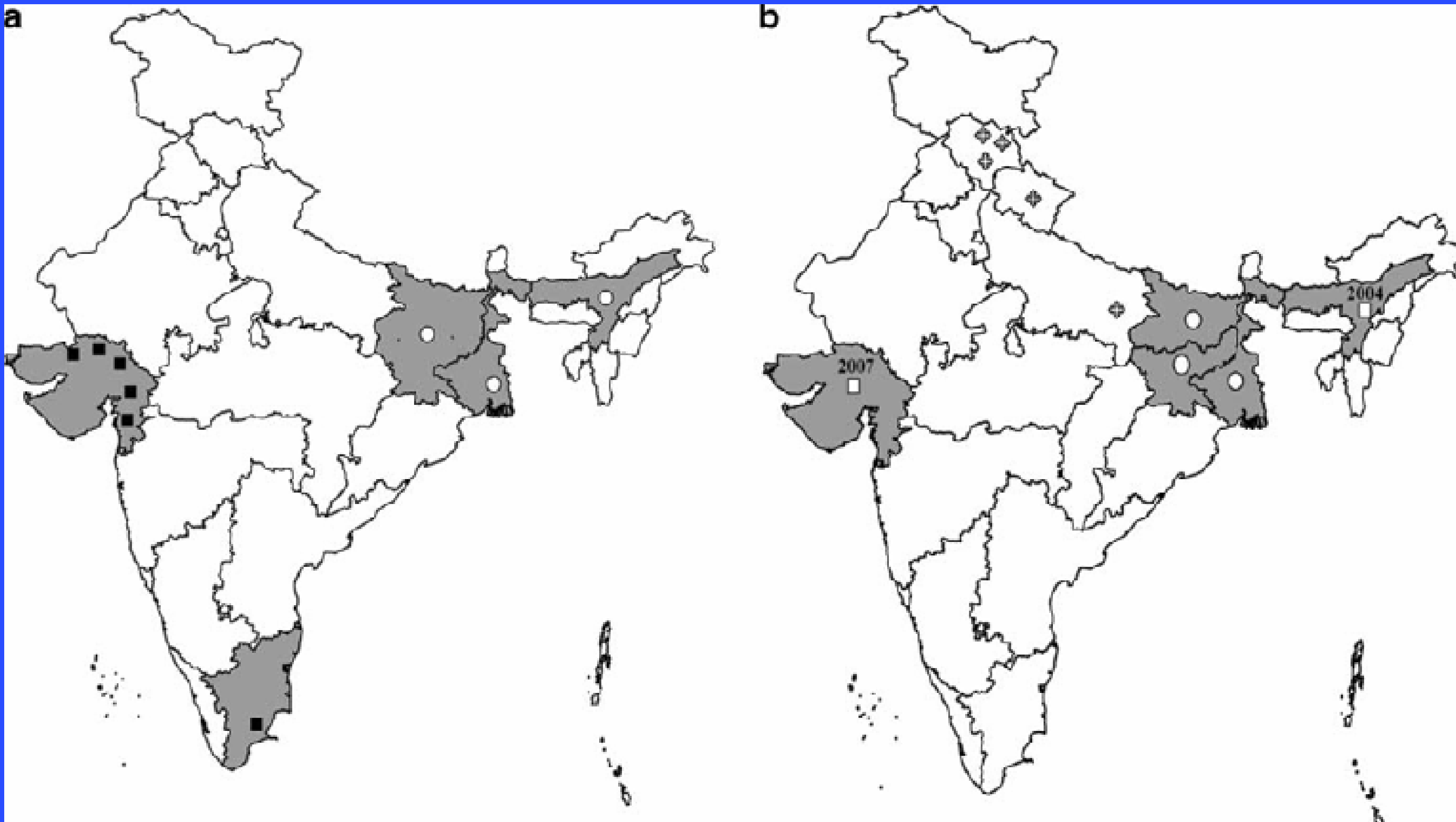
Cases reported from Hilly area also

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

Evolution of Approaches for Control of VBDs

- Late 19th and early to mid 20th centuries: Focus was on explaining the natural history, taxonomy, biology, and distribution of organisms and using this knowledge for control of measures
- 1960s: Emergence of Ecology based Vector control measures as use of DDT has been questioned
  - Ecology was equated to research and policy that deals with natural environment and protection

Control of VBDs

- Growing shift in ecological research towards concern with not only the degradation of the natural environment but an acceptance and recognition by a growing number of ecological scientists and researchers who focus on the “human-built” environment of our inseparable role as part of all ecosystems
- 1990s: Ecosystem Approach

Table 12.2. Components of Integrated Vector Control (based on WHO 2003, p. 5)

Type	Intervention	Targets	Products
Community education	behavioral change, application of all other interventions	all vectors	
Environmental management and sanitation	natural environment changes	mosquitoes, blackflies, snails, etc.	
	improved housing quality	vectors of Chagas disease, malaria, dengue	
	physical barriers to breeding sites	vectors of filariasis, trachoma	polystyrene beads in standing water bodies
Biological control	larvivorous fishes	mosquitoes	
	predators and competitors	snails	
	larviciding	urban mosquitoes, blackflies	microbial larvicides, organophosphates, neem extracts and other herbal insecticides
Chemical control	space spraying	urban mosquitoes	pyrethroids, organophosphates
	indoor residual spraying	vectors of malaria, lymphatic filariasis, leishmaniasis	pyrethroids, organophosphates, carbamates, DDT (malaria only)
	insecticide-treated materials	vectors of malaria, leishmaniasis, lymphatic filariasis, trypanosomiasis	pyrethroids
	household products	mosquitoes, flies, fleas	aerosols, coils, mats, repellents, natural products, etc.

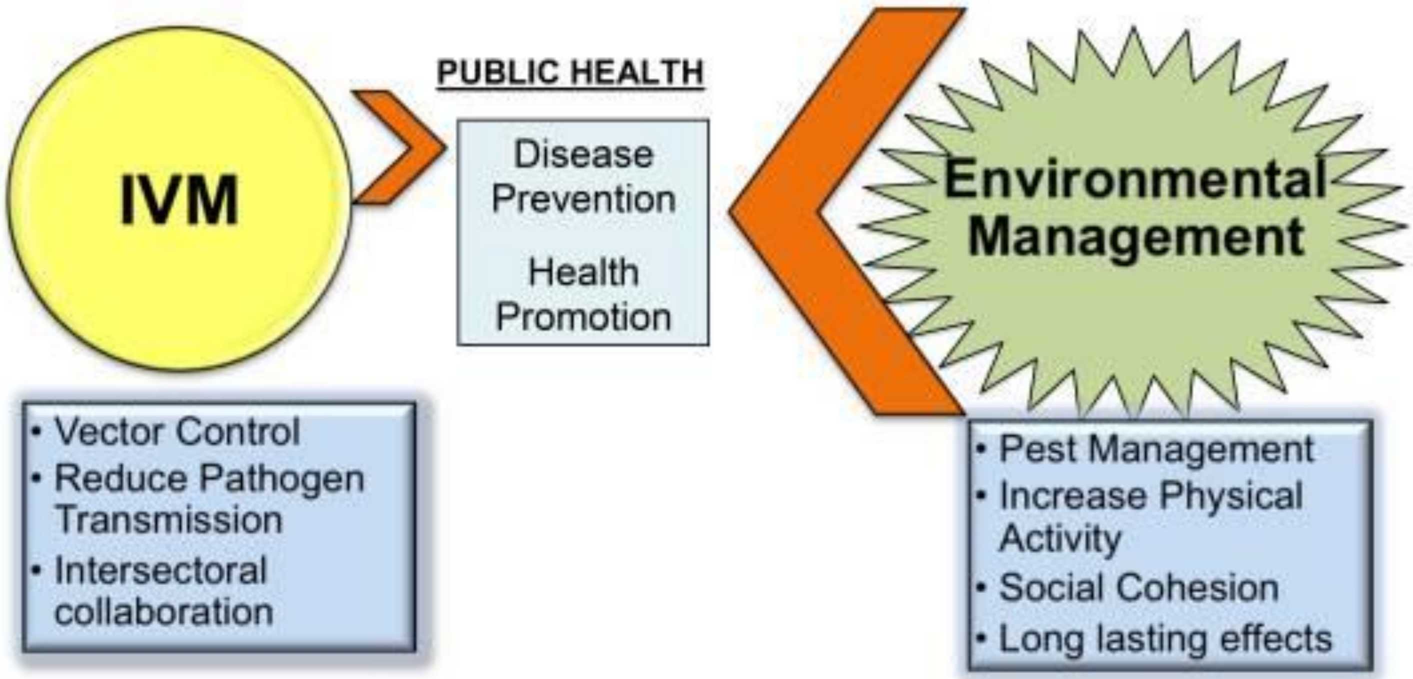


Figure 2: Trends Parasitol. 2014 Aug; 30(8): 394–400.


Thank you!