Introduction to Disaster Management

Disaster: Background

- Over the past decade, the number of natural and manmade disasters has climbed inexorably.
- From 1994 to 1998, reported disasters average was 428 per year but
- from 1999 to 2003, this figure went up to an average of 707 disaster events per year showing an increase of about 60 per cent over the previous years.
- The biggest rise was in countries of low human development, which suffered an increase of 142 per cent.

- Drought and famine have proved to be the deadliest disasters globally, followed by flood, technological disaster, earthquake, windstorm, extreme temperature and others.
- Global economic loss related to disaster events average around US $880 billion per year.

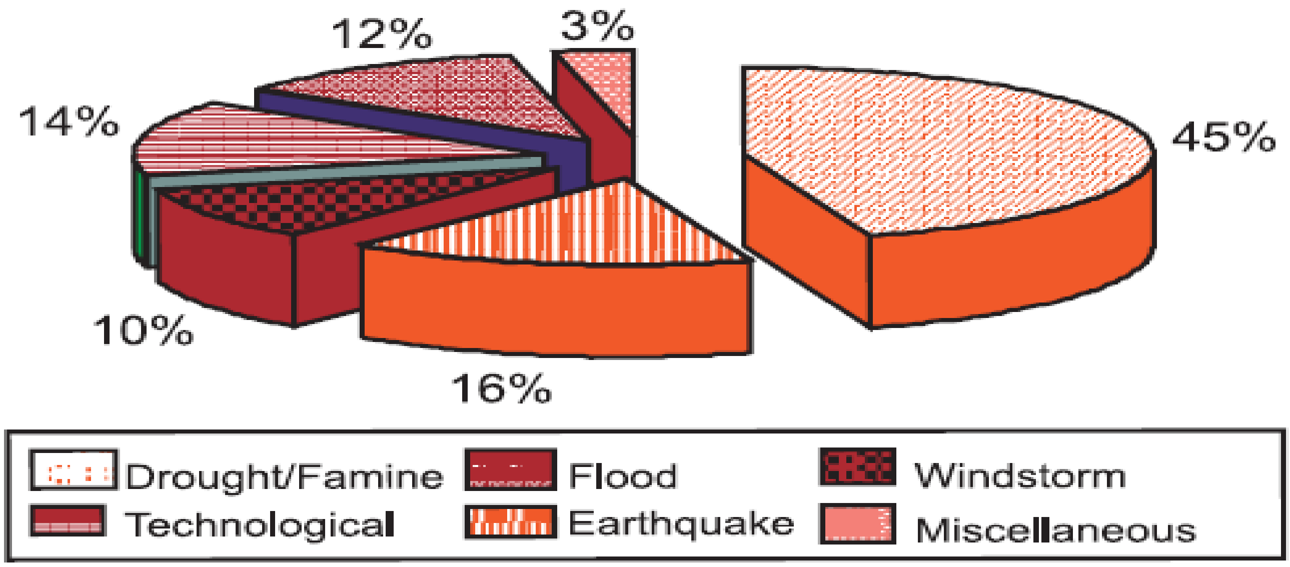
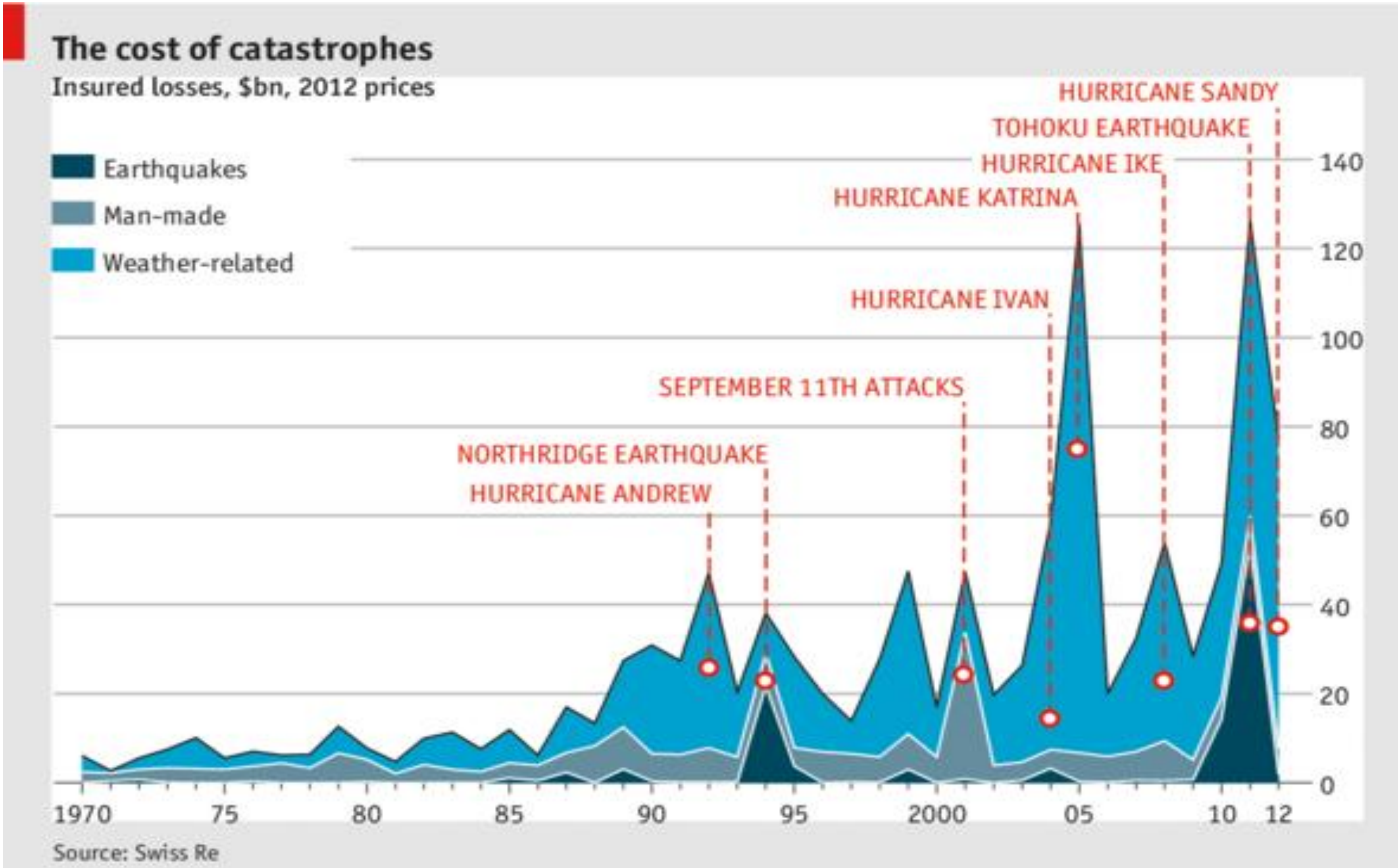


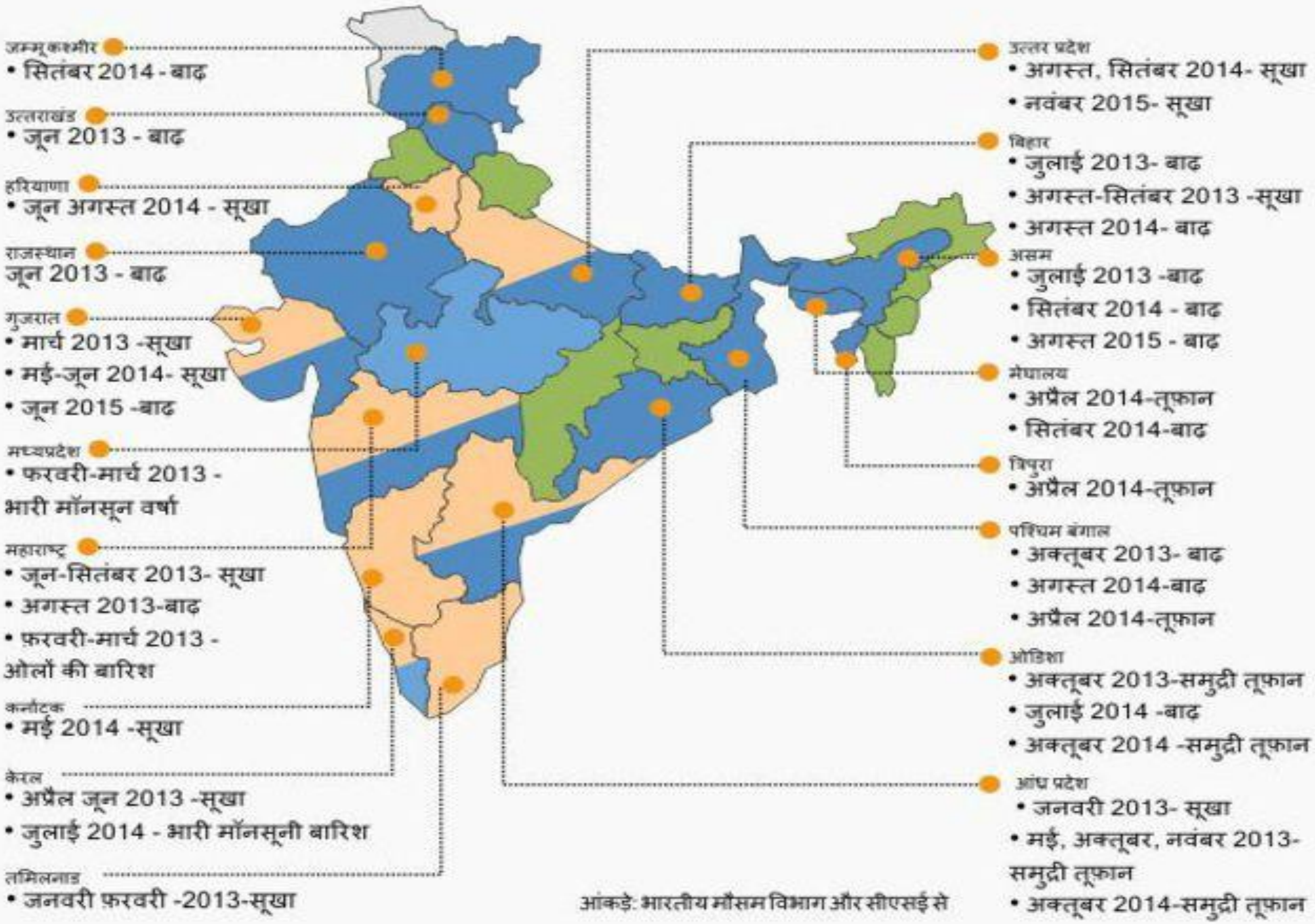
Fig : 1.1 World Scenario: Reported Deaths from all Disasters (1992-2001)

Cost of disasters



Between 2003-2013, natural disaster in developing countries affect more than 1.9 billion people, and caused more than US $ 494 bn in damages. Cost tripled over the previous decade.

कितनी तेज़ी से बदल रहा है भारत में मौसम



आंकड़े: भारतीय मौसम विभाग और सीएसई से

BBC हिन्दी

Disaster	Impact
Cyclone	
29th October 1971, Orissa	Cyclone and tidal waves killed 10,000 people
19th November, 1977, Andhra Pradesh	Cyclone and tidal waves killed 20,000 people
29th and 30th October 1999, Orissa	Cyclone and tidal waves killed 9,000 and 18 million people were affected
Earthquake	
20th October 1991 Uttarkashi	An earthquake of magnitude 6.6 killed 723 people
30th September 1993 Latur	Approximately 8000 people died and there was a heavy loss to infrastructure
22 May 1997 Jabalpur	39 people dead
29th March 1997, Chamoli	100 people dead
26th January, 2001, Bhuj, Gujarat	More than 10,000 dead and heavy loss to infrastructure
Landslide	
July 1991, Assam	300 people killed, heavy loss to roads and infrastructure
August 1993, Nagaland	500 killed and more than 200 houses destroyed and about 5kms. Road damaged.
18th August 1998, Malpa	210 people killed. Villages were washed away
Flood	
1978 Floods in North East India	3,800 people killed and heavy loss to property.
1994 Floods in Assam, Arunachal Pradesh, Jammu and Kashmir, Himachal Pradesh, Panjab, Uttar Pradesh, Goa, Kerala and Gujarat	More than 2000 people killed and thousands affected

Recent disasters in India

Name of Event	Year	State & Area	Fatalities
Sikkim Earthquake	2011	NE India with epicenter near Nepal Border and Sikkim	Most recent disaster
Cloudburst	2010	Leh, Ladakh in J&K	
Drought	2009	252 Districts in 10 States	-----
Floods	2009	Andhra Pradesh, Karnataka, Orissa, Kerala, Delhi, Maharashtra	300 people died
Kosi Floods	2008	North Bihar	527 deaths, 3.3 million persons
Cyclone Nisha	2008	Tamil Nadu	204 deaths
Floods	2005	Maharashtra	1094 deaths
Kashmir	2005	Pakistan, Partially Kashmir	1400 deaths in Kashmir (86,000 deaths in total)
Tsunami	2004	Coastline of TN, Kerala, A.P.,	10,749 deaths 5,640 persons missing 2.79 million people affected

Earthquake	2001	Gujarat	13,805 deaths 6.3 million people affected
Super Cyclone	1999	Orissa	Over 10,000 deaths
Cyclone	1996	Andhra Pradesh	1,000 people died, 5,80,000 housed destroyed, Rs. 20.26 billion estimated damage
Earthquak	1993	Latur, Marathwada	7,928 people died 30,000 injured
Cyclone	1990	Andhra Pradesh	967 people died
Cyclone	1990	Andhra Pradesh	967 people died,
Drought	1987	15 States	300 million people affected
Cyclone	1977	Andhra Pradesh	10,000 deaths;
Drought	1972	Large part of the country	200 million people affected

- **IPCC, temperature rise by 21st century is 1.8 – 4.0 °C**
- **CO_2 concentration: Rise from 280 ppm to ~400 ppm in 2015**

Why disaster management is important in India

- 59 per cent of the land mass is susceptible to seismic hazard;
- 12per cent of the total geographical area is prone to floods and river erosion;
- close to 5,700 kms, out of the 7,516 kms long coastline is prone to cyclones and tsunamis;
- 8 per cent of the total landmass is prone to cyclones;
- 70 per cent of the total cultivable area is vulnerable to drought.
- Hilly regions are vulnerable to avalanches/ landslides /hailstorms/cloudbursts.
- Other manmade hazards which are frequent and cause huge damage to life and property.

It is therefore important that we are aware of how to cope with their effects.

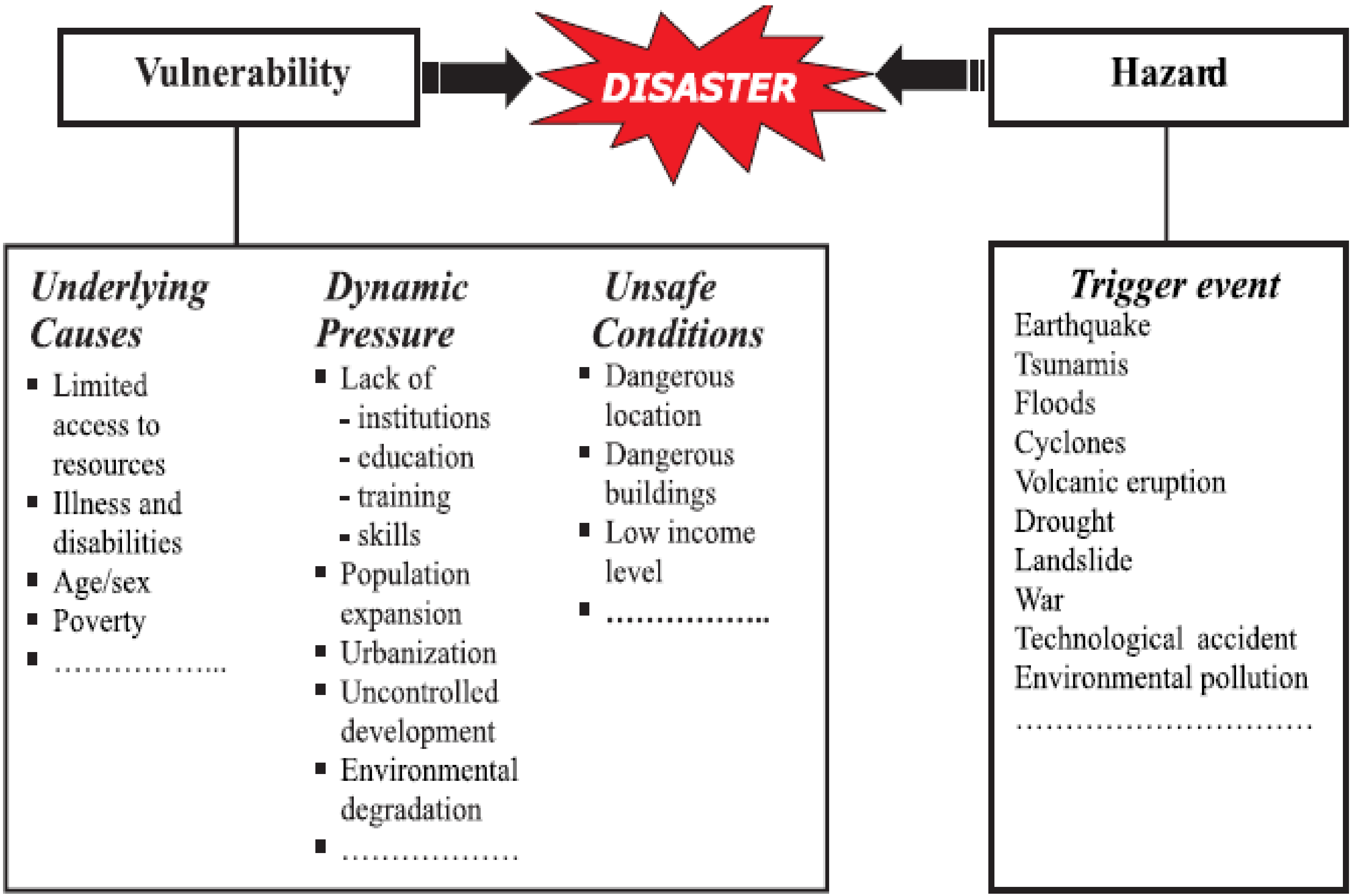
What is a disaster ?

- French word “Desastre”
  - ‘des’ meaning bad and ‘aster’ meaning star.
- Refers to ‘Bad or Evil star’.

- A disaster can be defined as

A serious disruption in the functioning of the community or a society causing wide spread material, economic, social or environmental losses which exceed the ability of the affected society to cope using its own resources”.

A disaster happens when a hazard impacts on the vulnerable population and causes damage, casualties and disruption.



- Any hazard – flood or cyclone triggers with greater vulnerability (inadequate access to resources, sick and old people, lack of awareness etc) would lead to disaster causing greater loss to life and property.

- Example: Earthquake in an uninhabited desert cannot be considered a disaster. An earthquake is disastrous only when it affects people, their properties and activities.

  Thus, disaster occurs only when hazards and vulnerability meet.

What is a hazard ?

‘a dangerous condition, that threat or have the potential for causing injury to life or damage to property or the environment.’ The word ‘hazard’ comes from French word ‘hasard’ , or Arabic word ‘az-zahr’ meaning ‘chance’ or ‘luck’.

Hazards can be grouped into two broad categories namely natural and manmade

- **Natural hazards:** caused because of natural phenomena (hazards with meteorological, geological or even biological origin).
- **Manmade hazards:** due to human negligence. Manmade hazards are associated with industries or energy generation facilities and include explosions, leakage of toxic waste, pollution, dam failure, wars or civil strife etc.

Various types of hazards

Types	Hazards	
Geological Hazards	1. Earthquake 2. Tsunami 3. Volcanic eruption	4. Landslide 5. Dam burst 6. Mine Fire
Water & Climatic Hazards	1. Tropical Cyclone 2. Tornado and Hurricane 3. Floods 4. Drought 5. Hailstorm	6. Cloudburst 7. Landslide 8. Heat & Cold wave 9. Snow Avalanche 10. Sea erosion
Environmental Hazards	1. Environmental pollutions 2. Deforestation	3. Desertification 4. Pest Infection
Biological	1. Human / Animal Epidemics 2. Pest attacks	3. Food poisoning 4. Weapons of Mass Destruction

Various types of hazards

Types	Hazards	
Chemical, Industrial and Nuclear Accidents	1. Chemical disasters 2. Industrial disasters	3. Oil spills/Fires 4. Nuclear
Accident related	1. Boat / Road / Train accidents / air crash Rural / Urban fires Bomb /serial bomb blasts 2. Forest fires	3. Building collapse 4. Electric Accidents 5. Festival related disasters 6. Mine flooding

What is a vulnerability ?

"The extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area."

It can be categorized into : physical; and socio-economic

- Physical Vulnerability: It includes notions of who and what may be damaged or destroyed by natural hazard such as earthquakes or floods.
- Socio-economic Vulnerability: Socio-economic condition by degree to which a population is affected by a hazard.

  Example, people who are poor and living in the sea coast don't have the money to construct strong concrete houses. They are generally at risk and loose their shelters when ever there is strong wind or cyclone.

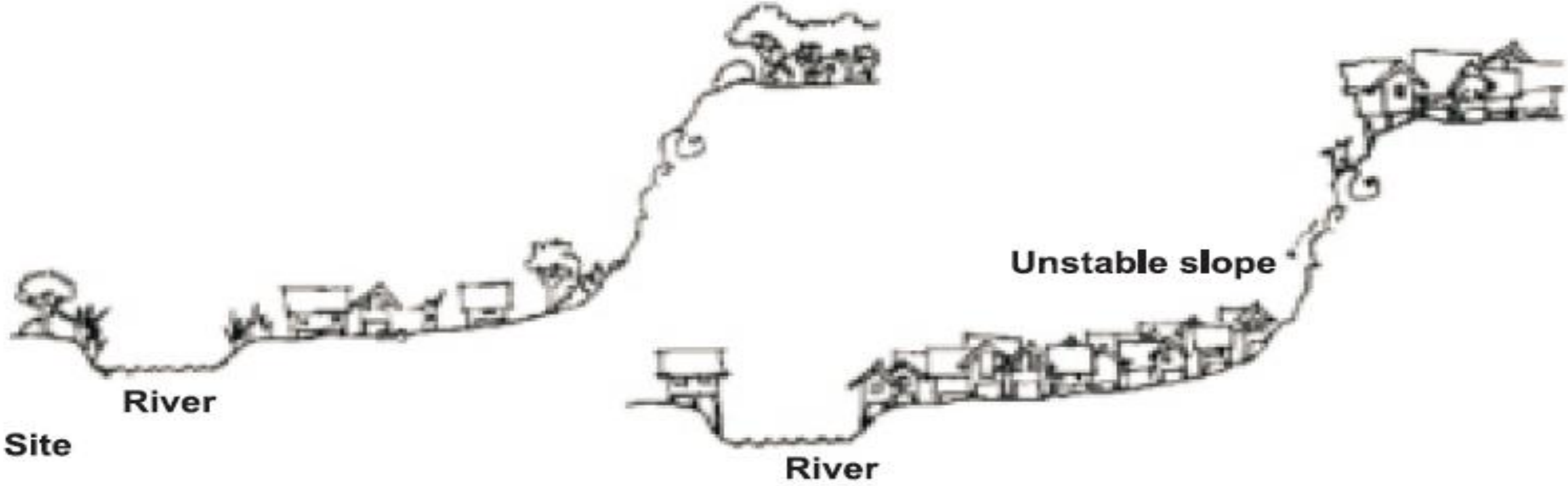


Figure 1.3 : Site after pressures from population growth and urbanization

Example of physical vulnerability is a hazardous slope:

Unchecked growth of settlements in unsafe areas exposes the people to the hazard. In case of an earthquake or landslide the ground may fail and the houses on the top may topple or slide and affect the settlements at the lower level even if they are designed well for earthquake forces.

Disaster management cycle

Includes sum total of all activities, programmes and measures taken up before, during, and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses. The three key stages of activities within disaster risk management are:

1. **Before a disaster (pre-disaster).**
2. **During a disaster (disaster occurrence).**
3. **After a disaster (post-disaster)**

Before a disaster (pre-disaster): Activities to reduce human and property losses caused by a potential hazard.
Example, by carrying out awareness campaigns, strengthening the existing weak structures, preparation of the disaster management plans at household and community level etc. **Such risk reduction measures** taken under this stage are termed as mitigation and **preparedness activities**.

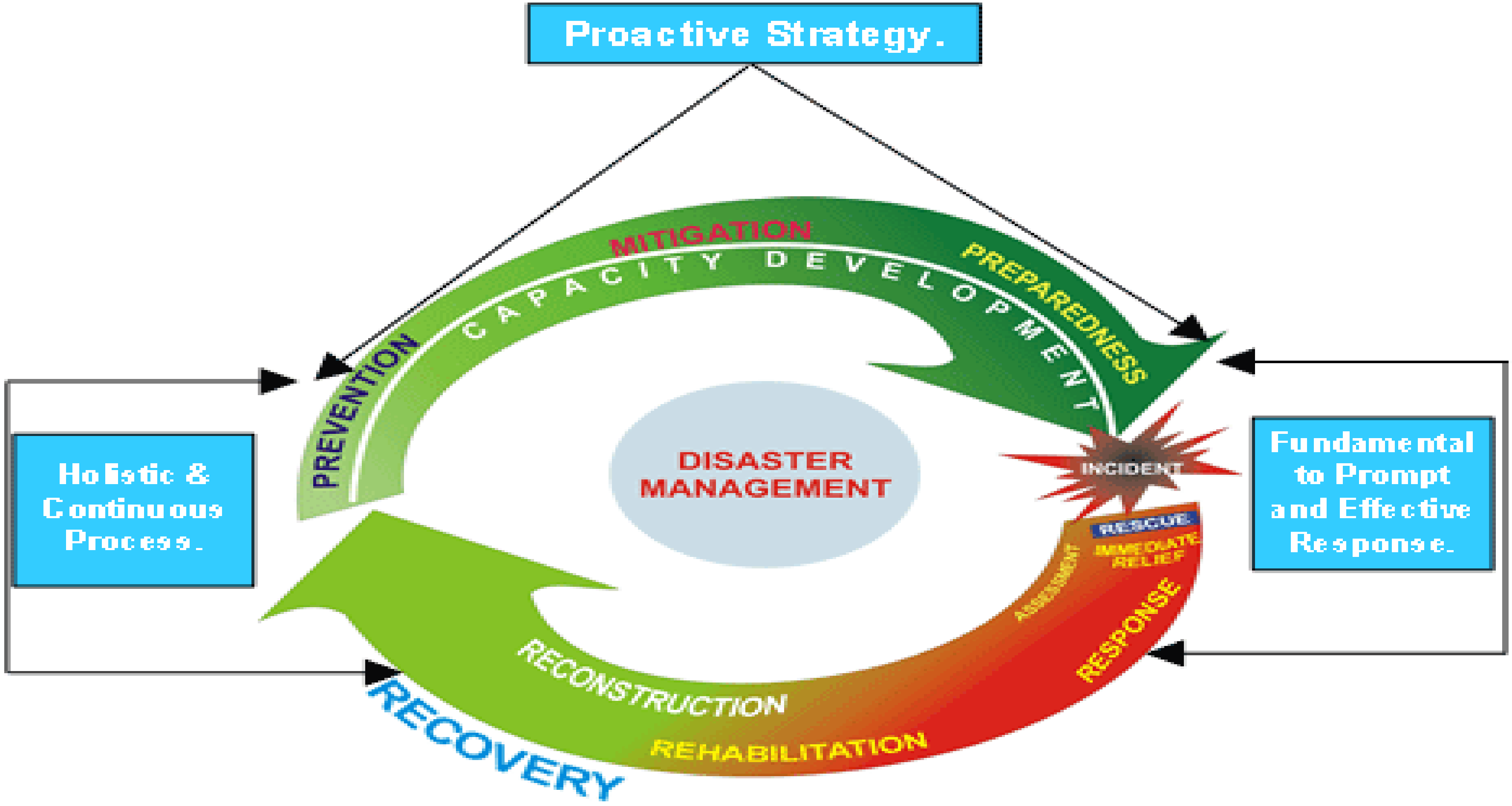
During a disaster (disaster occurrence).

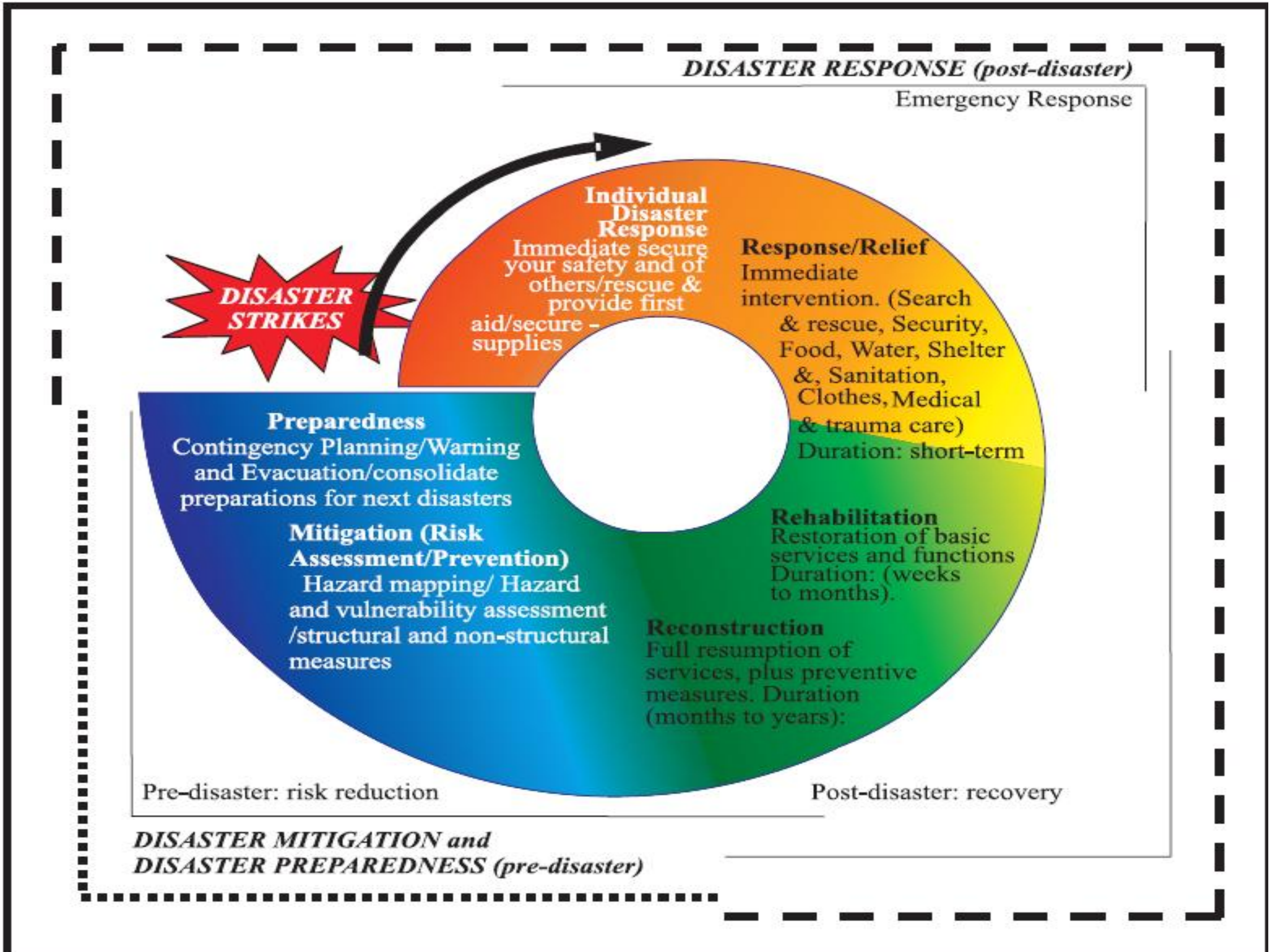
Initiatives taken to ensure the needs and provisions of victims are met and suffering is minimized. Activities taken under this stage are called **emergency response activities**.

After a disaster (post-disaster)

Initiatives taken in response to a disaster with a purpose to achieve early recovery and rehabilitation of affected communities, immediately after a disaster strikes. These are called as response and **recovery activities**.

DISASTER MANAGEMENT CONTINUUM





DISASTER RESPONSE (post-disaster)
Emergency Response
DISASTER STRIKES
Individual Disaster Response
Immediate secure your safety and of others/rescue & provide first aid/secure - supplies
Response/Relief
Immediate intervention. (Search & rescue, Security, Food, Water, Shelter &, Sanitation, Clothes, Medical & trauma care)
Duration: short-term
Preparedness
Contingency Planning/Warning and Evacuation/consolidate preparations for next disasters
Mitigation (Risk Assessment/Prevention)
Hazard mapping/ Hazard and vulnerability assessment /structural and non-structural measures
Rehabilitation
Restoration of basic services and functions
Duration: (weeks to months).
Reconstruction
Full resumption of services, plus preventive measures. Duration (months to years):
Pre-disaster: risk reduction
Post-disaster: recovery
DISASTER MITIGATION and DISASTER PREPAREDNESS (pre-disaster)

DISASTER MANAGEMENT CYCLE

A holistic and integrated approach will be evolved towards disaster management with emphasis on building strategic partnerships at various levels. The themes underpinning the policy are:

- Community based DM, including last mile integration of the policy, plans and execution.
- Capacity development in all spheres.
- Consolidation of past initiatives and best practices.
- Cooperation with agencies at national and international levels.
- Multi-sectoral synergy.

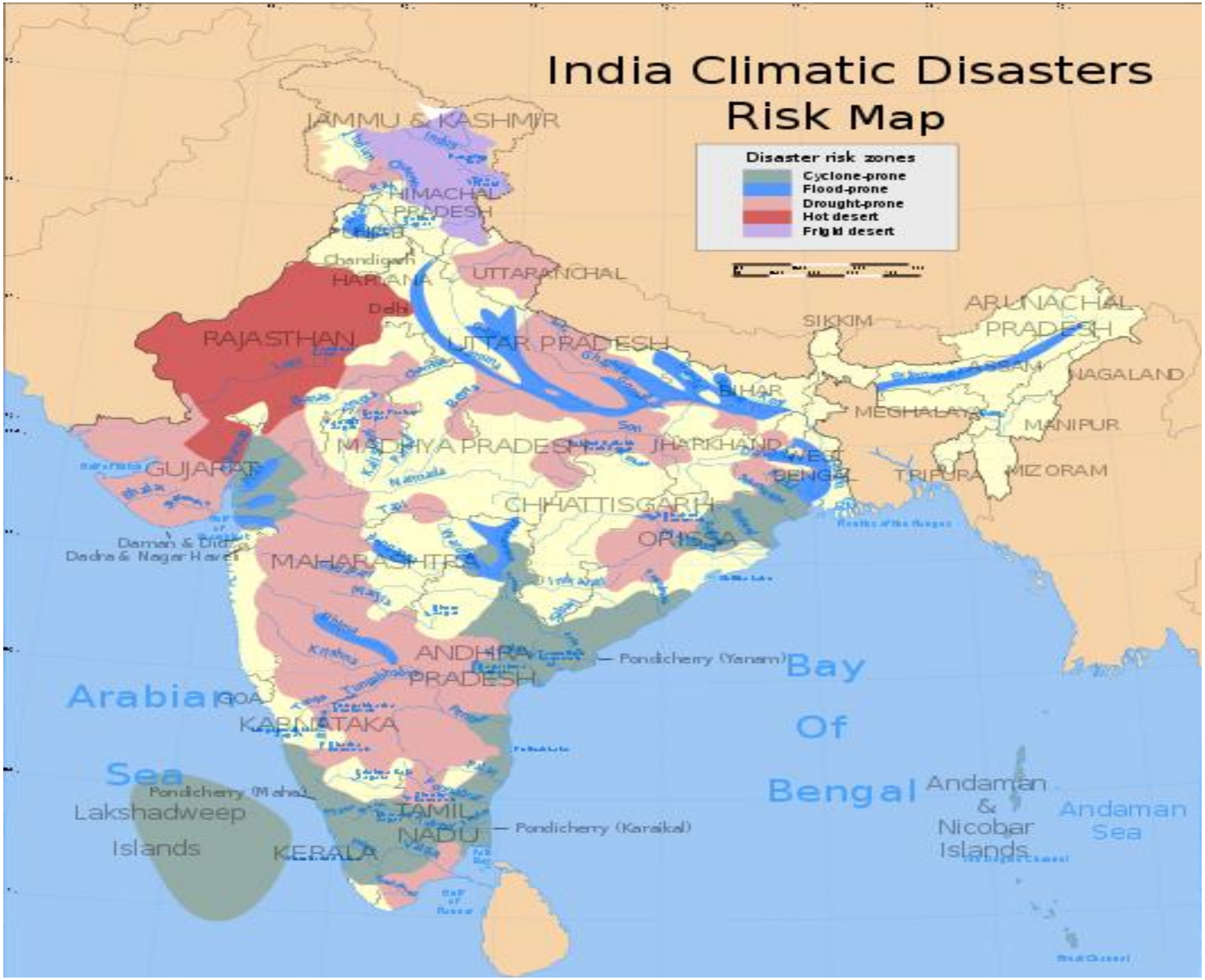
About NDMA

- NDMA: On 23 December 2005, the Government of India enacted the Disaster Management Act, which envisaged the creation of National Disaster Management Authority (NDMA), headed by the Prime Minister, and State Disaster Management Authorities (SDMAs) headed by respective Chief Ministers, to spearhead and implement a holistic and integrated approach to Disaster Management in India
- Vision: "To build a safer and disaster resilient India by a holistic, pro-active, technology driven and sustainable development strategy that involves all stakeholders and fosters a culture of prevention, preparedness and mitigation."

Functions and responsibilities of NDMA

- NDMA, as the apex body, is mandated to lay down the policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters. Towards this, it has the following responsibilities:-
- Lay down policies on disaster management ;
- Approve the National Plan;
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan;
- Lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the Purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;
- Coordinate the enforcement and implementation of the policy and plans for disaster management;
- Recommend provision of funds for the purpose of mitigation;
- Provide such support to other countries affected by major disasters as may be determined by the Central Government;
- Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with threatening disaster situations or disasters as it may consider necessary;
- Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

Thank you


India Climatic Disasters
Risk Map
Disaster risk zones
Cyclone-prone
Flood-prone
Drought-prone
Hot desert
Frigid desert
JAMMU & KASHMIR
HIMACHAL PRADESH
Chandigarh
HARYANA
UTTARANCHAL
Delhi
RAJASTHAN
UTTAR PRADESH
SIKKIM
ARUNACHAL PRADESH
NAGALAND
BIHAR
MEGHALAYA
MANIPUR
MADHYA PRADESH
JHARKHAND
WEST BENGAL
TRIPURA
MIZORAM
GUJARAT
CHHATTISGARH
ORISSA
Daman & Diu
Dadra & Nagar Haveli
MAHARASHTRA
ANDHRA PRADESH
Pondicherry (Yanam)
Bay Of Bengal
Arabian Sea
GOA
KARNATAKA
Pondicherry (Mahe)
Lakshadweep Islands
TAMIL NADU
Pondicherry (Karaikal)
KERALA
Andaman & Nicobar Islands
Andaman Sea

Natural Disasters

- Floods
- Drought
- Cyclone
- Earthquake
- Landslide
- Avalanche
- Volcanic eruptions
- Heat and cold waves
- Climate change
- Global warming
- Sea level rise
- Ozone depletion

Natural Disasters of The Last Ten Years

- **The Gujurat Earthquake, India, 26th May 2001**

With 20,000 fatalities, the Bhuj earthquake was a huge event.

- **The Guinsaugon landslide, Philippines, 17th February 2006**

The tragedy of the Guinsaugon landslide is that the authorities and local people were aware of the threat posed by the slope, and evacuated the town. However, when the heavy rainfall (brought by a typhoon) stopped, the people returned to their homes and schools, only to be buried.

- **The Bam Earthquake, Iran, 26th December 2003**

The earthquake was a direct hit on the ancient city of Bam, the centre of which collapsed almost completely. The death toll was 26,796 people, and poor building construction plays in disaster causation.

- **The Simeule / Nias earthquake, Indonesia, 28th March 2005**

With a death toll of 915.

- **The Kashmir earthquake (Pakistan and India), 8th October 2005:** The true toll from the Kashmir earthquake remains unclear – total in Pakistan is 73,338. The difficulties of providing assistance to a mountain population as winter approached.

- **The summer 2003 heatwave in Europe**

The exceptional temperatures recorded in Europe in Summer 2003 is estimated to have killed over 60,000 people.

- **The Wenchuan Earthquake, China, 12th May 2008**

The destruction of the schools in particular will remain in the memory for a long time.

- **Cyclone Nargis, Burma (Myanmar), 2nd May 2008**

- **Hurricane Katrina, USA, 29th August 2005**

The impact of Katrina on New Orleans remains one of the enduring images of the decade.

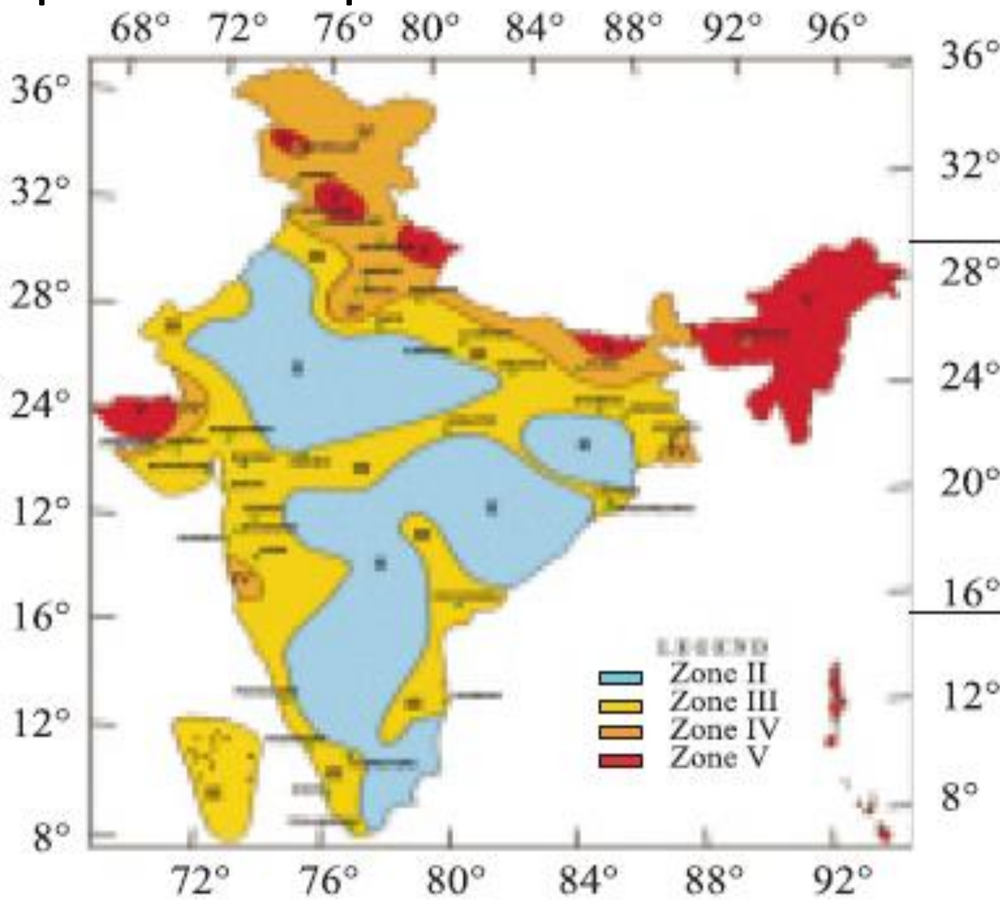
- **The Indian Ocean earthquake and tsunami, 26th December 2004:** The two obvious aspects of this disaster are of course the huge death-toll (165,708 in Indonesia alone, probably c.250,000 worldwide, according to the EM-DAT database) across a huge swathe of the coast around the Indian Ocean.

Top 5 worst natural disasters of 2011

- **Earthquake in Japan** —The 8.9-magnitude earthquake — one the strongest earthquakes ever recorded — that struck off of Japan's coast on March 11 would have been the year's worst disaster by itself. But it was the tsunami it triggered that would cause the most lasting damage.
- **Drought in East Africa** — A widespread drought across Kenya, Somalia, Ethiopia, Eritrea and Djibouti over the summer laid waste to food and water supplies across the region, sparking the worst famine in decades.
- **Floods in Thailand** —The waters first began to rise in July, and the flooding continued through December. About 800 people have been killed as a result of the floods, but some suggest that number is likely higher. More than 12 million people were affected and the financial cost has been astronomical.
- **Typhoon in the Philippines** — Tropical Storm Washi might be the most under-covered natural disaster of 2011, and it just happened. So far more than 1,200 people have been reported killed
- **Storms in the United States** — It's rare for the United States to make these kinds of lists, with the exception perhaps of Hurricane Katrina in 2005. But it makes the list for 2011 because of a combination of unusual and severe weather events that in total caused the country $35 billion in damages and killed more than 700 people.

Earthquake

It is the sudden shaking of the earth crust. The impact of an earthquake is sudden and there is hardly any warning, making it impossible to predict.



Zone	Magnitude
Zone V	Very High Risk Quakes of Magnitude *8* and greater
Zone IV	High Risk Quakesupto Magnitude *7.9*
Zone III	Moderate Risk Quakesupto Magnitude *6.9*
Zone II	Seismic Disturbancesupto Magnitude *4.9*

Source: IS 1893 (Part 1) : 2002 (BIS)

Year	Location	Magnitude of 6+
1950	Arunachal Pradesh - China Border	8.5
1956	Anjar, Gujarat	7.0
1967	Koyna, Maharashtra	6.5
1975	Kinnaur, Himachal Pradesh	6.2
1988	Manipur - Myanmar Boarder	6.6
1988	Bihar - Nepal Border	6.4
1991	Uttarkashi - Uttar Pradesh Hills	6.0
1993	Latur - Maharashtra	6.3
1997	Jabalpur, Madhya Pradesh	6.0
1999	Chamoli, Uttar Pradesh	6.8
2001	Bhuj, Gujarat	6.9
2005	Muzaffarabad (Pakistan) Impact in Jammu & Kashmir	7.4

Cause of Earthquake :

The earth’s crust is a rocky layer of varying thickness ranging from a depth of about 10 kilometers under the sea to 65 kilometers under the continents.

The crust is not one piece but consists of portions called **‘plates’** which vary in size from a few hundred to thousands of kilometers.

The ‘**theory of plate tectonics’** holds that the plates ride up on the more mobile mantle, and are driven by some yet unconfirmed mechanisms, perhaps thermal convection currents.

When these plates contact each other, stress arises in the crust.

These stresses can be classified according to the type of movement along the plate’s boundaries:

a) pulling away from each other,

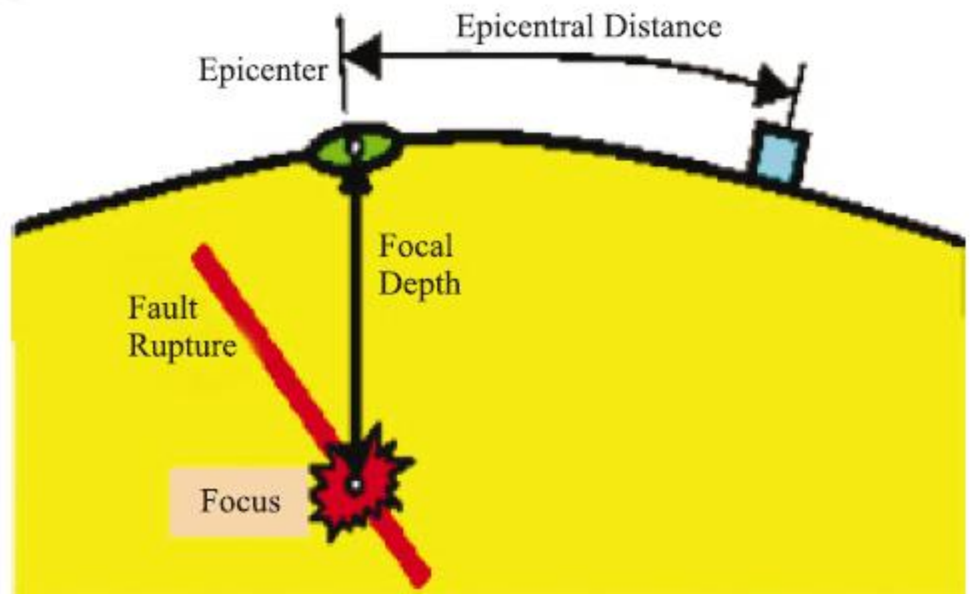
b) pushing against one another and

c) sliding sideways relative to each other.

All these movements are associated with earthquakes.

- The areas of stress at plate boundaries which release accumulated energy by slipping or rupturing are known as 'faults'. The fault rupture generates vibration called seismic waves, which radiates from the focus in all directions.

- The point of rupture is called the 'focus' and may be located near the surface or deep below it. The point on the surface directly above the focus is termed as the 'epicenter' of the earthquake .



Possible risk reduction measures

Community preparedness: for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is 'DROP, COVER and HOLD'.

Planning: The Bureau of Indian Standards has published building codes and guidelines for safe construction of buildings against earthquakes.

Public education: Educating public on causes and characteristics of an earthquake and preparedness measures. It can be created through sensitization and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students.

Engineered structures: Buildings need to be designed and constructed as per the building by laws to withstand ground shaking. Buildings on soft soil are more likely to get damaged even if the magnitude of the earthquake is not strong. Similar problems persist in the buildings constructed on the river banks with alluvial soil.

Cyclones

• Cyclone is a region of low atmospheric pressure surrounded by high atmospheric pressure resulting in swirling atmospheric disturbance accompanied by powerful winds blowing in anticlockwise direction in the Northern Hemisphere and in the clockwise direction in the Southern Hemisphere.

• They occur mainly in the tropical and temperate regions of the world.

Cyclones are known by different names in different parts of the world:

- *Typhoons in the Northwest Pacific Ocean west of the dateline*
- *Hurricanes in the North Atlantic Ocean, the Northeast Pacific Ocean east of the dateline, or the South Pacific Ocean.*
- *Tropical cyclones - the Southwest Pacific Ocean and Southeast Indian Ocean.*
- *Severe cyclonic storm" (the North Indian Ocean)*
- *Tropical cyclone (the Southwest Indian Ocean)*
- *Willie-Willie in Australia*
- Tornado in South America

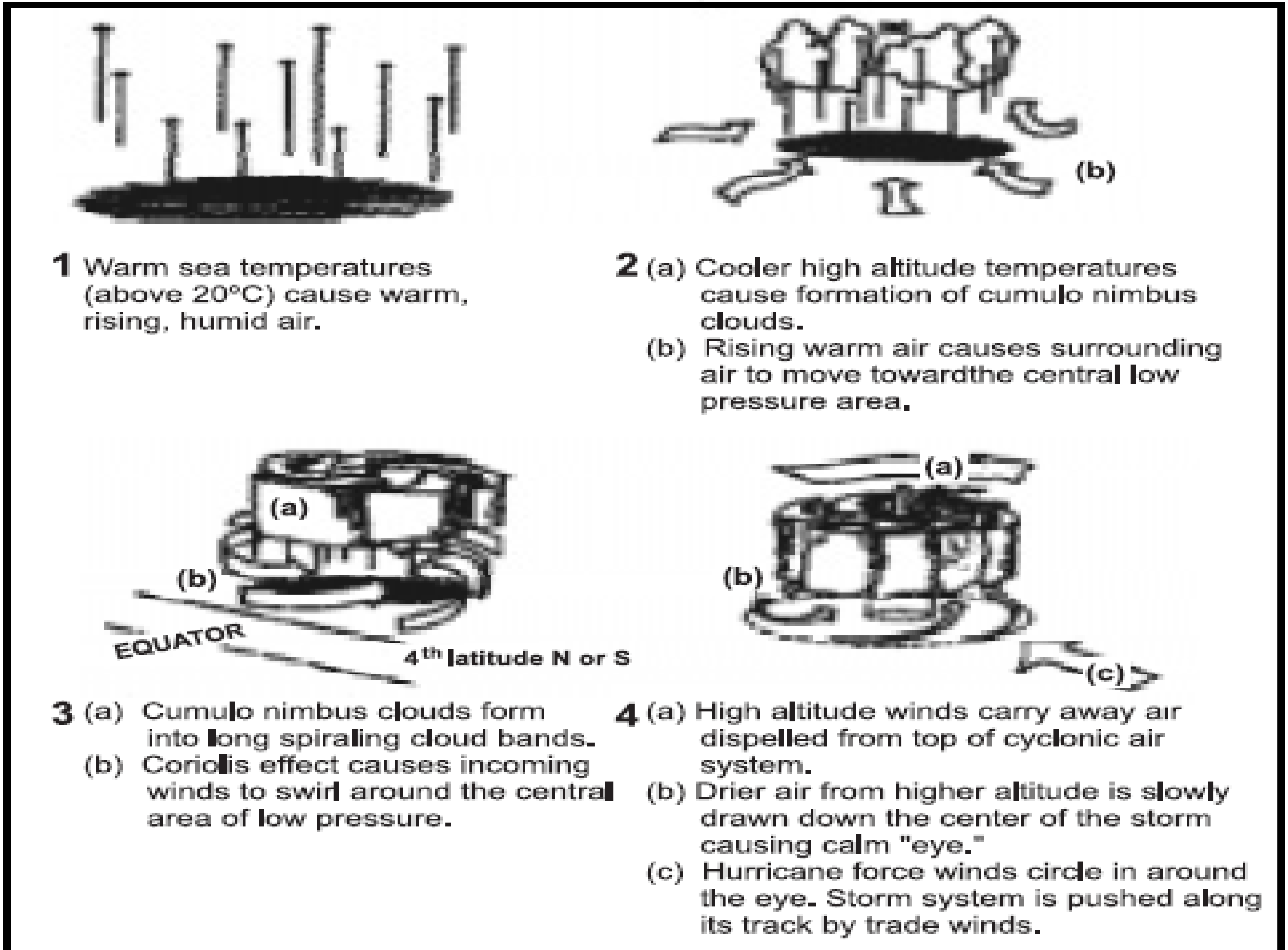


Fig 2.3.2 Stages of cyclone formation

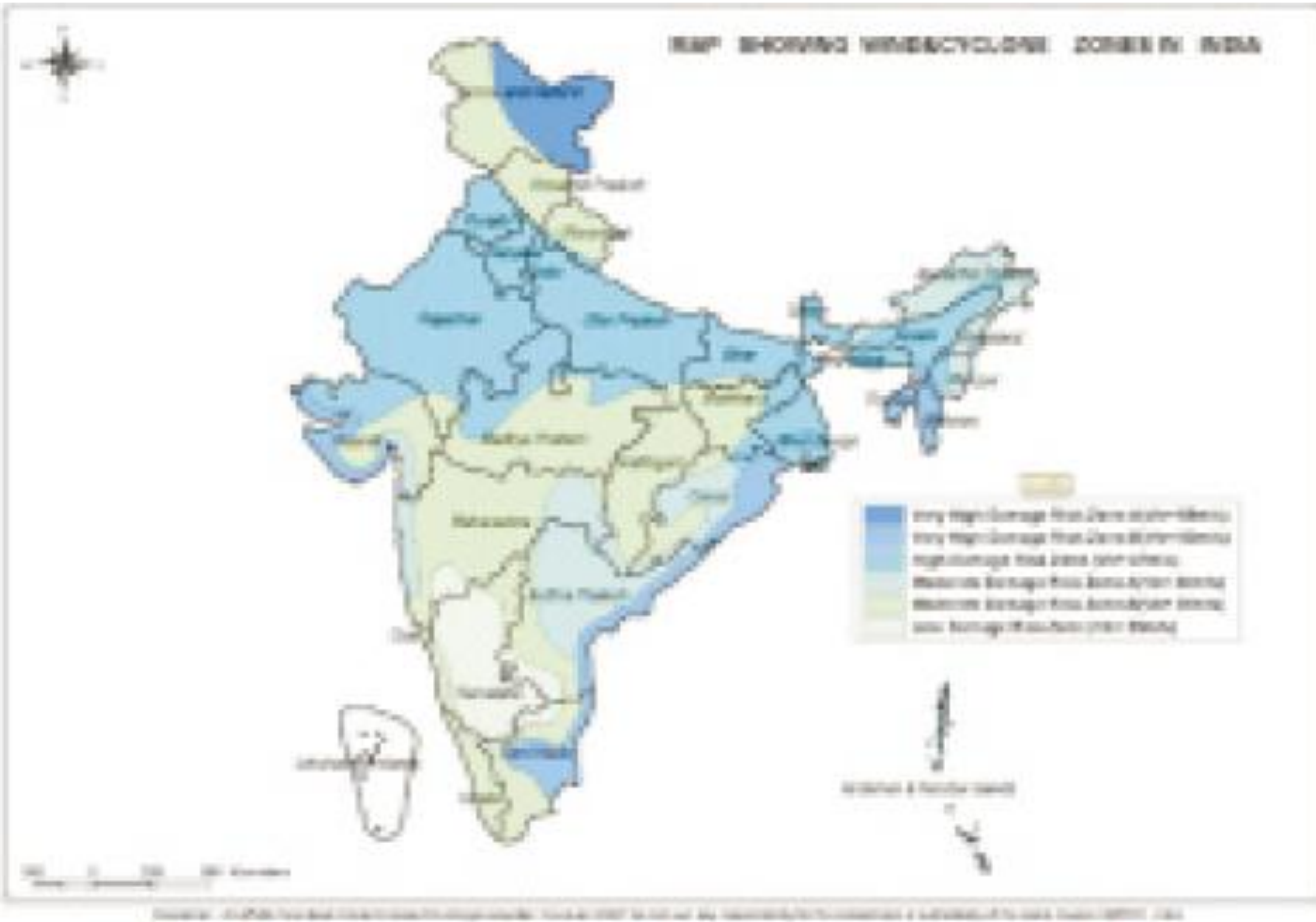


Fig 2.3.4 Wind and Cyclone map of India

Sl No	Year	Area	Death toll
1	1971	Eastern Coast	9658
2	1972	Andhra Pradesh and Orissa	100
3	1977	Chennai, kerala & Andhra Pradesh	14,204
4	1979	Andhra Pradesh	594
5	1981	Gujarat	470
6	1982	Gujarat & Maharashtra	500
7	1984	Tamil Nadu & Andhra Pradesh	512
8	1985	Andhra Pradesh	5000
9	1990	Andhra Pradesh	957
10	1990	Orissa	250
11	1999	Orissa	8913

(Source: Office of the US Foreign Disaster Assistance)

Possible risk reduction measures

- **Coastal belt plantation -** green belt plantation along the coastal line in a scientific interweaving pattern can reduce the effect of the hazard.

Hazard mapping – Meteorological records of the wind speed and the directions give the probability of the winds in the region.

Cyclones can be predicted several days in advance. A hazard map will illustrate the areas vulnerable to cyclone in any given year. It will be useful to estimate the severity of the cyclone and various damage intensities in the region.

Land use control: designed so that least critical activities are placed in vulnerable areas.

Improving vegetation cover – The roots of the plants and trees keep the soil intact and prevent erosion and slow runoff to prevent or lessen flooding. A row of planted trees will act as a shield. It reduces the energy.

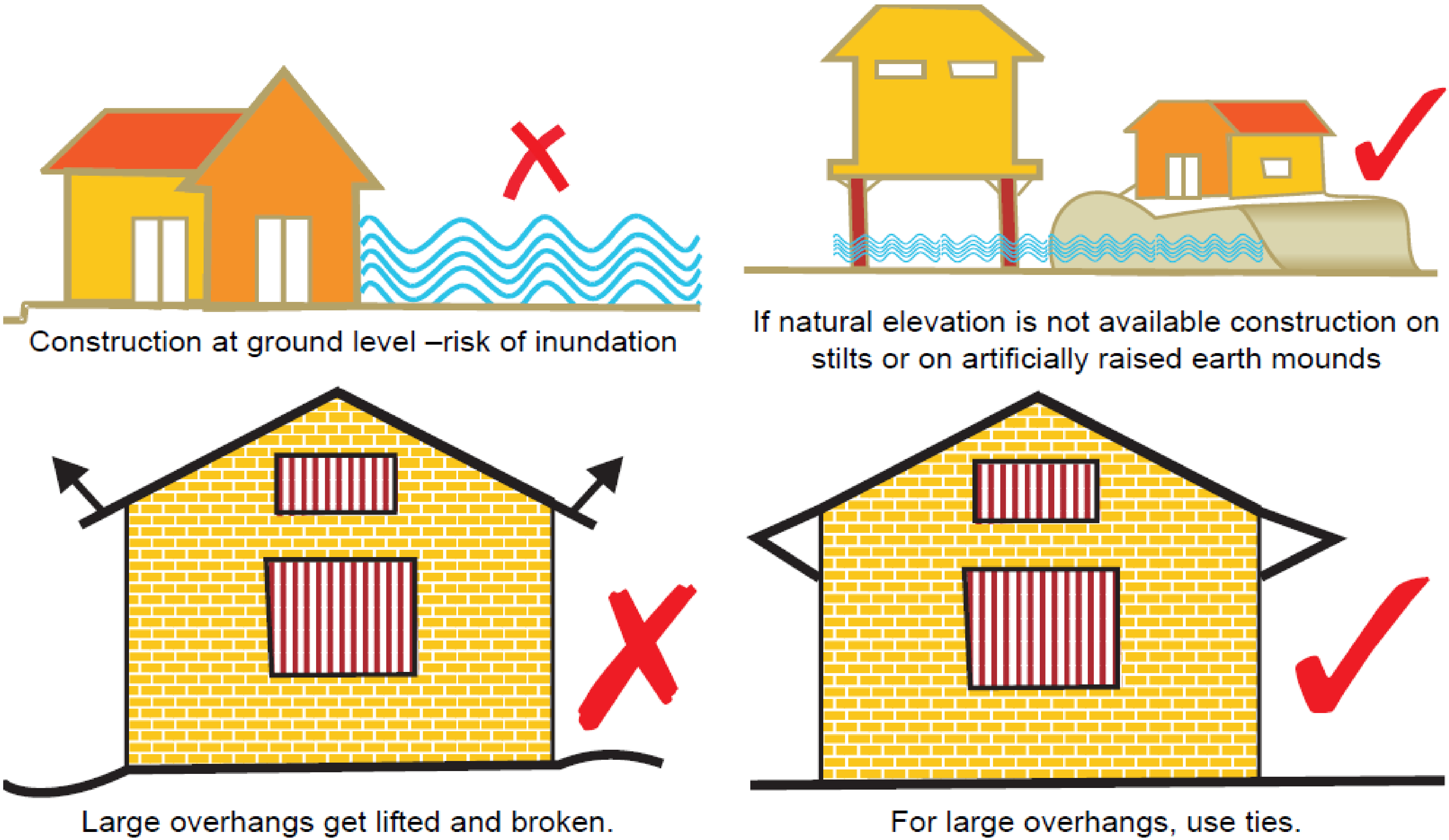


Fig. 2.3.8 Safe Construction Practices

Engineered structures – structures need to be built to withstand wind forces.

DROUGHT

What is Drought?

Drought is either absence or deficiency of rainfall from its normal pattern in a region for an extended period of time leading to general suffering in the society.

It is interplay between demand that people place on natural supply of water and natural event that provides the water in a given geographical region.

It is a slow on-set disaster and it is difficult to demarcate the time of its onset and the end.

Cause of drought: Any unusual dry period which results in a shortage of useful water.

- World Water Day: March 22 (Since 1993)
- International Decade for Action **'Water for Life'** 2005-2015. Declared on World Water Day March 23, 2005.
- International Year of Water Cooperation - 2013
- Water Conservation Year- 2013 (MoWR, GoI)

World Water Day- 2012: Water and Food Security

The world is thirsty because we are hungry

What on earth do you know about water?

- Approximately 80 per cent of earth's surface is covered with water but only 1% of it is fresh water that we can use.
- About 2.7 per cent of the total water available on the earth is fresh water of which about 75.2 per cent lies frozen in Polar Regions and another 22.6 per cent is present as ground water. The rest is available in lakes, rivers, atmosphere, moisture, soil and vegetation. This 1% of water is now threatened by pollution!
- Today, we have approximately the same amount of water as when the Earth was formed. Earth will not get/generate any more water!
- We are using up the fresh water faster than we are recharging our groundwater

Water Resources of India

IRRIGATION POTENTIAL

***Major & Medium (Surface Water)**

Ultimate	58.5 million ha
Utilized (up to 2006-07)	34.4 million ha

*** Minor Irrigation**

(A) Surface Water

Ultimate	17.3 million ha
Utilized (up to 2006-07)	8.3 million ha

(B) Ground Water

Ultimate	64.1 million ha
Utilized (up to 2006-07)	48.4 million ha

(C) Total (Surface & Ground)

Ultimate	81.4 million ha
Utilized (up to 2006-07)	56.7 million ha

Total (Major & Medium +Minor)

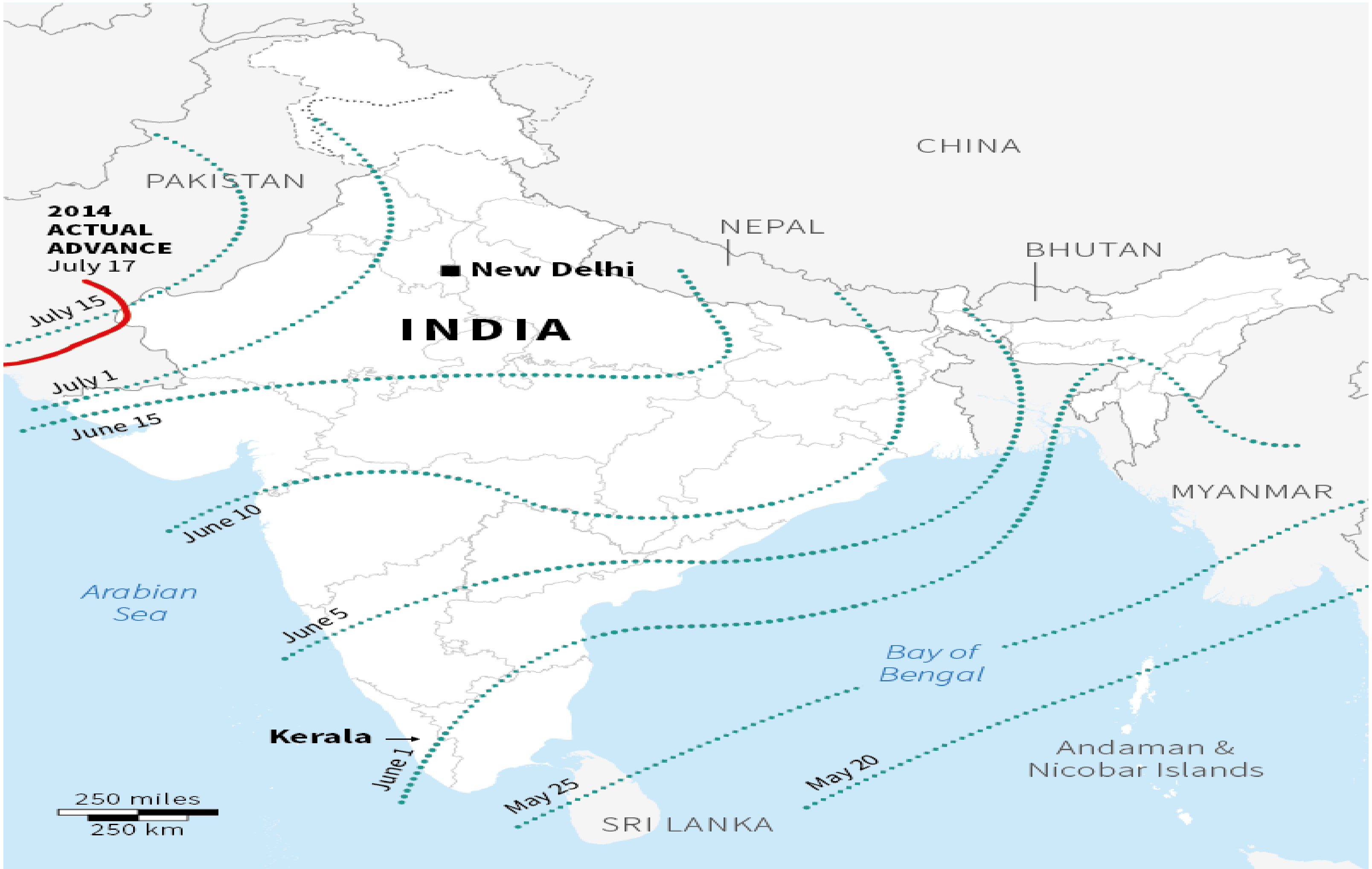
Ultimate	139.9 million ha
Created (up to 2006-07)	123.3 million ha

Area Irrigated (2009-10)

Gross	86.42 million ha	Net	63.26 million ha (FAI)

Source: Ground Water Year Book – India 2010-11.

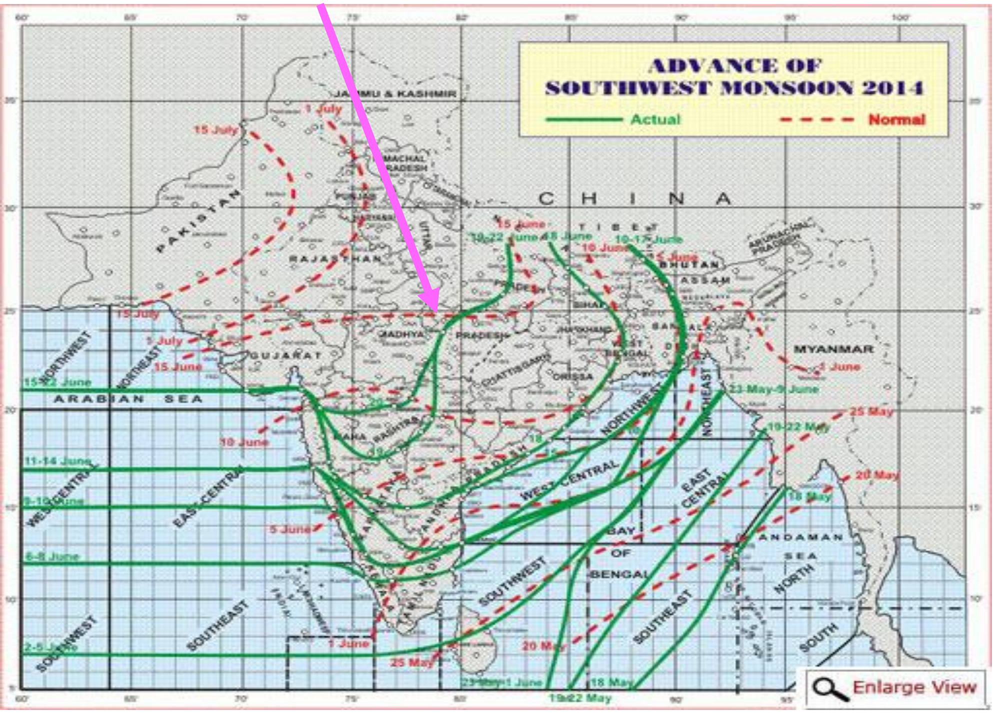
Normal flow of SW Monsoon

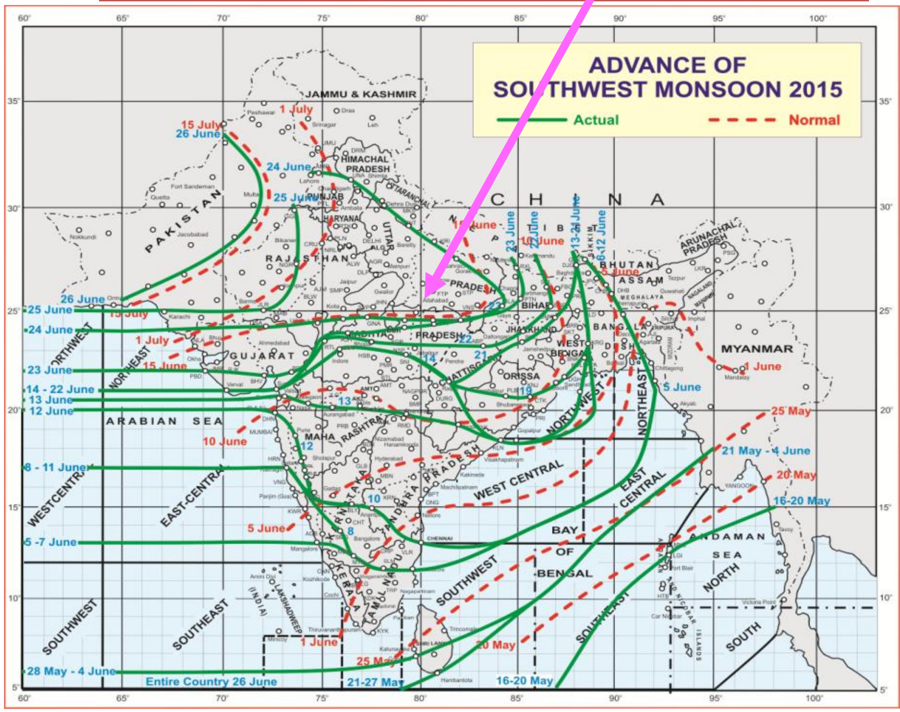


Onset date of Southwest Monsoon in MP
June 10-15 : Normal onset

Onset Monsoon: 10-22 June 2014

14-22 June 2015

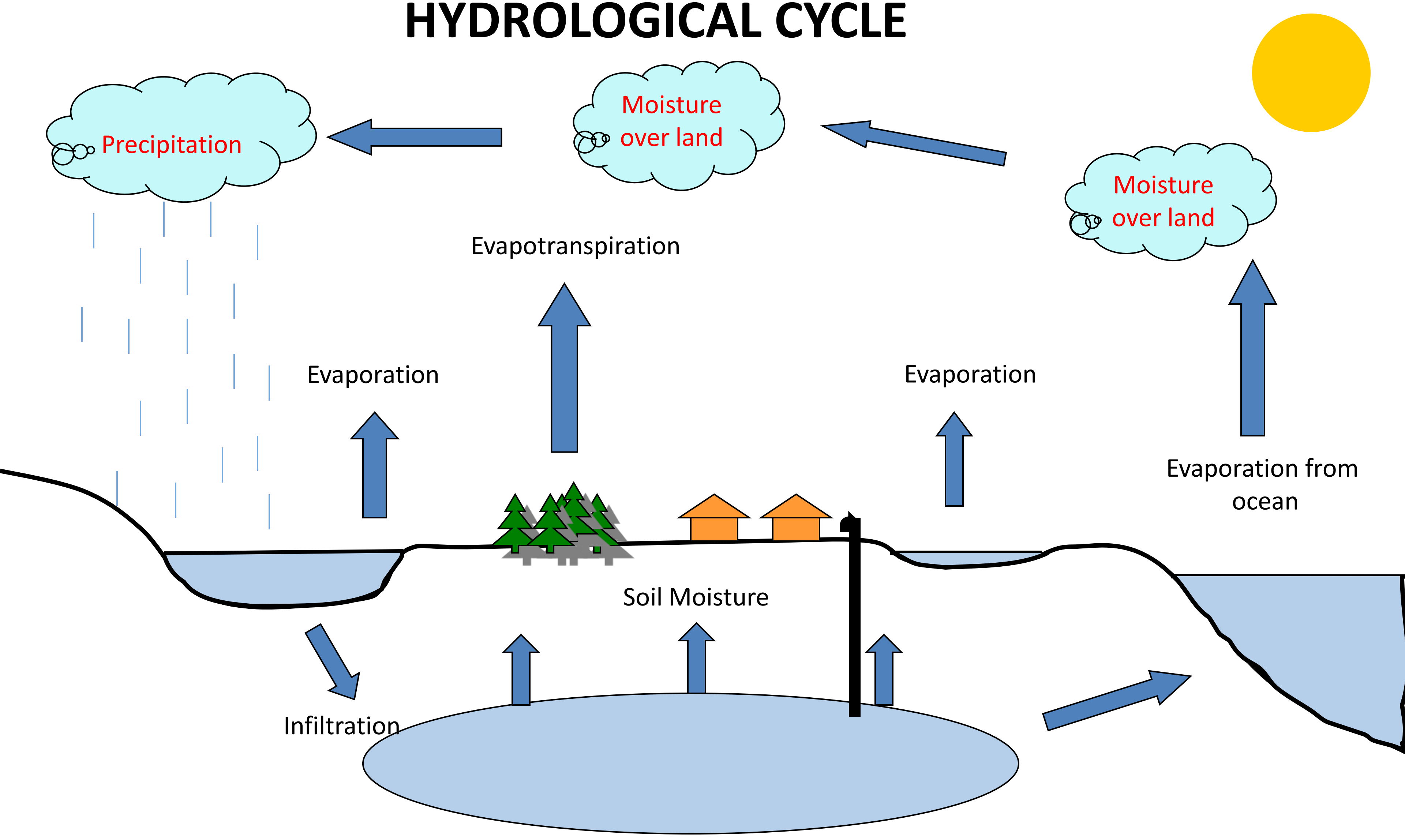




Mean rainy days and duration of SWM in different fortnights

Onset of SWM	Rainy days	Duration
1st FN of June	54.07	102.07
2nd FN of June	51.7	94.6
1st FN of July	40.75	72.0

HYDROLOGICAL CYCLE



Can you think of some more vulnerability factors to drought?

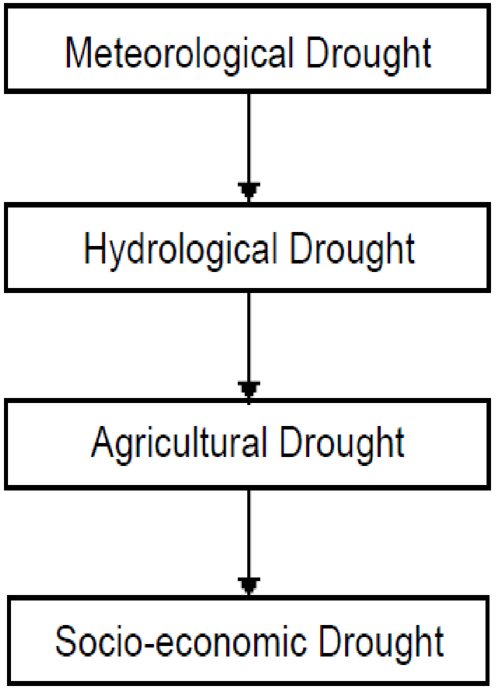
- Low soil moisture holding capacity
- Absence of irrigation facilities
- Livestock without adequate fodder storage facilities
- Poor water management
- Deforestation
- Over grazing
- Water consuming cropping patterns
- Excessive ground water draft
- Soil erosion
- Population growth and urbanization
- Industrialization
- Global warming

Drought Mathematics

The following criteria have been set by the Indian Meteorological Division (IMD) for identifying the drought.

- *Onset of drought:* Deficiency of a particular year's rainfall exceeding 25 per cent of normal.
- *Moderate drought:* Deficit of rainfall between 26-50 per cent of normal.
- *Severe drought:* Deficit of rainfall more than 50 per cent of normal.

Types of drought



Meteorological drought :

absence/deficit of rainfall from the normal. It is the least severe form of drought and is often identified by sunny days and hot weather.

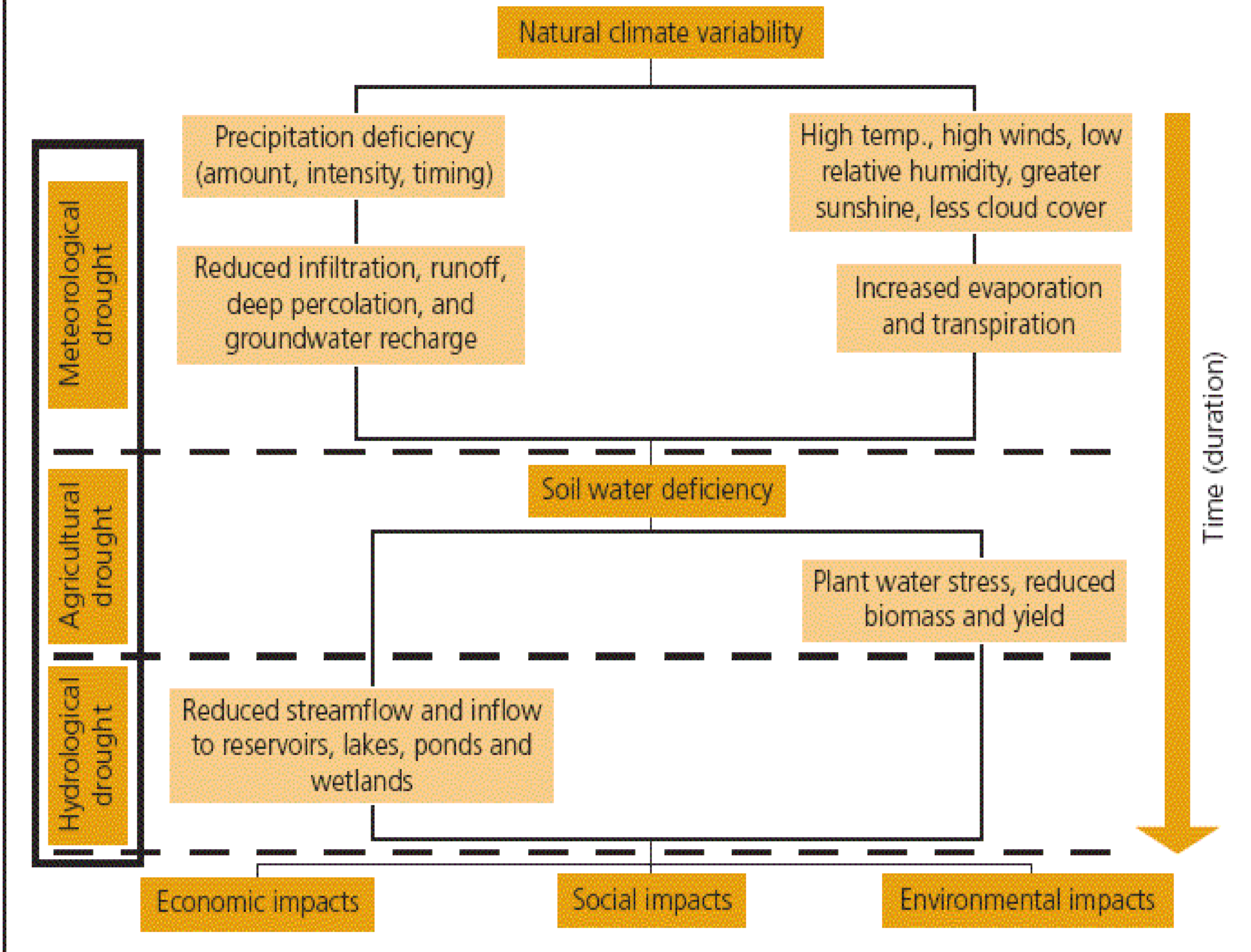
Hydrological drought

leads to reduction of natural stream flows or ground water levels, plus stored water supplies. The main impact is on water resource systems.

Agricultural drought

occurs when moisture level in soil is insufficient to maintain average crop yields.

An extreme agricultural drought can lead to a famine, causing widespread disease and death from starvation.


Natural climate variability
Precipitation deficiency (amount, intensity, timing)
High temp., high winds, low relative humidity, greater sunshine, less cloud cover
Reduced infiltration, runoff, deep percolation, and groundwater recharge
Increased evaporation and transpiration
Meteorological drought
Soil water deficiency
Agricultural drought
Plant water stress, reduced biomass and yield
Hydrological drought
Reduced streamflow and inflow to reservoirs, lakes, ponds and wetlands
Time (duration)
Economic impacts
Social impacts
Environmental impacts

Drought management options:

(1) Soil and water conservation
(2)Agronomic and engineering measures.

1 . Soil and Water Conservation

Conservation practices minimize the disruption of the soil's structure, composition and natural biodiversity, thereby reducing erosion and soil degradation, surface runoff, and water pollution.

Water savings associated with the various interventions

- Proper scheduling of canals (matching supply with demand) : 40-60%
- Precision leveling through laser levelers : 15-20%
- Scientifically designed check basins/border strips : 10-30%
- Zero tillage : 20-30%
- Adoption of Pressurized Irrigation Systems : 40-70%
- Land configuration -Ridge/furrow or raised/sunken beds : 20-25%
- Use of tissue cultured eucalyptus, banana, sugarcane etc : ~30%

Conserving every single drop

- Cut /Lower water use through developed technologies
  - Drip irrigation: Wet area near plant roots. Require ½ - ¼ water than traditional irrigation
  - Drought tolerant crops: Seeds available
  - Cover crops: grown in between harvest . Mitigate the drought by conserving soil moisture
  - Laser leveling fields: Flatten field to make rainwater spread equally.
  - Conservation tillage: Sown crops without removing/burning crop residue of previous crop
    - To retain more water

Established practices of soil and water conservation:

- ✓**Crop rotation**
- ✓**Contoured row crops**
- ✓**Terracing**
- ✓**Tillage practices**
- ✓**Erosion-control structures**
- ✓**Water retention and detention structures**
- ✓**Windbreaks and shelterbelts**
- ✓**Litter management**
- ✓**Reclamation of salt-affected soil.**

CLOUD SEEDING: Injecting clouds with seeding agents like dry ice, silver iodide, sodium chloride, from an aircraft for producing artificial rains

2. Agronomic and engineering measures

Agronomic measures include

- ✓ **contour farming,**
- ✓ **off-season tillage,**
- ✓ **deep tillage,**
- ✓ **mulching and**
- ✓ **providing vegetative barriers on the contour.**

These measures prevent soil erosion and increase soil moisture.

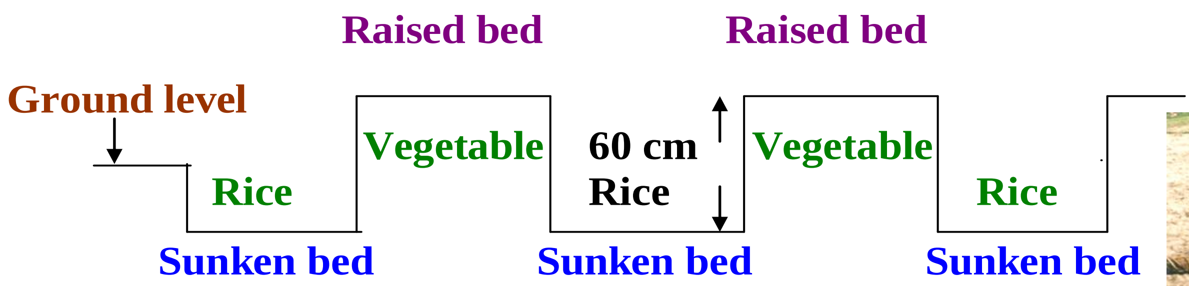
Improving water productivity through cropping systems approach in loamy sand (Punjab, India)[1]

Cropping systems	Rice equivalent yield (t ha^{-1})	Irrigation water use (cm)	Irrigation water productivity* (kg m^{-3})
Rice – wheat	13.7	205	0.67
Maize - wheat	12.6	84	1.50
Maize – wheat-greengram	15	117	1.28
Maize – potato-greengram	18.2	124	1.47
Maize – Potato-onion	27.6	127	2.17
Cotton-wheat	10.2	82	1.24
Summer Groundnut-potato-pearl millet (F)	16	109	1.47

[1] Adopted from *Gill and Sharma (2005)*; *Calculated in terms of rice equivalent yield

Enhanced water use efficiency through land modification

Alternate raised and sunken beds (50:50) 30 m length, 5 m width and 0.6 m height.

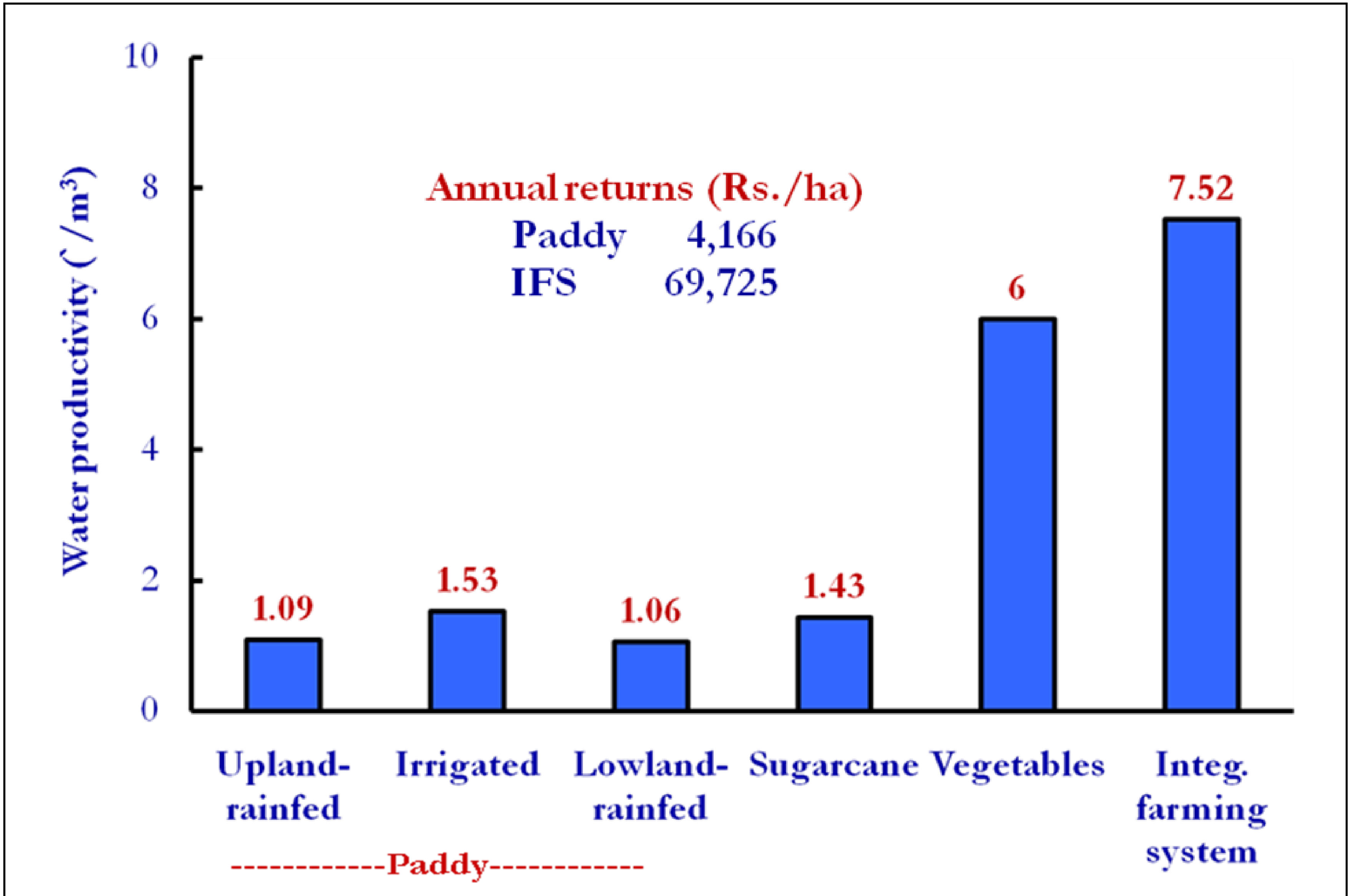


Schematic diagram of alternate raised and sunken bed system

Productivity	
Rice	**5.23 t/ha**
Fish	**3.7 t/ha**
Pointed gourd	**4.74 t/ha**
Water expense	**226.55 kg/ha-cm**
Gross productivity of water	**Rs.8.96/m3**
Net productivity of water	**Rs.6.90/m3**
Net Return	**1.2 lakh/ ha**
B:C ratio	**4.78**

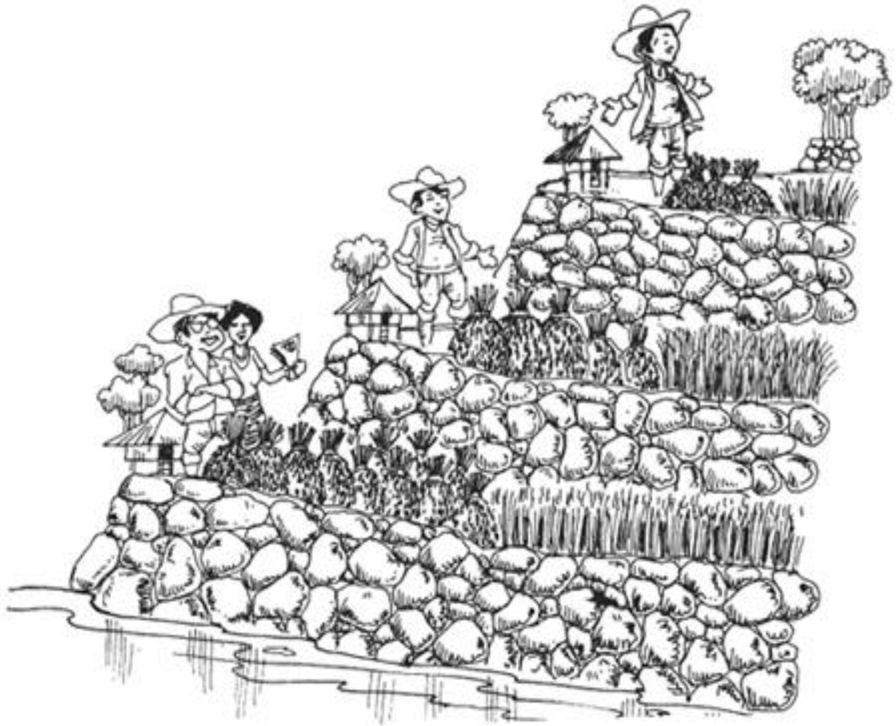
Construction of alternate raised and sunken beds in canal command

Rice, fish and vegetable farming



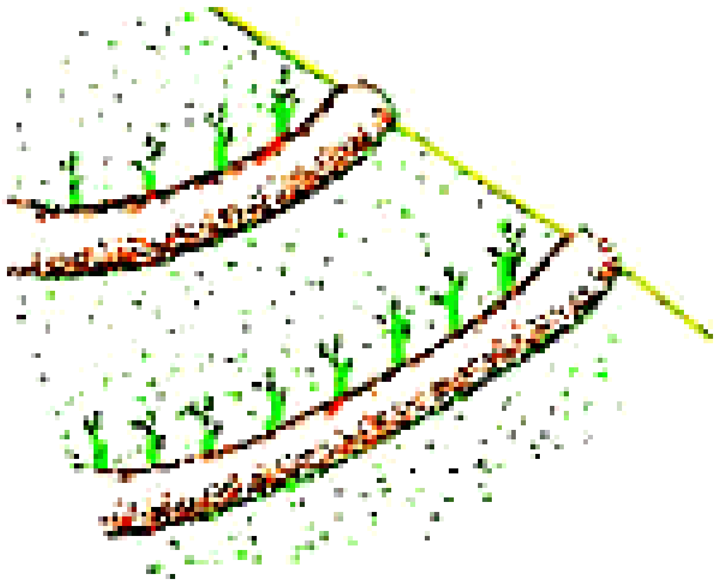
Water productivity in different Cropping/Farming systems

Engineering measures differ with location, slope of the land, soil type, and amount and intensity of rainfall.



Measures commonly used are the following:

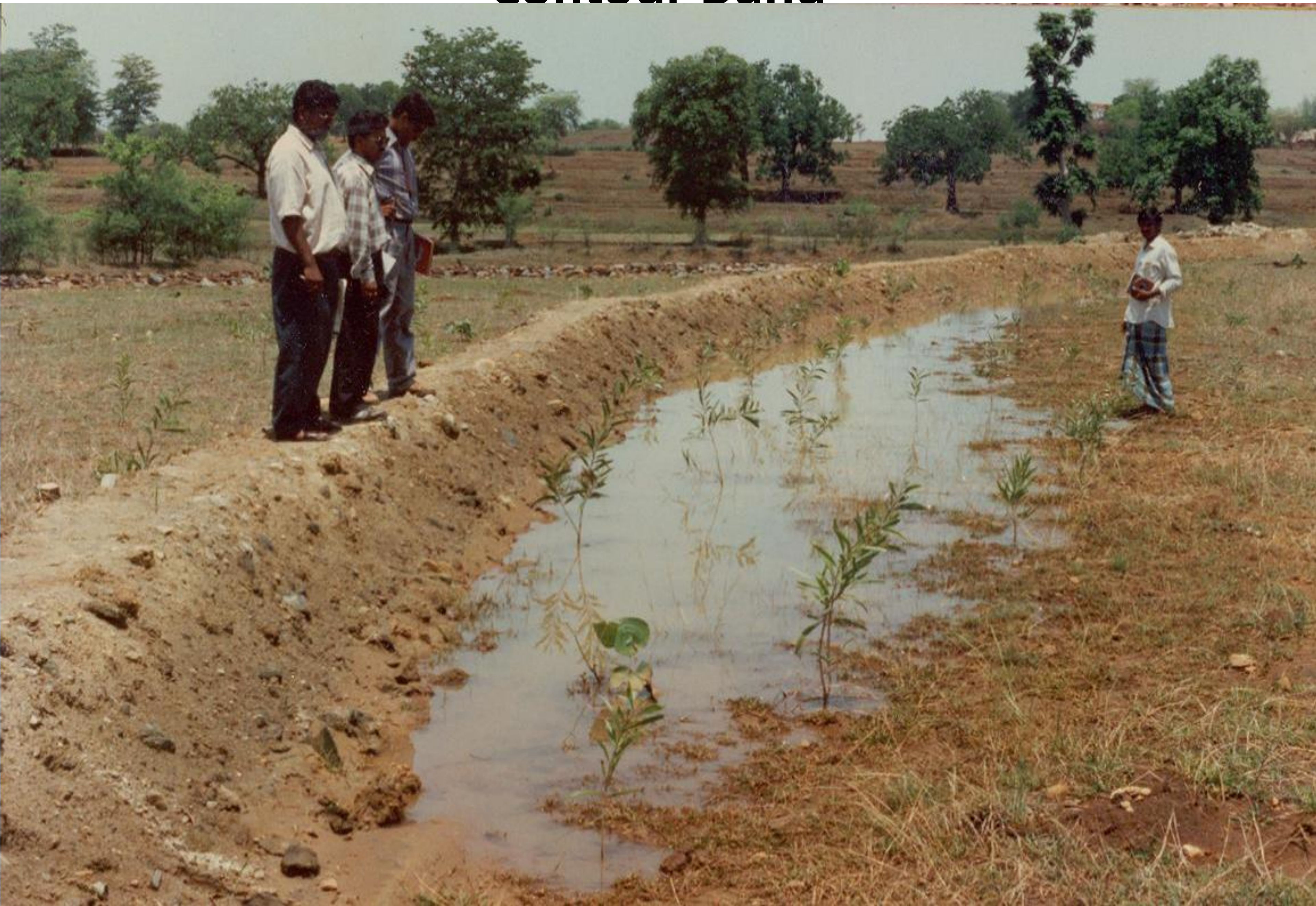
✓Contour bunds, trenches and stone walls



✓Check dams and other gully-plugging structures

✓Percolation ponds

Contour Bund



Farm Bund

Contour bunds, trenches and stone walls:

Prevent soil erosion and obstruct the flow of runoff.

Check dams and other gully-plugging structures :

Temporary structures constructed with locally available materials.

Types of check dams are

(1)the brush-wood dam

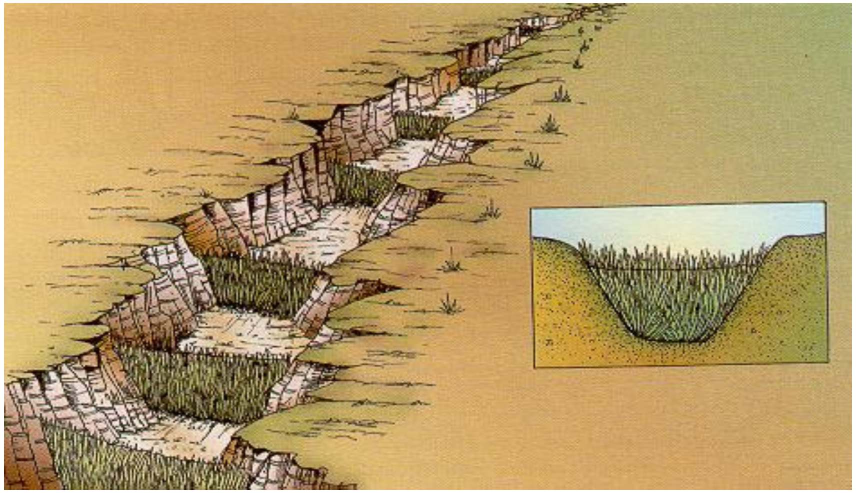
(2)the loose-rock dam and

(3)the woven-wire dam.

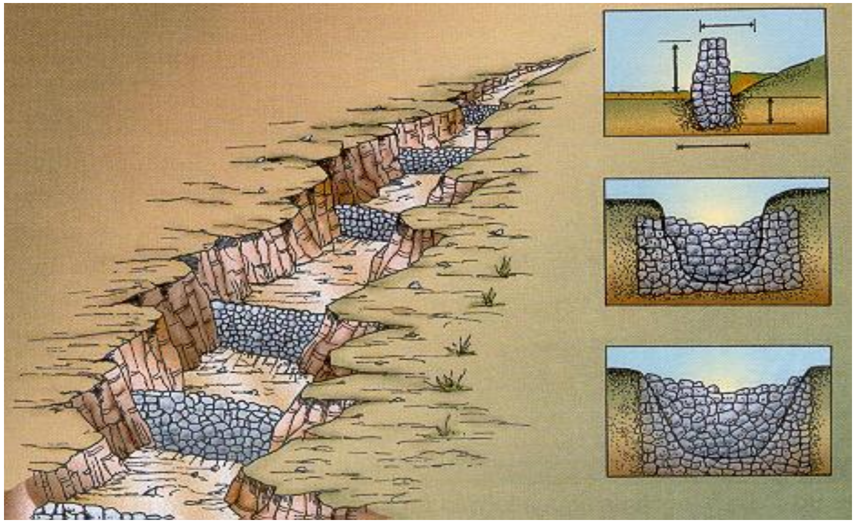
Percolation ponds:

- Livestock and recharge the groundwater.
- They are constructed by excavating a depression to form a small reservoir, or by constructing an embankment in a natural ravine.

LOOSE BOULDER DAM



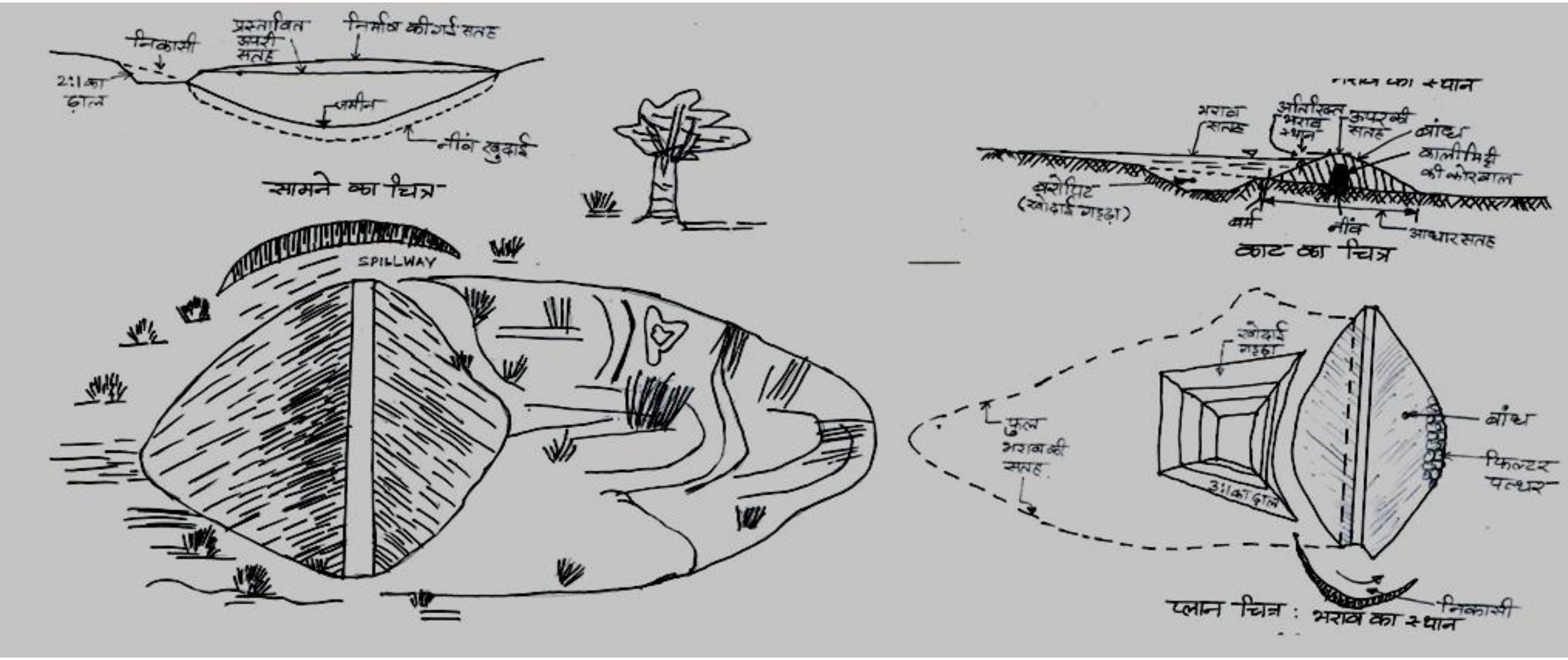
Check dams made out of brush wood



Check dams made out of loose rock

CHECK DAM / ANICUT

EARTHEN DAM / PERCOLATION TANK



STOP DAM

A very good example of mitigating drought in MAH

What a mitigation approach can do? A success story

The people of Ralegan Siddhi in Maharashtra transformed the dire straits to prosperity. Twenty years ago the village showed all traits of abject poverty. It practically had no trees, the topsoil had blown off, there was no agriculture and people were jobless. Anna Hazare, one of the India's most noted social activists, started his movement concentrating on trapping every drop of rain, which is basically a *drought mitigation* practice.

So the villagers built check dams and tanks. To conserve soil they planted trees. The result: from 80 acres of irrigated area two decades ago, Ralegan Siddhi has a massive area of 1300 acres under irrigation. The migration for jobs has stopped and the per capita income has increased ten times from Rs.225 to 2250 in this span of time.

The entire effort was only people's enterprise and involved no funds or support from the Government.

Ralegan, before drought mitigation efforts

Ralegan, after drought mitigation efforts

KHADIN-Traditional water harvesting system in RAJ

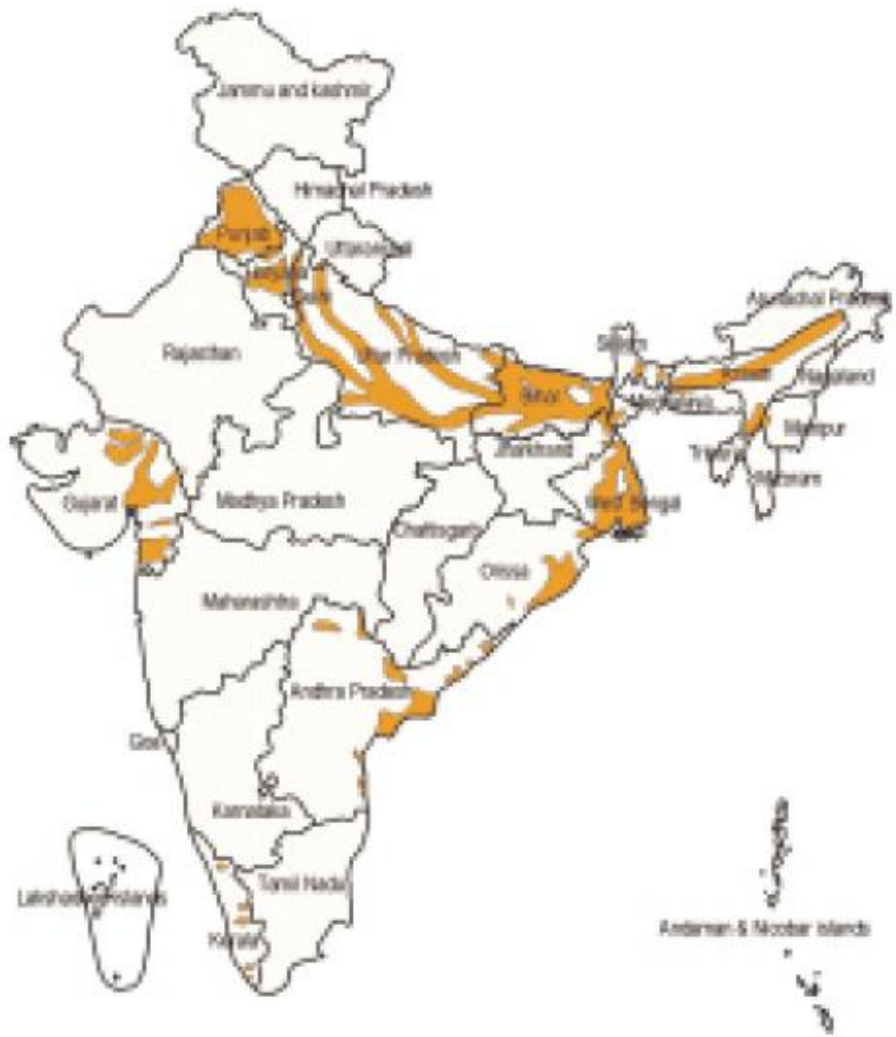
- Traditional rain water harvesting technique used in western Rajasthan.
- Khadin system is a runoff farming on stored soil profile moisture and ground water charging system.
- Based on the principle of harvesting rainwater on farmland and subsequent use of this water-saturated land for crop production
- Main feature is a very long (100- 300 m) earthen embankment built across the lower hill slopes lying below gravelly uplands. Sluices and spillways allow excess water to drain off
- Create positive impact on the ecology of the region, effectively by
  - Checking soil erosion and increasing vegetation cover.
  - arid wasteland productive.
  - A runoff agriculture, a lot of water gets stored on the land, partly going down deep, sideways


FLOODS

Definition

A flood is an overflow or accumulation of an expanse of water that submerges land.

Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its normal boundaries.

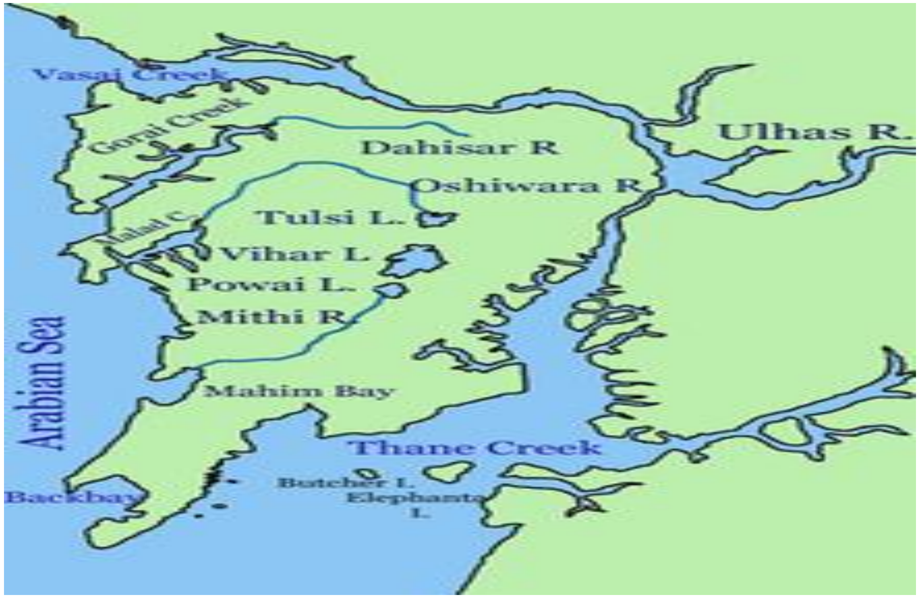


FLASH FLOOD

RIVER FLOOD

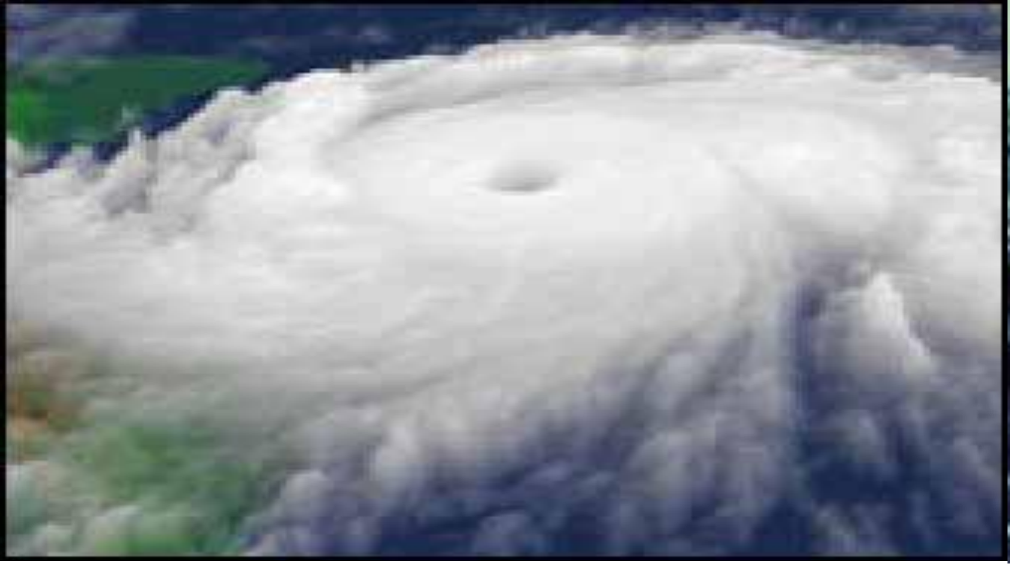
Flash floods are distinguished from a regular flood by a **timescale of less than six hours**

Flash floods-Mumbai rains 2005



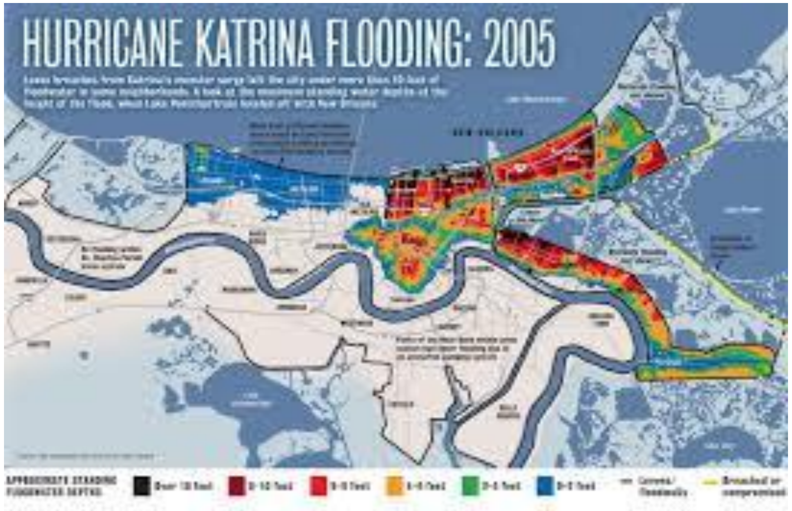
Example: Uttarakhand Flash flood

The flash floods triggered by very heavy rainfall and cloudburst in Uttarakhand on 16-17 June 2013, affected 12 out of the 13 districts in Uttarakhand. The 4 districts that were worst affected were Rudraprayag, Chamoli, Uttarkashi and Pithoragarh. The deluge has washed away roads, bridges and other infrastructure. So far about 10000 deaths are reported and many are still reported missing



COASTAL FLOODS

Hurricane flood-Katrina, New Orleans, Lousiana



Death toll in major floods in India

Year	Number of people killed	Location
1961	2,000	North
1968	4,892	(1) Rajasthan, Gujarat - (2) North-East, West Bengal, Assam
1971	1,023	North India
1978	3,800	North, Northeast
1980	1,600	Uttar Pradesh, Bihar, Gujarat, Kerala, Haryana
1989	1,591	Maharashtra, Andhra Pradesh, Gujarat
1994	2,001	Assam, Arunachal Pradesh, Jammu and Kashmir, Himachal, Punjab, Uttar Pradesh, Goa, Kerala, Gujarat states
1995	1,479	Bihar, Haryana, Jammu & Kashmir, Punjab, Uttar Pradesh, West Bengal, Maharashtra
1997	1,442	Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Sikkim, Uttar Pradesh, West Bengal states
1998	1,811	Assam, Arunachal, Bihar, Kerala, Meghalaya, Punjab, Sikkim, Uttar Pradesh, West Bengal states
2000	1,290	Gujarat, Andhra Pradesh, Assam, Arunachal Pradesh, Bihar, Himachal Pradesh, Kerala, Madhya Pradesh, Punjab, Uttar Pradesh, West Bengal

Flood Disaster Management

The various measures adopted for flood mitigation may be categorized into two groups:

- Structural
- Non- structural

The general approach was aimed at preventing floodwaters from reaching the potential damage centers, as a result of which a large number of embankments came up along the various flood prone rivers.

structural measures

- Levees and flood walls
- Reservoirs
- Diversion of floodwaters.

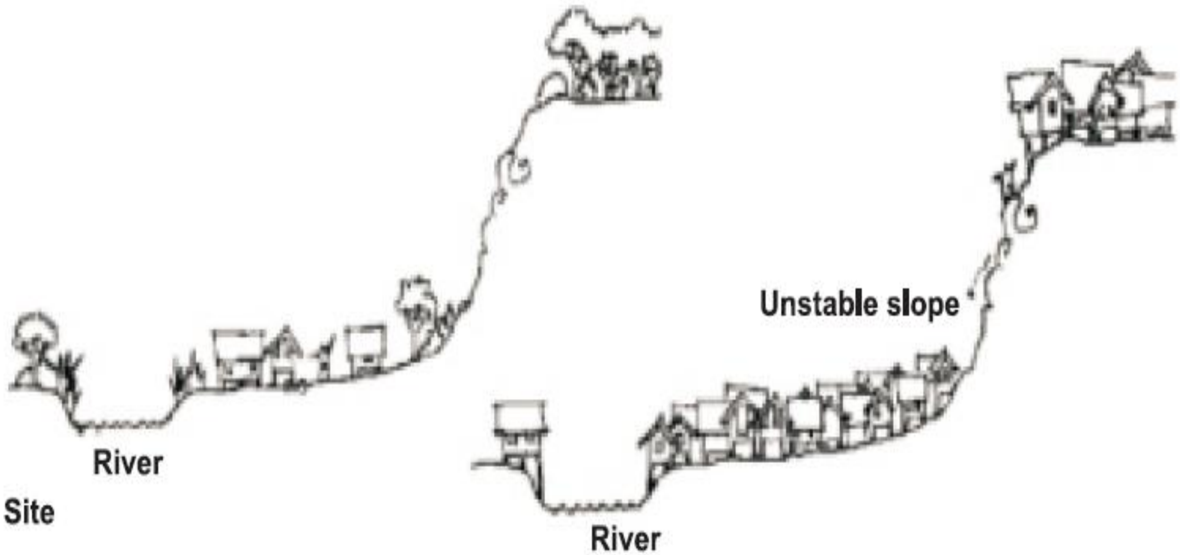


Figure 1.3 : Site after pressures from population growth and urbanization

<u>Example of physical vulnerability is a hazardous slope:</u>

Unchecked growth of settlements in unsafe areas exposes the people to the hazard. In case of an earthquake or landslide the ground may fail and the houses on the top may topple or slide and affect the settlements at the lower level even if they are designed well for earthquake forces.

Levees and Floodwalls

Probably the best known flood control measure is a barrier of earth (levee) or concrete (floodwall) erected between the watercourse and the property to be protected.

Levees placed along the river or stream edge degrade the aquatic habitat and water quality of the stream.

They also are more likely to push floodwater onto other properties upstream or downstream.

Floodwalls perform like levees except they are vertical-sided structures that require less surface area for construction.

Floodwalls are constructed of reinforced concrete, which makes the expense of installation cost prohibitive in many circumstances.

Reservoirs :

Reduce flooding by temporarily storing flood waters behind dams or in storage or detention basins.

Reservoirs lower flood heights by holding back, or detaining, runoff before it can flow downstream.

Flood control reservoirs are most commonly built for one of two purposes.

Large reservoirs **are constructed to protect property from existing flood problems.**

Smaller reservoirs, **or detention basins are built to protect property from the impacts of new development**
(i.e., more runoff).

Diversion :

A diversion is a new channel that sends floodwaters to a different location, thereby reducing flooding along an existing watercourse.

During flood flows, the floodwaters spill over to the diversion channel or tunnel, which carries the excess water to a receiving lake or river.

Diversions can be surface channels, overflow weirs, or tunnels.

Diversions are limited by topography; they will not work in some areas.

Non-structural measures,.

Being implemented in the country for modifying the susceptibility to flood damages through:

- **Flood plain management**

- **Flood proofing including disaster preparedness, and response planning and**

- **Flood forecasting and Warning**

Measures Setting up of flood forecasting and warning services is one of the most cost-effective non-structural measures available.

The flood forecasting organization set up in Central Water Commission is presently responsible for issuing forecasts at 166 stations, of which 134 are for water level forecast and 32 for inflow forecast used for optimum operation of certain major reservoirs.

These 166 stations are located in 14 flood prone states and 1 Union Territory.

Rise in Sea levels

THE IPCC SCIENTIFIC REPORT ON CLIMATE CHANGE (2007)

- Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise
- The effect will be exacerbated by increasing human-induced pressures on coastal areas
- Sea-level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas
- Sea levels rose 17 centimeters in the 20th century.
- Increasing between 7 and 22 inches by 2100

MAJOR CAUSES OF SEA LEVEL RISE

- Melting of glaciers and ice caps

  The polar ice caps, mountainous glaciers and snow sources begin to melt at a faster rate than before and are replaced at a slower rate

- Thermal expansion of seawater

  The globe warms and the sea water will start to expand, So more water is being added through melting while the existing water is expanding

Effects of sea level rise

- Increased coastal erosion
- Higher storm-surge flooding
- Extensive coastal inundation (flooding)
- Changes in surface water quality and groundwater characteristics
- Increased loss of property and coastal habitats

Major Impacts Of Sea-level Rise On Agriculture

- Reduced production and productivity
- The rise in sea level will also increase flood risk, raise the groundwater table and prolong water logging.
- During dry seasons, saline water will dominate the deltaic area for much longer periods and shortages of freshwater for agriculture
- Salt water intrusion
- Saline toxicity

- A higher sea level intensifies erosion on natural beaches, with particularly serious impact on sandy beaches
- It is estimated that a sea level rise of 50 cm would result in the disappearance of about 70% of the sandy beaches
- A rise of 1 meter would result in a 2.7-fold increase in land below high tide and a 2.1-fold increase in density of inhabitants on the remaining land
- High risk for inhabitants on lowlands
- Increased flood risk and potential loss of life

- Loss of nonmonetary cultural resources and values
- Impacts on agriculture and aquaculture through decline in soil and water quality
- Affects tourism & recreation
- Transportation functions

Farming absorbs 22% cost of disaster in developing countries

- 1/4th damage caused by natural disaster affect agricultural sector in developing countries (UNFAO)
- Decrease in yield due to disaster event
- Over the last 10-year period, estimated losses of $70 bn in crops and livestock sector due to natural disasters. Of which, Asis estimated damages were $ 28 bn followed by Africa as $22 bn.
- Of 22%, production losses due to drought is 77 %

CLIMATE CHANGE

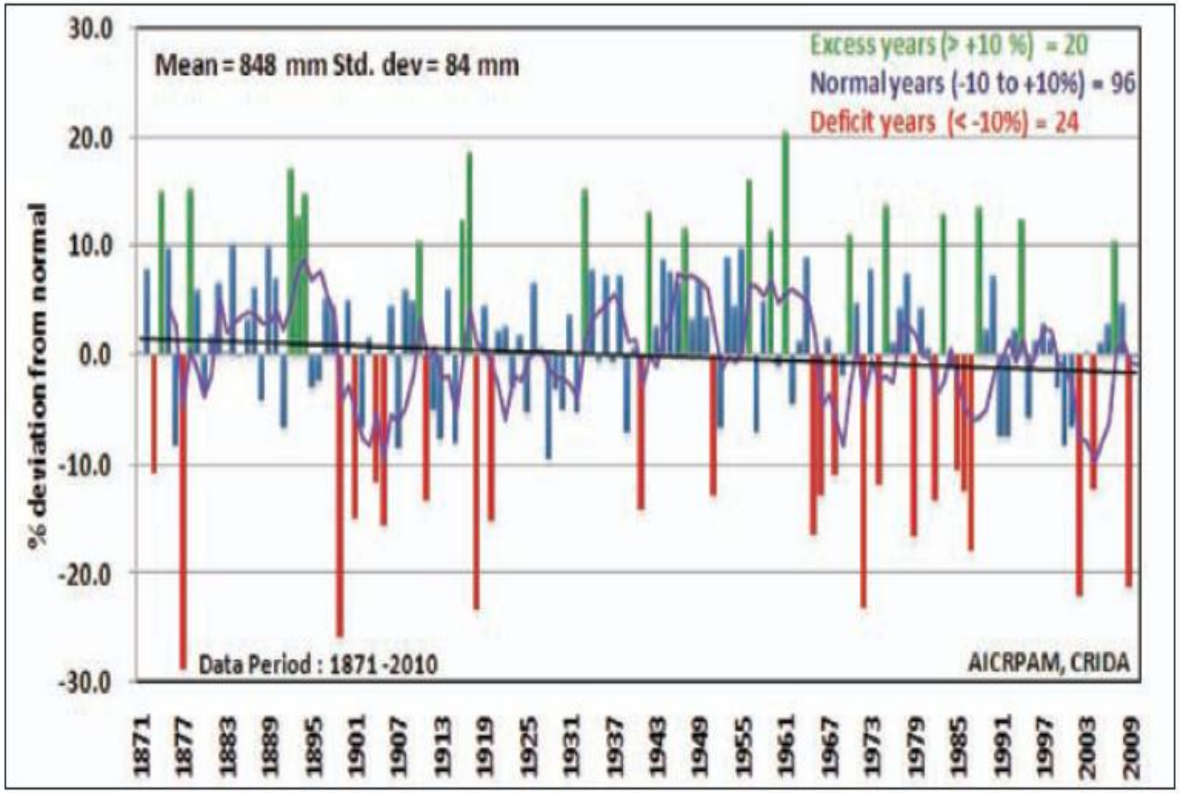


Fig. 1 : Inter-annual variability of Indian monsoon rainfall 1871-2010. Bars denote percentage departure from normal (blue) with excess (green) and deficient (red) years. The long term trend is denoted by the black line. The violet curve denotes decadal variability of Indian monsoon rainfall.

What is El Niño?

- Warming of sea surface waters in the central and eastern tropical Pacific Ocean.
- El Niño: the ocean part: Warm phase of ENSO: El Niño - Southern Oscillation
- Southern Oscillation: the atmospheric part; a global wave pattern
- La Niña: is the cold phase of ENSO: Cool sea temperatures in tropical Pacific

- EN events occur about every 3-7 years

ENSO

A natural mode of the coupled ocean-atmosphere system

ENSO: EN and SO together:

Refers to whole cycle of warming and cooling.

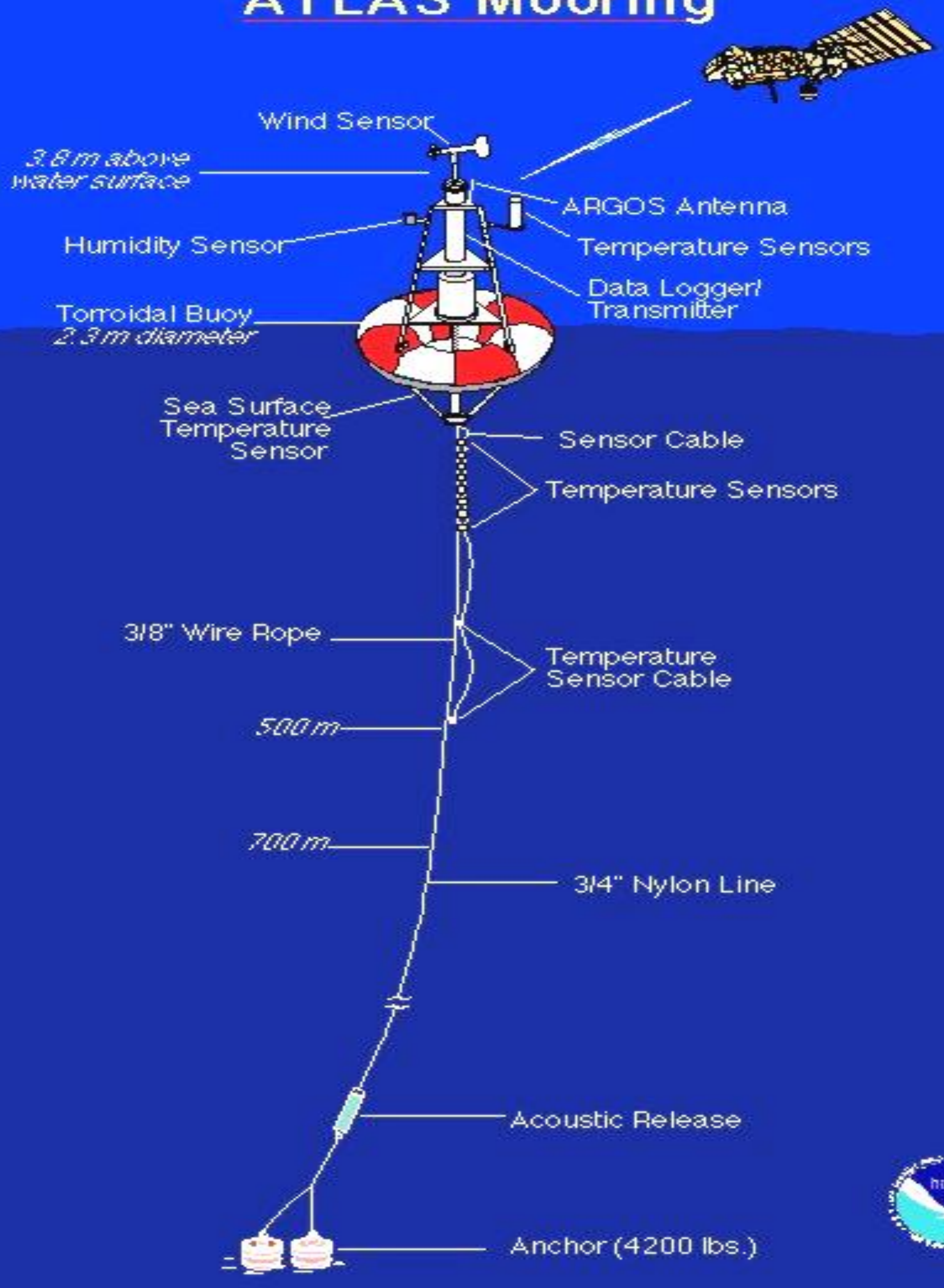
ENSO events have been going on for centuries (records in corals, and in ice layers in glaciers in South America)

ENSO arises from air-sea interactions in the tropical Pacific

Measuring El Niño

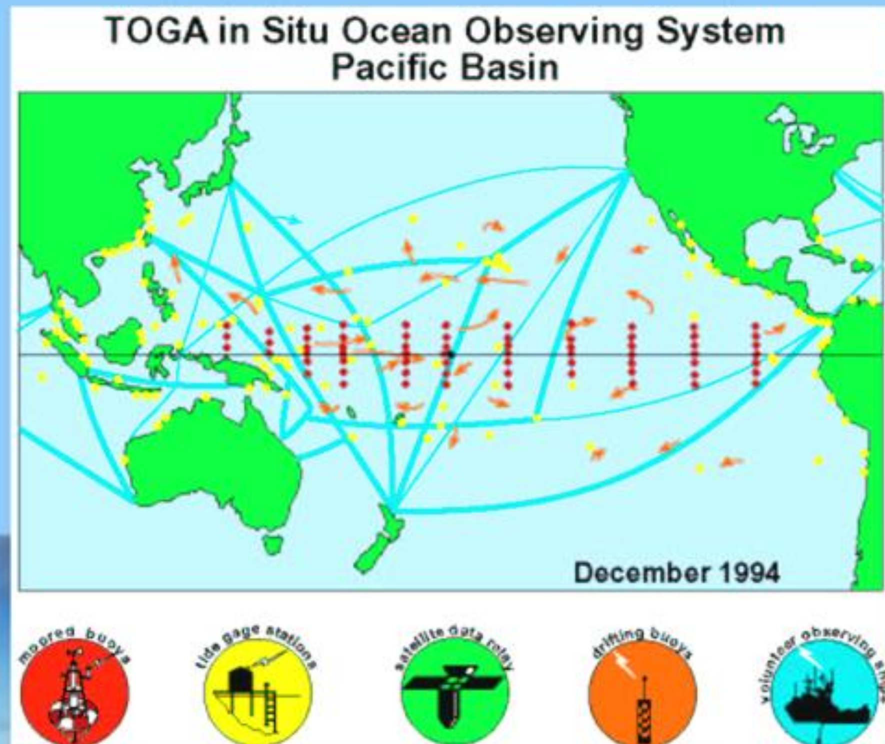
Buoys

ATLAS Mooring



The ENSO Observing System

The ENSO observing system build up during the TOGA period (right panel) is one of the main cornerstones for successful prediction of ENSO events. Without a continuous collection (in space and time) of different meteorological and oceanographic data using the capabilities of research vessels, ships of opportunity, surface and satellite observations and the evolving knowledge and technology of climate modelling successful forecasts of ENSO events would not be possible. Compared to the benefit of the society the cost for the maintenance of the observing system and the modelling resources are neglectable.



Photos: above and right: maintenance of the TAO array (courtesy NOAA/PMEL), upper right: "classical" sea surface temperature measurements (bucket) (courtesy G. Meehl)

AV/G1/99-6

Global warming

⇓

Heating ↑

⇓

Temperature ↑ & Evaporation ↑

⇓

water holding capacity ↑

⇓

atmospheric moisture ↑

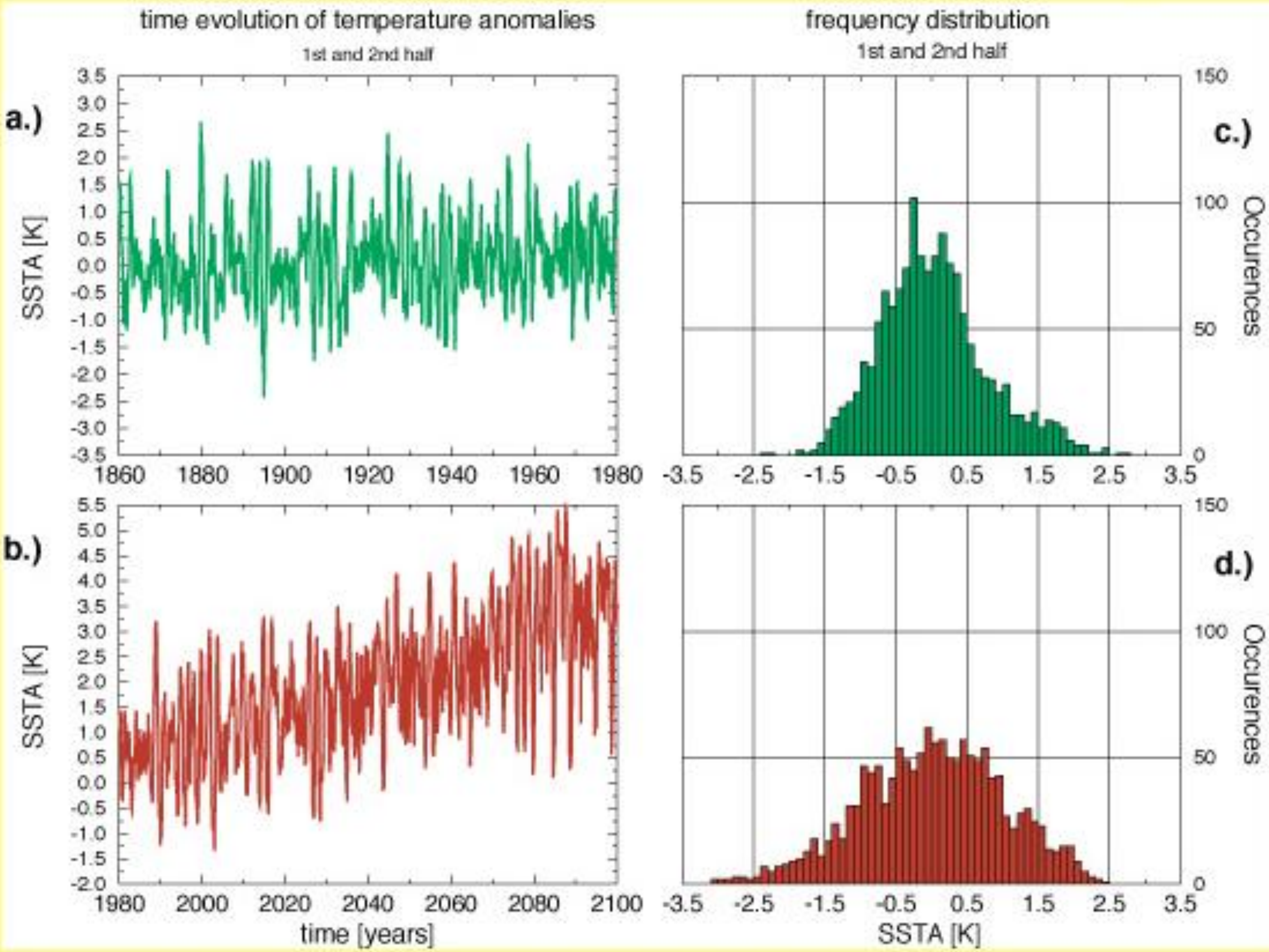
⇓ ⇓

greenhouse effect ↑ & rain intensity ↑

⇓

Floods & Droughts

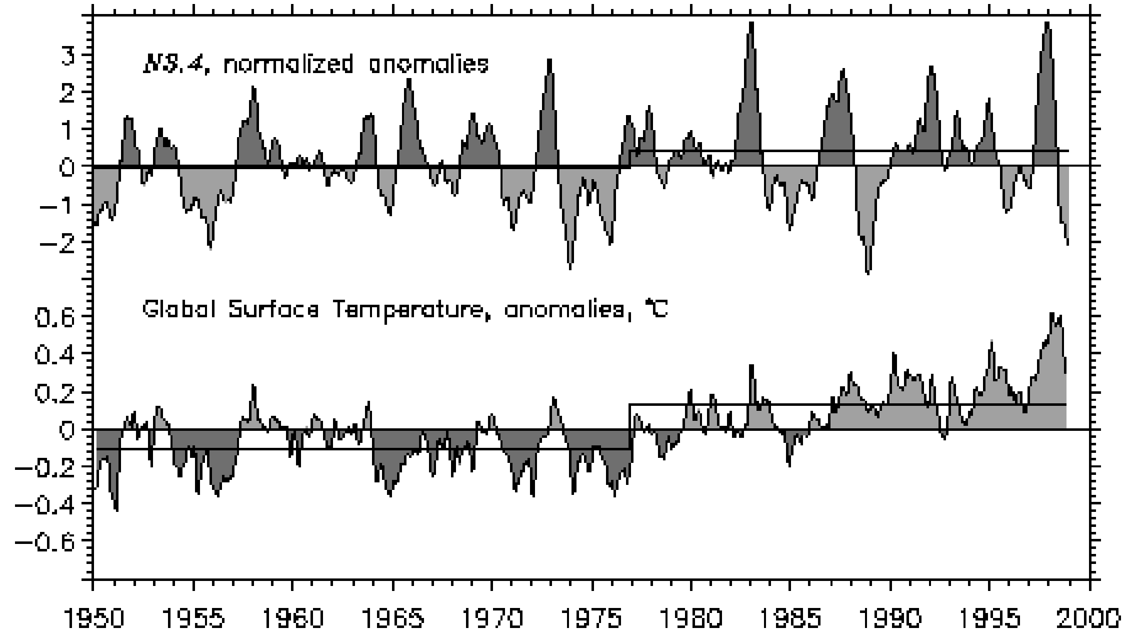
El Niño and Climate Change



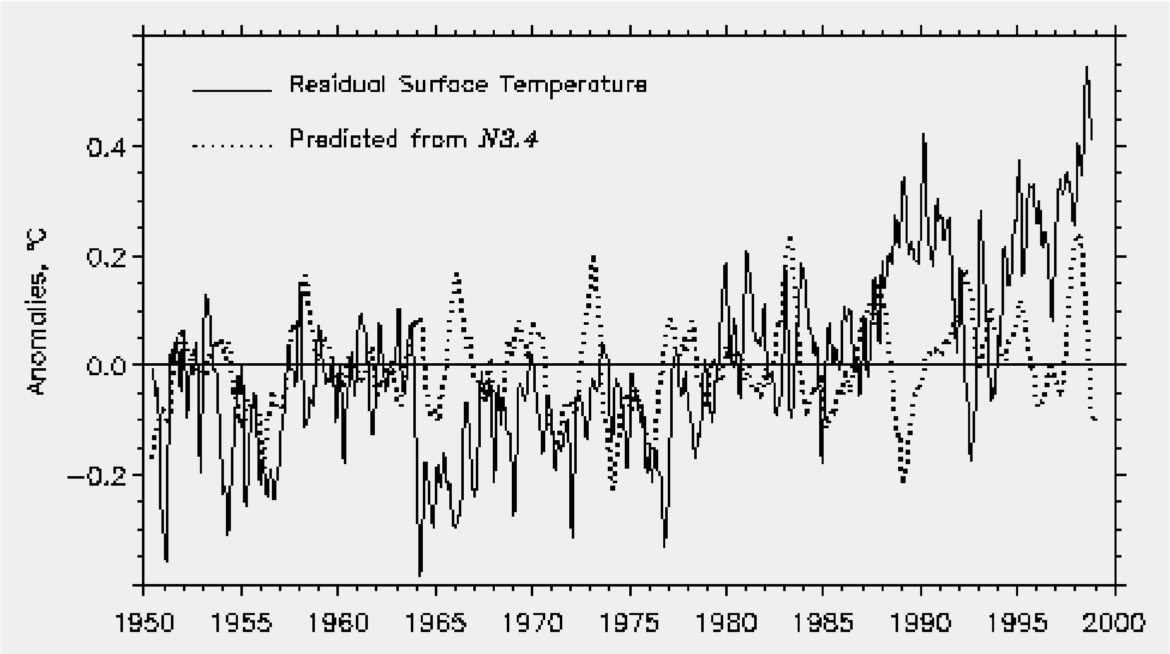
Simulated tropical Pacific (Niño-3) SST anomalies and frequency distribution of El Niño in a climate change Experiment (ECHAM4/OPYC). Source: Timmermann et al., 1999, Nature, 398, 694-697

AV/G1/99-8

There is a mini global warming with El Niño: 0.24°C peak in 1998, 0.17°C for year



Trenberth et al. 2002



How will El Niño events change with global warming?

El Niño involves a build up and depletion of heat as well as major redistribution of heat in the ocean and the atmosphere during the course of events.

- Because GHGs trap heat, they interfere.
- Possibly expand the Pacific Warm Pool.
- Enhance rate of recharge of heat losses.
- More warming at surface: enhanced thermocline → enhanced swings
- More frequent El Niños?
- Some models more El Niño-like with increased GHGs.
- But models do not simulate El Niño well
- Nor do they agree

The hydrological cycle is expected to speed up with increased GHGs. Increased evaporation enhances the moisture content of the atmosphere which makes more moisture available for rainfall. ENSO-related droughts are apt to be more severe and last longer, while floods are likely to be enhanced.

Kyoto Protocol

- Adopted in 1997
- Cut CO_2 emissions by 5% from 1990 levels for 2008-2012
- Symbolic only, since cuts will not significantly impact global warming

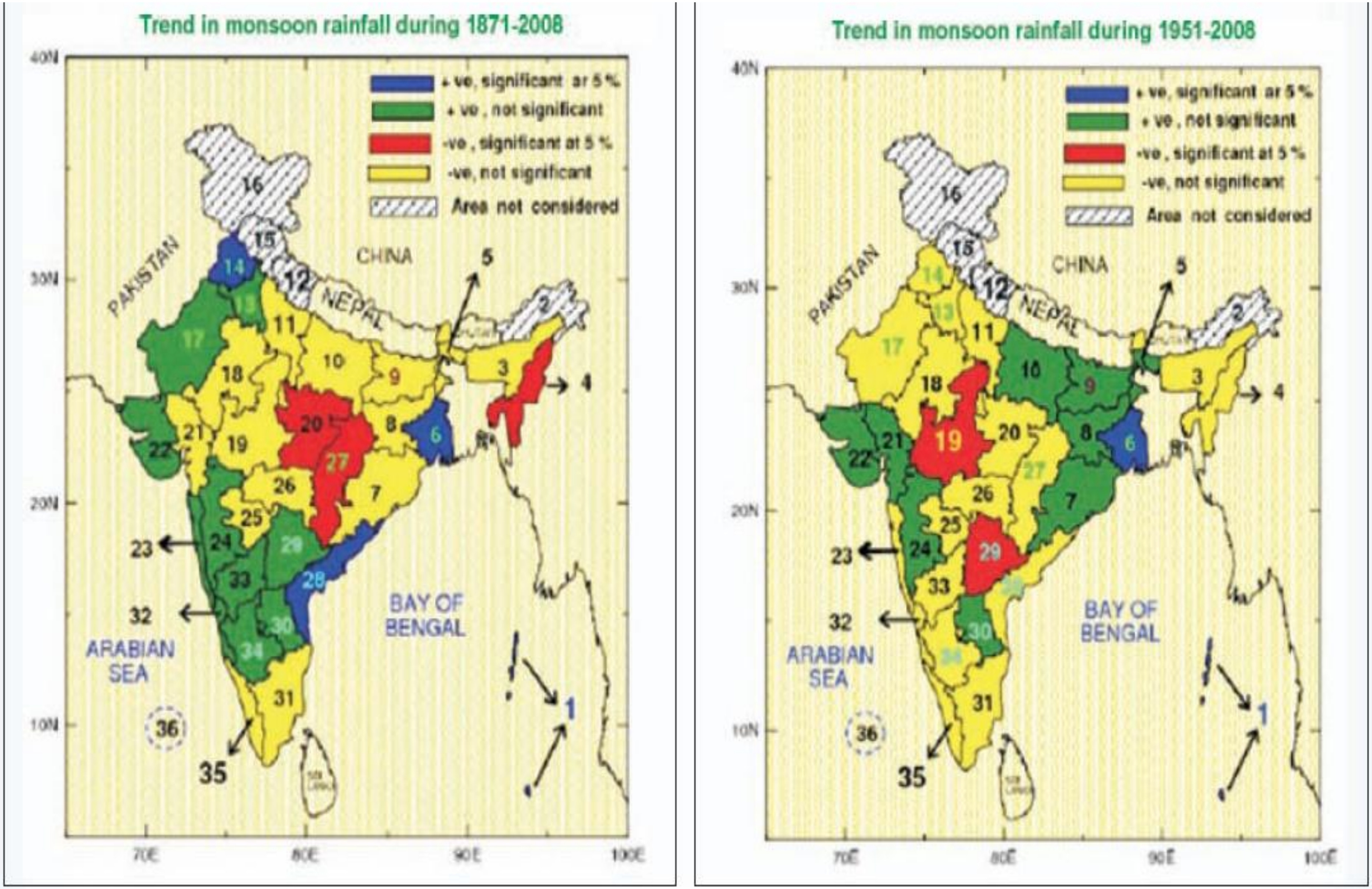
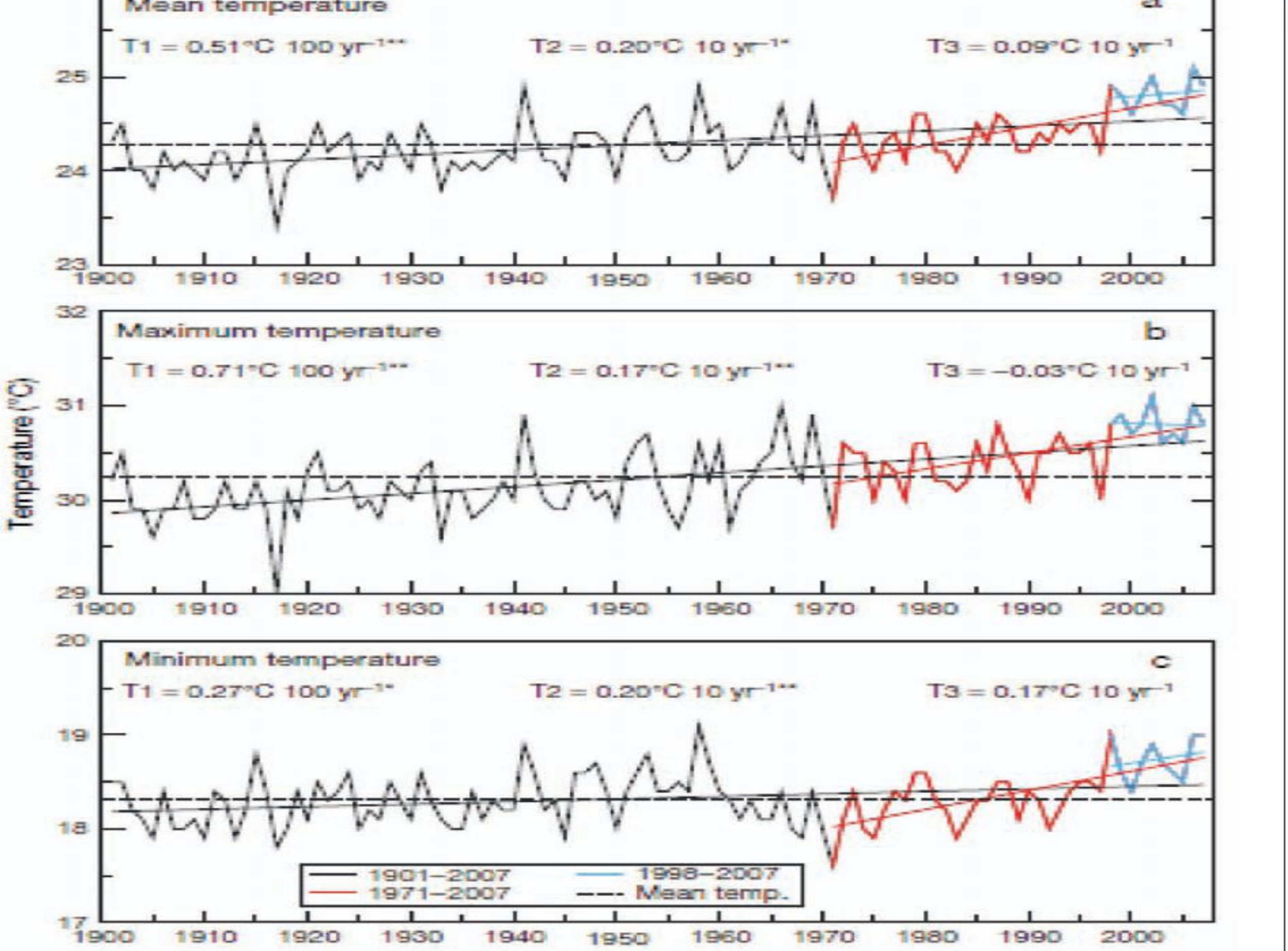


Fig. 2 : Trends in summer monsoon rainfall for 1871-2008 (a) and 1951-2008, (b) for 36 meteorological subdivisions (INCCA, 2010)



4: All-India annual mean, maximum and minimum temperature variations during trend periods 1901- 2007