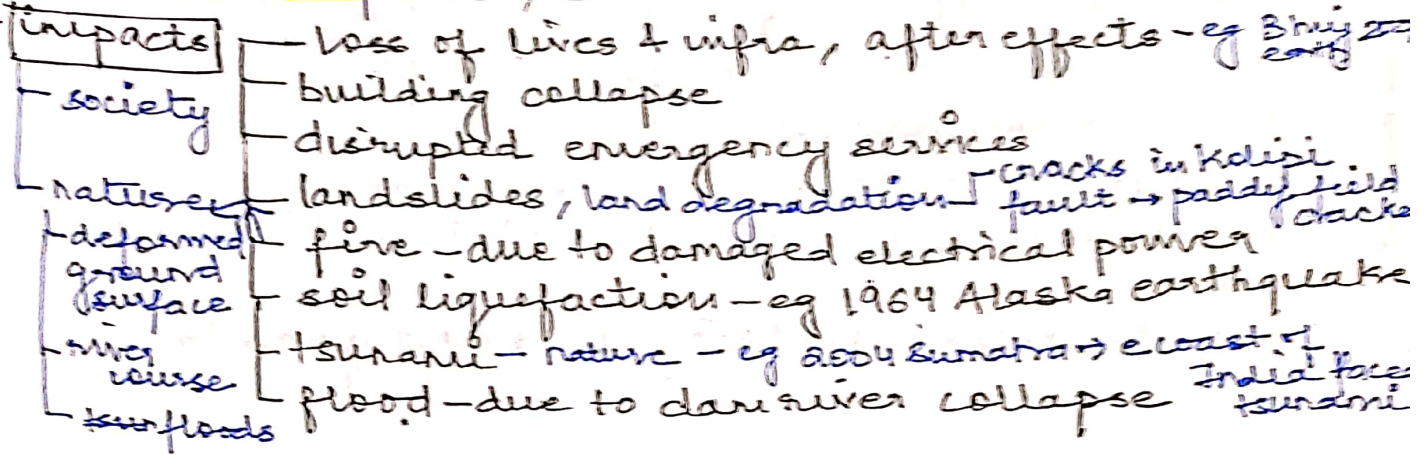


EARTHQUAKES - 11% of which is Risk V.

59% landmass prone, due to crustal movements



Steps taken by GoI -

- National Centre for Seismology under MoES for monitoring
- establishment of 115 observatories across country
- seismic micronization of cities to build earthquake resistant buildings
- NDMA led awareness drives ^{print} and sensitization drives ^{social} e-media
- following guidelines of BIS, BMTC, etc for construction of buildings and circulation of such
- EWS - alert warning on P waves after occurrence of earthquake
- CSS National Risk Mitigation Project

Concerns/Challenges -

- lack of awareness about risk
- inadequate attention to structural mitigation
- enforcement of building codes - infra
- inadequate preparedness & response
- outdated seismic maps
- inadequate enforcement - eg NDMA on Ahmedabad buildings
- licensing of engineers
- cannot be predicted
- Eurasian - India plates

NDMA 6 pillared approach -

- earthquake resistant construction & retrofitting
- regulation and enforcement of building codes & compliance
- selective retrofitting of existing structures
- awareness & preparedness
- capacity dev - edu, research
- response - search & rescue, command system, NDRF, etc
- plans, targeted groups
- medical preparedness

Steps needed -

- ✓ prioritising safety of high buildings that are capable of causing huge damage
- ✓ sensitisation drives
- ✓ trainings at schools
- ✓ construction of camps at isolated places for earthquake rescue
- ✓ Mitigate after effects by aids and grants

* lessons from Japan

TSUNAMIS - around 5,700 km of total coastline
vulnerable

3

Tsunamis are caused by earthquakes or other seismic eruptions on ground of oceans.

Impacts -

death of lives and infra damage

Oxfam reports 4x women than men died due to their waiting on beach for fishermen to return

spread of water borne diseases

env - groundwater exploitation, trees and sand dunes, saltwater infiltration, poisoning of freshwater

eco - devastation of local economies, fishermen, tourism

after effects - trauma, impairment

Steps taken -

- Implementation of ICZM plan

- inclusion of ocean zone in CRZ rules

- regulations on sand mining

- safety of settlements

- EWS - Indian Tsunami EWCentre by INCOIS

- Adoption of UNESCO "Tsunami Ready Programme"
eg - OD introduced it in 2 villages - Tsunami ready villages
community level

- Multi hazard vulnerability map atlas on coast

- INCOIS led workshops, training & mock exercises

- SMART scheme of MoES

- Bio shields developed

Challenges -

- documentation issues of traditional knowledge

- community awareness

- high casualties in thickly populated areas

- heavy damage due to mining

NDMA -

→ preparedness -

- decision support and SOPs
- R & D
- training & capacity building
- medical preparedness
- DM plans

→ Mitigation

Structural

- mainstream DM plan
- standards of protection for structures
- institutionalised designs

Non structural

- sand dunes along coast
- coastal forests
- submerged dykes
- beach nourishment
- sandy ramps
- elevated hutments
- mangroves
- land use pattern

→ Regulation & enforcement

→ emergency response

→ ensure implementation

Way forward -

- satellite imageries and timely warnings
- mock drills and awareness
- learning signs
eg - receding of waves, higher waves
- co-existence of structural and non structural measures

CYCLONES - - 40% population lives within 100km of ^{coastline}

are large revolving tropical storms caused by winds blowing around a central area of low atmospheric pressure.

- exposed to around 10% of tr cyclones in world

Impacts -

- deaths
- storm surge
- infrastructure damage
- inland flooding
- disturbs daily activities - impacts GDP ^{Disasters 2% of GDP} 12% of GDP (agr & ser)
- reduces soil fertility, fall of trees
- strong winds cause damage to telecommunications, houses, etc
- increases inequality and aggravates poverty
- ecosystem - wetlands, aquaculture
- crop damage - eg - cyclone Niran (2020) damaged horticulture

Issues -

- Local scale hazard mapping
- capacity development
- assessment of shoreline changes
- wetland conservation
- sustainability of measures
- ~~longer~~ ^{less} time gap b/w detection & impact
- vulnerability and info sharing
- low data and absence of land use norms

GoI Steps taken -

- I) Improved cyclone monitoring and forecast - MoES
 - Global Ensemble Forecast System
 - upgradation and of Decision Support System and Tropical Cyclones Warning Services - IMD
- II) ITCWC at INCOIS after 2004 Tsunami & Cyclone
- III) Cyclone Warning Centres at 4 places and 3 at w coast - India is 2nd to none in EWS for cyclones
- IV) Atmosphere & Climate Research Modelling Observing Systems and Services (ACROSS) scheme -
- V) Web-DCRA (Web based Dynamic Composite Risk Atlas) and Decision Support System tool for real time cyclone and impacts
- VI) Shelter equipments under NCRMP for emergency situations

NDMA -

- 7 staged EWS
- aircraft probing cyclone facility
- dev of centralised lead time impact assessment
- coastal zone management -
 - biohields, mangroves, shelter belts, afforestation
 - coastal flood plain management
 - groundwater resources, sustainable land use
 - crop & livestock protection
- awareness and dissemination
- disaster risk management - civil society, NGOs
- response - medical, quick response
- implement guidelines
- NDRF

Way forward -

- Eddy detection technique to advance detection time for preparation
- regulate coastal erosion
- NDMA guides community based EWS and evolve village level response
- search and rescue should be prioritised
- eg - BD - 1999 super cyclone
Amphan

FLOODS - 2006 - Ganga Flood control - 39 districts flood prone

Acc to NC on floods - 80% of India's land is flood prone

Causes - 12% of total geo area is flood prone

- inadequate capacity of rivers to contain high flows
- poor drainage, choked manholes with plastics
eg - Mumbai
- heavy rains [brought down by SW monsoon (80% of rain)
KL and UK floods 2021, GJ 2022]
- excess irrigation & waterlogging
- siltation of riverbeds and reduced capacity to hold water [cyclones & cyclonic circulations, cloud bursts]
- tidal effects and bank erosion - eg OD
- changed course of river - Bihar, Kosi, AS Brahmaputra
- GLOF, snow melts [rivers originating in nei countries]

Steps taken -

- structural [construction of channels and embankments]
- Non structural [town protection works]
- Flood management [dredging & desilting rivers - Mittal Committee]
- Training programmes [forecast system - CWC]
- Flood forecasting networks by CWC [Draft bill for flood plain zoning programme - 11th plan - assistance to states]
- Bilateral forums - Nepal, China, Bhutan, Pak, Bang [Flood watch app - chances of floods]
- WRIS - digitised data [Damini app on google]
- alerts on google Nowcast

Challenges/ Gaps -

- non availability of digital elevation model of flood prone areas
- zoning regulations implementation in all states
- no available forecast for all rivers
- soil erosion
- lack of public participation
- understaffed and underfunded municipalities and panchayats
- lack of coordination b/w stakeholders
- No bills for solution for flood & erosion in NER
- reactive post disaster management approach

Growing challenges -

1. As per CWC Flood forecasting network, in last 3 years (2019-2021) in addition to flood prone areas, extreme floods witnessed in other areas due to excess rain in short duration.

2. NE floods

3. flooding of sand mines & coal mines

- Govt - tech. guidance
- fin resources for critical areas via DONER
- NEC schemes for control activities
- Flood management programme for NE & border areas extended till 2022
- satellite data - NESAC and CWC

Mitigation -

- Interlinking of rivers as per National Perspective Plan by NWDA
- IMD Flash Flood Guidance
- Flood EWS for NER in 2012
- National Hydrology Project - NRSC/ISRO - medium range spatial models for Tapi and Godavari
- Flood plain zoning as per Rashtriya Bazh Aayog

Way forward -

- use of geospatial data for models
- Funding earmarked for flood resistant infra and disaster relief
- evacuations - NDRF and Air force
- drainage improvement
- Medical preparedness.
- NITI aayog recommendations
 - extend FMBAP
 - National Water Model
 - tech use
 - balance str. & non str integrated man.
 - eg- amphibian houses of Netherlands

Impacts

• Social

- loss of lives
- risk of violence
- affect habitation
eg - AS
- affect essential services
- spread of diseases

• Economy

- loss of property
- eco loss -
68% of losses
among all
disasters by
flood (Emergency
Events Database)

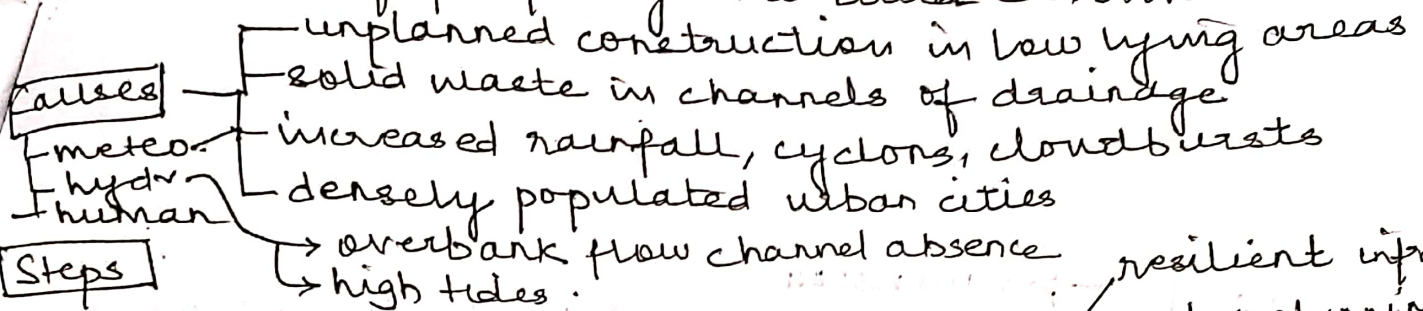
- ags land
- female unempl

• Env

- ecology
- positive consequences

Urban Flooding - 6x volume & 2-8x peak than rural floods

inundation of property in a built environment



- signatory to Sendai framework on DRR

- Newcast of IMD for forecast

- ADB loans for Chennai floods to build flood protection infra

- Flood preparedness - zoning & land use planning

resilient infra
urban planning
land use
reduce loss of lives & risk of flooding

NDMA

- I) EWS and communication
- II) design & management of urban drainage
- III) Rainwater harvesting
- IV) Conservation of water bodies
- V) Response
- VI) Sanitation
- VII) Urban Flooding Cells within MOUD

Darangere and Agartala -
map drainage system
remove illegal encroach
storm water drains

✓ sponge cities
Challenge

✓ SOP for mitigation under

AMRUT

Impacts

- inundation and damage to vital infra
- disruption to roads & services
- eco losses - local & global
- disease outbreak

✓ Flood management programme

✓ Uniform system of alert & warnings

✓ IFLOWS - Mumbai

Challenges

- access to areas
- water supply & waste management
- awareness
- choked drains

* IPCC indicates increase in instances of heavy rainfall in shorter span of time

Mitigation - { pre monsoon
during monsoon - EW & effective response
post monsoon

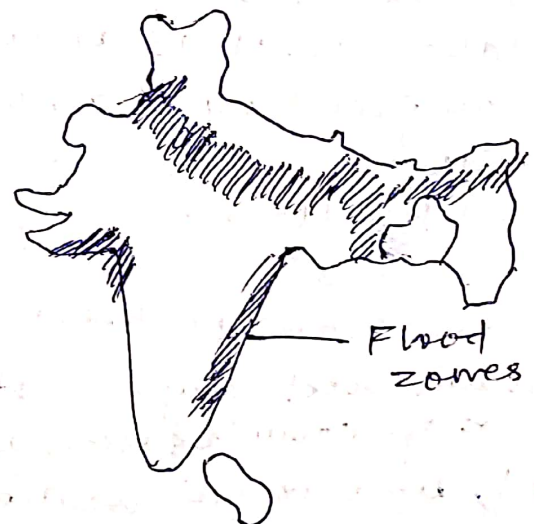
- on time evacuations
- go at higher levels and take valuables - water proof bag
- install gas connection, electric panels at heights, check valves at sewer traps
- info dissemination - Mumbai automatic weather stations to record rainfall every 15 mins
- rain gardens, 'sponge cities'

Way forward

- Mumbai, model of solid waste disposal site
- Infra improvements -
 - demarcation of existing drainage path - no encroachments
 - use of proper engineering designs for flyovers, bridges
 - storage of water in tanks at rooftop or ground, holding ponds
 - resurfacing of road level
- Individual - life insurance, flood risk map to be known
- Community - awareness, and response eg - school children
- City - authorities to follow law in spirit & practice, cooperate with people
- investment in infra & by laws, mitigation - only 7% of total cost of damage
- after disaster medical precautions
- * proper planning & retrofitting of best practices as no city is flood free safe

NDMA Guidelines

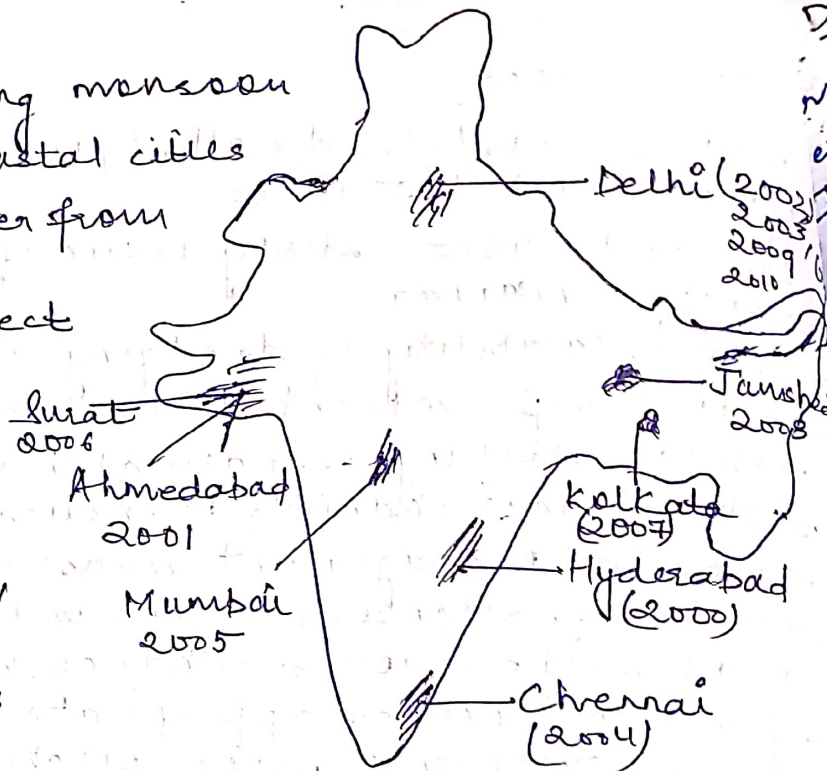
- FLOOD - 2008
- embankments / flood walls / flood levees to be constructed after detailed studies
- CWC and s govt - study issue of rise in river beds in scientific manner
- explore viability of dredging as remedy for river beds
- channel improvement to reduce flood level in rivers
- prohibit blocking of natural drainage channels and construct new channels to ensure flow of excess rainwater
- watershed management measures - afforestation, check dams, detention basins in river catchments to prevent soil erosion & enhance water conservation
- s govt to consider appropriate anti-erosion measures - such as revetments, slope pitching, permeable & impermeable spurs using conventional materials, geosynthetics
- raised platforms / flood shelters by s govt
- sea walls, coastal protection works
- basin wise flood hazard mitigation models
- integrated platform for interaction - CWC, IMD, NRSA on real time basis
- cooperation with neighbours - Nepal, Bhutan, China - to obtain data on real time basis
- s govt to enact and enforce appropriate flood zoning regulations laws
- reclamation of existing wetlands / natural depressions
- Training & cap building
- community engagement to volunteer services, counselling
- media to disseminate timely & accurate info
- strengthen Ganga Flood control Board and Brahmaputra board.



→ URBAN FLOODS

→ Risk -

- increased rainfall during monsoon
- storm surges affect coastal cities
- sudden release of water from dams
- urban heat island effect leading to increased rainfall
- global climate change
- sea level rise
- coastal towns, upstream/downstream of dams, inland cities, hilly areas



→ Guidelines

- EWS - CNC to maximise real time hydro-meters network to cover all urban centres
- use of Doppler Weather Radars to be expanded to cover all urban areas
- coordination mechanism among all agencies
- state of art automatic water level recorders throughout drainage networks
- catchment for storm water drainage in all ULBs, contour mapping for catchment planning
- inlets on roads to drain water to roadside drains
- rainwater harvesting in all houses
- Rain gardens for public parks and stormwater management
- penal action against drain encroachments
- flood hazard assessment
- database of NUIS to cover infra facilities
- urban flooding is a separate disaster, unlike riverine flooding
- flood shelters
- awareness
- restoration, post floods

* Volunteered Geographic Information participants

* use of crowdsourced data on use of approximate water level, logging and location; real time info can be provided

DROUGHTS - 68% of country's area is drought prone

Drought is a natural hazard that affects a large spatial extent over a longer period of time.
It occurs in area with meagre rain, water scarcity, inefficient resource management, water exploitation, limited recharge

IMPACTS - phy, socio, eco, env
→ on communities -

NC on Agri

- crops, unempl., inflation
 - livestock
 - high lending → debt
 - suicides
 - competition among people for water increases
- economy - agro based industries
GDP loss, loss of human capital, increased deficit

→ env. unsustainability, water shortage

→ migration, documentation, undermines social resilience

FACTORS that influence vulnerability -

- temporal & spatial rainfall distribution
- precipitation & soil moisture
- ground water levels & stream flow
- water shortage
- cropping patterns & land use
- socio - eco - weaker pop, farm holding size



CHALLENGES

- delays in drought declaration
- no consultative process incl. all stakeholders
- lack of vulnerability maps with procedures & assessment
- minimise losses - relief centric approach than mitigation effort
- No cell for Ind. Drought Management - & also lack of database
- ICT use, RSTech - limited use of climate info
- identify best practices for adoption
- Common policy for short-term management and long term resilience
- issue in climate forecasting models
- suboptimal management of water resources

DROUGHT MANAGEMENT

- ← intensity assessment & monitoring
- ← drought declaration & area prioritization for management
- ← dev & impl. strategies

INITIATIVES taken -

→ Atal Bhujal Yojana,
Catch the rain

- PMKSY - AIBP - Irrigation projects to benefit Drought p.
Area programmes
- JTM - Har Ghar Jal - water distribution to release dependence on groundwater, supply info
- CSS - MoRD - Watershed Dev - PMKSY → Krishi app
- States - prevent aquifers exploitation - Model Bill circulated by MoTS to all states
- CGWA - guidelines on groundwater extraction
- National Water Policy 2012 - community management
- Financial allocation by centre under NDRF
- NDRF & SDRF, PMFBY - relief measures
- NDMA guidelines -
 - assessment & EWS
 - prevention & mitigation
 - cap. dev
- DMC at 2 level
- vul. maps for each state by state DMCs
- real time drought related info by ICT
- watershed dev
- ground based and space based info integrated
- damage assessment - agn prodⁿ, depletion of water resources, livestock population
- micro level analysis & forecasting - automatic weather station, rain gauges
- drought resistant crop varieties
- cloud seeding policy for mitigation
- crop diversification / drip irrigation
- provision of credit in drought affected areas
- afforestation - subabul, casurina, biodiesel (Jatropha, pongamia)
- awareness

relief & response
[relief
[financing
[supply
[relief
[programme

Solutions -

- Agn measures - MI, liquid fertiliser, space tech, farm ponds, water intensive crops
- awareness - NCC, Scouts, NSS
- tree plantation and catchment protection
- restoration of water bodies

TIMELY declaration -

- DMC
- weekly data
- collection of data
- online publication of received data

- 3 phased decl.
- interim seasonal relief measures
- forewarning & preparedness

MITIGATION -

- pilot studies in all categories
- cloud seeding
- crop diversification, MI
- protective irrigation
- credit to affected areas & price support
- afforestation
- insurance for diff agro climatic zones

CROPS LIVESTOCK -

- fodder need, fodder crops cult.
- tank bunds
- periodic utilization of fodder banks
- fish & aquaculture preservation
- online availability of info
- market intervention to maintain price
- water conservation

*Causes of recurring droughts -

- variable rainfall during SW monsoon - uneven distribution
- Met. events - El Niño
- Increased extremities of climate and heat frequency
- limited irrigation coverage, prevalence of rainfed agr, poor irrigation techniques
- Inadequate water availability - over exploitation, suboptimal conservation

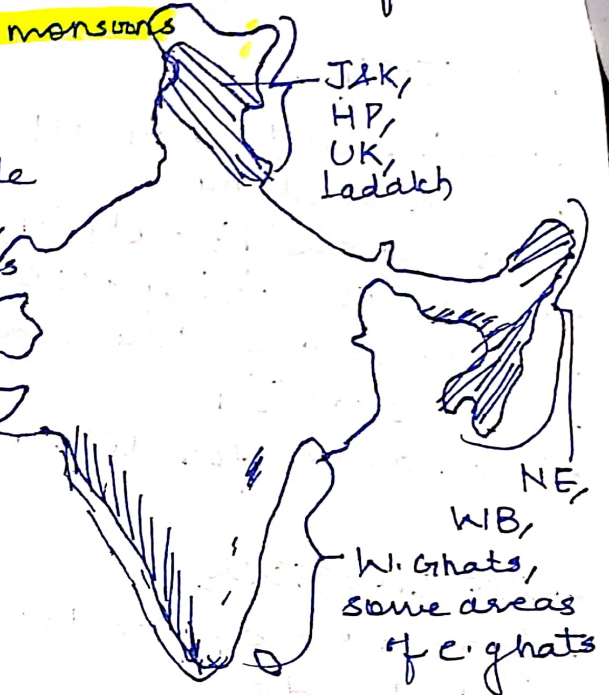
LANDSLIDES -

Landslides are hydro-geological hazard. They occur due to flow of materials under influence of gravity and stress.

12.6% of Indian landmass is landslide prone, esp in hilly and mountainous areas. - Landslide Atlas of India
It affects 15% of land area esp dur. monsoons

IMPACTS

- Short term - loss of lives, cultivable land, env impact (erosion, soil loss), pop. shift, relocate establishments
- property destruction, - eco loss
- transportation eg - KL Idukki
- reduce efficacy of hydro projects
- floods



CAUSES

- increased dev activities - Uttarakhand
- earthquake & high landslide zones
- heavy precipitation - UK (2013)

more frequent due to cc, deforestation

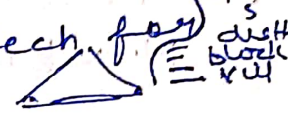
steep slopes - Malpa tragedy (1998) -
unstable mass fractured rocks
mitigation challenges

poor lithology - Manipur - 2022
heavy rains - Mumbai - 2021
Kerala - 2021
LNW monsoon

INITIATIVES -

- LANDSLIP - prototype regional Landslide EWS - GSI
- National Landslide Susceptibility Mapping programme
- Landslide Mitigation and Detailed Project Report preparation

LANDSLIDE RISK MANAGEMENT STRATEGY - NDMA - 6

- i) Landslide Hazard zonation - vul. risk mapping at macro & meso level
 - use of UAV, Laser scanner, EO data, quality data
- ii) Landslide monitoring and EWS - rainfall threshold based, wireless netw. of all such stations ground inst. based, surface geo. maps
- iii) Awareness generation programmes - local masses, edu. masses, latest tech and techniques
- iv) Capacity building of stakeholders - new tech for inputs, genuine target groups in rcc & adm, 
- v) Mountain Zone regulation and Policies.
- vi) stabilisation & mitigation & creation of SPV for management

ISSUES in management -

- LHZ than L. Susp. zonation, small landslides due to road cutting, etc diff. to predict
- lack of threshold model for spatial occurrence
- LEWS - challenges - limited resources, precise forecast, geotechnical data, comm. netw. in remote areas, awareness
- Lack of basic data, inventory on large scale, training of trainers, target group identification
- mitigation issues due to different areas and indifferent attitude of people.

- human caused -

28% ~~the~~ incidents of stone falls due to construction work

- Critical Infra der lacking

* Landslide Hazard Mitigation -

- area specific measures
- limit construction & agr activities
- large scale afforestation, bunds
- terrace farming

CLOUD BURSTS

Cloud burst is extreme amount of precipitation in a short period of time which is capable of creating flood like conditions.

It is localised but intense rainfall activity

[rainfall of 10 cm or more in 1 hour over 10 km area]

India receives 116 cm of rain over entire year

eg - Mumbai floods - 2005

COMMON OVER HIMALAYAS -

- local topology, wind system, pressure gradients

ISSUES -

- commonly over areas having ^{not} measuring instruments
- lack of forecast in case of cloudbursts - no capability to predict exactly how much rain will fall, more diff. to predict for smaller areas

IMPACTS

- trigger landslides and flash floods
- excessive destruction downstream - life and property
- water concentration in valleys & gullies
- damage to flora - fauna and utilities

- no evidence of increasing cloudbursts - IMD
- extreme rainfall events will increase

SOLUTIONS -

- constant update on weather
- follow up and dissemination of IMD warnings
- shelter
- Doppler radars - (expensive)
- identification of vulnerable areas
- reduce inhabitation of low lying areas.

GLACIAL LAKE OUTBURSTS FLOOD (GLOF)

- It is created when water dammed by glacier or moraine is released suddenly due to trigger mechanisms. It leads to sudden discharge of large ~~amount~~ volumes of water and debris which causes flood downstreams.



FACTORS

- large lake volume
- narrow and high moraine dam
- stagnant glacier within ice
- avalanche displacement waves - calving glaciers, hanging glaciers, rock falls, melting ice core
- earthquakes or landslides
- climate change
- rapid increase in glacial lakes due to retreating glaciers eg - Kedarnath tragedy 2013

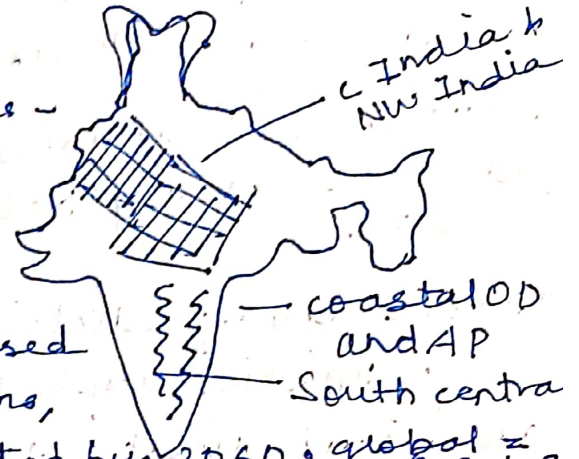
NDMA Guidelines -

- Identify potentially dangerous lakes
- Use of Technology - SAR to detect changes, remote monitoring of lake bodies from space
- Channeling potential floods - reducing volume of water - controlled breaching, pumping out water, tunnel through moraine
- Uniform codes for construction activity - land use planning procedures in GLOF prone areas, framework for infra dev & excavation
- Enhanced EWS - sensor based monitoring using technical systems
- Training local manpower
- 80% of search & rescue is carried by local community.
- assisted by local teams in planning
- comprehensive Alarm Systems -

HEATWAVE - a period of unusually hot weather with above normal temperatures that last for 3 or more days.

→ India - 40°C - plains, 30°C - hilly
during March-June

→ Causes
[natural] - atm. circulation anomalies - HP areas, upp. tropospheric, jet streams
[local effects] - depleted soil moisture, enhanced sensible heat flux
- global forcing - ENSO, Ind. ocean modulate



- Duration of heatwaves have increased by about 3 days during last 30 years, further increase of 12-18 days expected by 2060, global = $0.8-1.8$ day
- In future, increased over area - incl. S parts of India
- Climate change is causing more frequent & stronger heatwaves

→ Shift from eastern region of Gangetic WB, Bihar to NW, C, further S region of India
- exposure - 40mm (2012) to 80mm (2016)

Impacts -

- Human health - deaths, dehydration, heat stroke
- Ecosystems - GLOF in n. Pak, wildfires, coral bleaching, species extinction
- Agriculture
- Energy
- Water
- Economy - around 34 mn will face job loss due to reduced output by 2030
- social - less income, loss of lives
- Why heatwaves?
 - concretisation of land
 - urban heat island
 - rise in global temp
 - climate change
 - tropical zone - high UV rays
 - high rural population

NDMA guidelines

- Establish EWS and inter agency coordination
- Capacity building / training programme for health care professionals
- Public awareness & community outreach
- Collaboration with non government and civil society

* Challenges

- no statutory recognition under DMA Act 2005
- lack of research
- narrow analysis of urban ward level data
- lack of public awareness
- half hearted attempts
- unavailability of basic services

Solutions ahead -

- Adaptation to minimise impacts -
 - developing heat response plan ← EWS
 - ← awareness
 - ← tech intervention
- IITM Pune - heatwaves can be predicted 2 weeks before advance - using MOES Extended Range Prediction System
- MOES study - prediction can happen one season before - using Mission Coupled Climate Forecast Model
- Regional Climate Models over Indian subcontinent
 - eg - LMDZ4, ESM2M
- Holistic efforts to reduce forest fires vulnerability
- Active use of social media for community sensitisation

Steps initiated

- IMD led heat action frameworks - colour coded warnings
- National Monsoon Mission (NMM) - advanced prediction system for Early warnings
- IMD - Forecast Demonstration Project - detailed daily reports
- Ministry of Health releases guidelines on DoS + Dots
- IARI InfoCrop simulation model - impact on farm yield on time
- ICAP - 2019

* New courses -

- absence of rainfall and convective activities for long period
- absence of Western Disturbances
- subsidence of warm & dry air in lower & middle tr. levels over N. Arabian sea & adjoining S Pak & GI

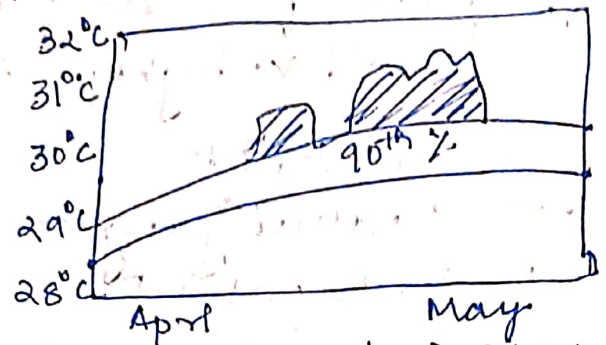
MARINE HEAT WAVES

eg - 2015 Bengal deadliest

- periods of extremely high temp in ocean.
- became 34% more frequent and 17% more longer b/w (1925-2016)

Impacts -

- coral bleaching
- seagrass destruction
- loss of kelp forests
- fisheries sector
- 85% of corals in Manner got bleached due to m.h. in 2020
- monsoon - results in dry conditions over central Indian subcontinent



Causes -

- ocean warming - eg Indian ocean - increased h/w at rate of 1.5 events per decade
- breaks in wind patterns → heat remains trapped at ocean surface for longer
- El Nino - Ind. ocean warming
- carbon emissions - 90% of warming due to GHG emissions absorbed by oceans.

Impacts

- Habitat destruction
- Forced migration of sea animals
- Monsoon impact - in Ind ocean
- changing climatic conditions - ↑ rains in south peninsula
- increase in cyclonic activity

Forest Fires

- more than 36% of forest cover is prone to frequent forest fires (SFR-2021)
- 6% v. highly fire prone

- RJ Sariska TR
- MP Ladkui jungles
- OD Simlipal TR

✓ NAP on Forest Fires (2018)

✓ CSS Forest Fire prevention & management scheme

* absence of proper institutional framework within for dept

✓ FSI - alert issues, monitoring, danger rating, man agn portal

* lack of holistic approach

* no provision for separate allocation under CS schemes

* inadequate capacity & training

* extreme gaps in knowledge sharing

NDMA - Cold Wave

- Identification of cold wave risk
- vulnerability assessment
- qualitative early warning
- forecast and alert dissemination

✓ IMD colour coded warning