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MODULE 5

HAZARD AND DISASTER MANAGEMENT PLANS FOR FLOODS, TIDAL WAVES.

STRUCTURAL MEASURES FOR FLOOD MANAGEMENT

- 1. Embankments/Banks, Flood Walls, Flood Levees
- 2. Dams, Reservoirs and other Water Storages
- 3. Channel Improvement
- 4. Desilting/Dredging of Rivers
- 5. Drainage Improvement
- 6. Diversion of Flood Water
- 7. Catchment Area Treatment/Afforestation
- 8. Anti-erosion Works
- 9. Sea Walls/Coastal Protection Works

Embankments/Banks, Flood Walls, Flood Levees

- The embankment system in the river restricts the river to its existing course and prevents it from overflowing the banks.
- Embankments are constructed generally with earth easily available from nearby areas.
- In developed areas where adequate space is not available or land is very expensive, concrete or masonry floodwalls are constructed.
- Embankments (including ring- bunds and town- protection works) are the most popular method of flood protection and have been constructed extensively in the past.
- Embankments are designed and constructed to afford a degree of protection against floods of a certain frequency and intensity or against the maximum recorded flood depending upon the location protected and their economic justification.

Dams, Reservoirs and other Water Storages

- Lakes, low lying depressions, tanks, dams and reservoirs store significant proportions of flood water and the stored water can be released subsequently when the flood has receded.
- The stored water can also be used subsequently for irrigation, power generation, and meeting industrial and drinking water needs.
- In the case of large multipurpose reservoirs, a proper reservoir regulation schedule can be worked out for optimum benefit from the project as a whole.
- Their capacities can be improved by desilting and constructing embankments around them.
- some of the water stored in these water bodies percolates below the ground thereby adding to the groundwater storage.

Channel Improvement

- A channel can be made to carry flood discharge at levels lower than its prevailing high flood level by improving its discharge carrying capacity.
- Channel improvement aims at increasing the area of flow or the velocity of flow (or both) to increase its carrying capacity.
- Channel improvement has not been resorted to widely in India mainly because of the high costs involved and topographical constraints.

Desilting/Dredging of Rivers

- silting at places where the rivers emerge from the hills into the plains, at convex bends and near their outfall into another river or lake or sea, is a natural phenomenon.
- Accordingly, rivers exhibit a tendency to braid/meander/form deltas.
- Various committees/ experts appointed to look into this problem have not recommended desilting/dredging of the rivers as a remedial measure.
- Selective desilting/dredging at outfalls/confluences or local reaches can, however, be adopted as a measure to tackle the problem locally.

Drainage Improvement

- Surface water drainage congestion due to inadequacy of natural or manmade drainage channels results in flooding in many areas.
- In such cases constructing new channels and/or improving the capacity of existing channels constitute an effective means of flood control.
- However, the possibility of drainage congestion and flooding in the downstream area is to be kept in mind while formulating such schemes.

Diversion of Flood Water

- Diverting all or a part of the discharge into a natural or artificially constructed channel, lying within or in some cases outside the flood plains is a useful means of lowering water levels in the river.
- The diverted water may be taken away from the river without returning it further downstream or it may be returned to the river some distance downstream or to a lake or to the sea.
- This measure can be used successfully to prevent flooding around cities.
- The flood spill channel skirting Srinagar city and the supplementary drain in Delhi are examples of diverting excess water to prevent flooding of the urbanised areas.

Catchment Area Treatment/Afforestation

- Watershed management measures such as developing the vegetative cover i.e. afforestation and conservation of soil cover in conjunction with structural works like check dams, detention basins etc. serve as an effective measure in reducing flood peaks and controlling the suddenness of the runoff.
- This, however is not very effective during a large flood although, it does help in reducing the siltation of reservoirs and to some extent, silt load in the rivers as well.

Anti-erosion Works

- Anti-erosion works are normally taken up only for protection of towns, industrial areas, groups of thickly populated villages, railway lines and roads where re-location is not possible on socio-techno- economic grounds, long lengths of vital embankments.
- Bank erosion can be minimized by adopting measures that aim at deflecting the current away from the river bank or which aim at reducing the current along the bank of the river and induce silt.
- The anti- erosion measures in the form of revetment or pitching along with launching apron and spurs of earth protected by armour of stones or spurs of loose stones or stones in wire-mesh crates aim at increasing resistance of the bank to erosion and deflecting the current away from the bank.
- These generally shift the problem in the upstream or the downstream and necessitate further works to safeguard the land against erosion.

- Geo-synthetic material (woven geotextile) available in various forms like big bags and tubes etc. can be filled in-site with riverbed sand to form the groynes, spurs and revetments.
- The dredging of the channels in the selected reaches which have silted up can be tried.
- Geo web filled with concrete overlaid on geo-fabric filters in lieu of stone revetment and launching apron is also a new development.
- Pilot schemes using these and other new technologies will be taken up to evaluate their performance and techno-economic viability.

Sea Walls/Coastal Protection Works

- The erosion of land by the sea waves in coastal areas is a serious problem.
- Sea walls/coastal protection works in the form of groynes etc. are constructed to prevent flooding erosion in coastal areas by sea water.

NON-STRUCTURAL MEASURES

- Non-structural measures strive to keep people away from flood waters.
- It contemplates the use of flood plains judiciously, simultaneously permitting vacating of the same for use by the river whenever the situation demands.
- This technique allows the use of flood plains by reducing the disaster dimension, while retaining its beneficial effects.
- 1. Flood Plain Zoning
- 2. Flood Proofing
- 3. Flood Forecasting and Warning

Flood Plain Zoning

- The basic concept of flood plain management is to regulate the land use in flood plains in order to restrict the damage due to floods, while deriving maximum benefit from them.
- This is done by determining the location and extent of the areas likely to be affected by floods of different magnitudes/frequencies and to develop those areas in such a fashion that the resulting damage is minimal.
- It, therefore, envisages laying down limitations on development of both the unprotected as well as protected areas.
- in the unprotected areas, boundaries of areas in which developmental activities will be banned, are to be established to prevent indiscriminate growth.
- In the protected areas, only such developmental activities can be allowed, which will not involve heavy damage in case the protective measures fail.
- Zoning cannot remedy existing situations, although, it will definitely help in minimizing flood damage in new developments.

Pre-requisites for the Enforcement of Flood Plain Zoning

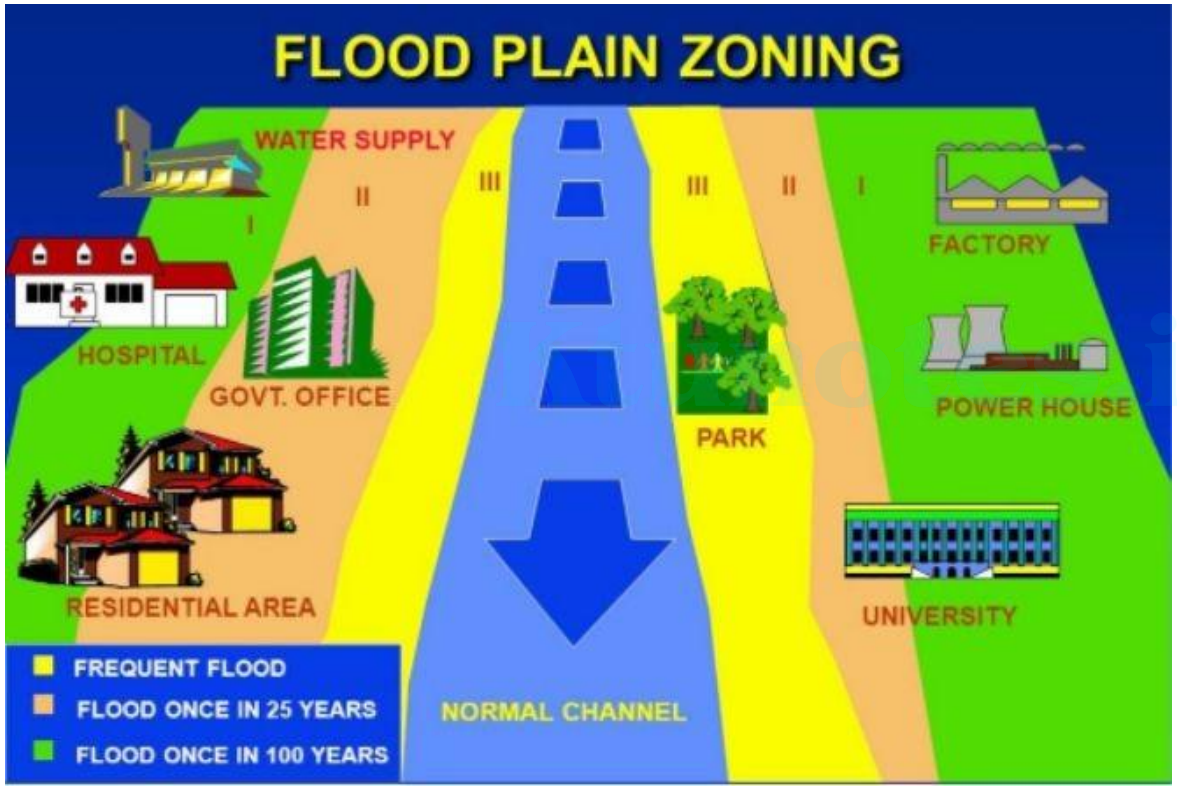
- The basic requirements to be taken care of before implementing flood plain zoning are as follows:
  - (i) Broad demarcation of areas vulnerable to floods.
  - (ii) Preparation of a large-scale maps (1:10,000/1:15,000) of area vulnerable to floods with contours at an interval of 0.3 m or 0.5 m.
  - (iii) Marking of reference river gauges with respect to which, the areas likely to be inundated for different magnitudes of floods will be determined.
  - (iv) Demarcation of areas liable to inundation by floods of different frequencies, e.g., like once in two, five, ten, twenty years and so on. Similarly, demarcation of areas likely to be affected on account of accumulation of rainwater for different frequencies of rainfall like 5, 10, 25 and 50.
  - (v) Marking of likely submersion areas for different flood stages or accumulation of rainwater on the maps.

Regulation of Land Use in Flood Prone Areas

- The area likely to be affected by floods up to a 10-year frequency should be kept reserved only for gardens, parks, playgrounds, etc.
- Residential or public buildings, or any commercial buildings, industries, and public utilities should be prohibited in this zone.
- In area liable to flooding in a 25-year frequency flood, residential buildings could be permitted with certain stipulation of construction on stilts (columns), minimum plinth levels, prohibition for construction of basements and minimum levels of approach roads, etc.
- In urban areas there should be double- storeyed buildings. Ground floors could be utilized for schools and other non-residential purposes.

Categorisation and Prioritisation of Structures in Flood Plains Zoning

- In the regulation of land use in flood plains, different types of buildings and utility services can be grouped under three priorities from the point of view of the damage likely to occur and the flood plain zone in which they are to be located:
  - 1. Priority 1: Defense installations, industries, public utilities like hospitals, electricity installations, water supply, telephone exchanges, aerodromes, railway stations, commercial centres, etc. -Buildings should be located in such a fashion that they are above the levels corresponding to a 100- year frequency or the maximum observed flood levels. Similarly they should also be above the levels corresponding to a 50-year rainfall and the likely submersion due to drainage congestion.
  - 2. Priority 2: Public institutions, government offices, universities, public libraries and residential areas. -Buildings should be above a level corresponding to a 25-year flood or a 10-year rainfall with stipulation that all buildings in vulnerable zones should be constructed on columns or stilts as indicated above.
  - 3. Priority 3: Parks and playgrounds. -Infrastructure such as playgrounds and parks can be located in areas vulnerable to frequent floods. Since every city needs some open areas and gardens, by restricting building activity in a vulnerable area, it will be possible to develop parks and play grounds, which would provide a proper environment for the growth of the city.


FLOOD PLAIN ZONING
WATER SUPPLY
I
II
III
III
II
I
FACTORY
HOSPITAL
GOVT. OFFICE
PARK
POWER HOUSE
RESIDENTIAL AREA
UNIVERSITY
FREQUENT FLOOD
FLOOD ONCE IN 25 YEARS
FLOOD ONCE IN 100 YEARS
NORMAL CHANNEL

Flood Proofing

- Flood proofing measures help greatly in the mitigation of distress and provide immediate relief to the population in flood prone areas.
- It is essentially a combination of structural change and emergency action, not involving any evacuation.
- The techniques adopted consist of providing raised platforms for flood shelter for men and cattle, raising the public utility installation especially the platforms for drinking water hand pumps and bore wells above flood level, promoting construction of double-storey buildings wherein the first floor can be used for taking shelter during floods.
- In case of urban areas, certain measures that should be taken up as soon as flood warning is received, are installation of removable covers such as steel or aluminium bulk heads over doors and windows, permanent closure of low level windows and other openings, keeping store counters on wheels, closing of sewer wells, anchoring and covering machinery and equipment with plastic sheets, etc.
- In the existing developed areas, possibilities of protecting against submergence or relocating to safer areas vital installations like electricity sub-stations/ power houses, telephone exchanges, the pumping stations meant for drinking water supply etc., will be seriously examined and appropriate measures will be undertaken by the state governments/SDMAs, to make them safe against floods.

Flood Forecasting and Warning

- Flood forecasting (FF) enables us to be forewarned as to when the river is going to use its flood plain, to what extent and for how long.
- The forecast of a flood may be for the water level (stage forecast), discharge (flow forecast) and area likely to be submerged (inundation forecast) at various points/particular stations at a specific time.
- Flood forecasting services include the following phases:
- (i) Data Collection
- (ii) Transmission of Data to the Forecasting Centers
- (iii) .Data Processing and Formulation of Forecasts
- (iv) Dissemination of Flood Forecasts and warnings

MEDICAL PREPAREDNESS

- Creating Awareness
- Medical Stores
- Patient Evacuation Plan
- **Disaster Management Plans** -Disaster Management Plans need to be prepared by all hospitals. Medical facilities, training of medical personnel, creating awareness about drowning and its management will be a part of the plan. Hospitals must nominate an officer for coordinating management for flood casualties. Contingency plans will be made ready for providing additional beds. Oxygen cylinders, continuous positive air pressure (CPAP) ventilators, dressing materials, blood and IV fluid for transfusion will be stocked. The hospital casualty room is to be equipped with resuscitation equipment like suction apparatus, airways laryngoscope, pulse oxymeter, defibrillator and lifesaving drugs. In the aftermath of a flood, public health response is one of the prime responsibilities of medical authorities.

FLOOD RESPONSE

- Response System
  - Management and control of the adverse consequences of floods will require coordinated and effective response systems at all levels-national, state, district, local and community. Many of the components of response initiatives will remain the same for different types of disasters. These systems need to be developed considering the multi-hazard scenario of the region to optimally utilize available resources.
- Institutionalization
  - The scale of response for floods and the corresponding role players will be identified and mobilised at the district, state or national levels depending on the magnitude and the severity of the event. Systems will be institutionlised by the DMAs, at various levels, for coordination between the various agencies like central government ministries and departments, state governments, district administration, ULBs, PRIs and other stakeholders for effective post-flood response..

FLOOD RESPONSE

Evacuation Plan

- Evacuation of human population and livestock is the only prescribed means to save them from the fury of floods. Evacuation of flood affected communities can be one of the most difficult response operations, especially, when it involves large population. Evacuation needs to be carried out as a precautionary measure based on warning indicators, prior to impact, in order to protect flood- threatened persons from the full effects of the disasters. Evacuation may also be necessary after the area has been flooded in order to move persons from a flood-affected area to safer and better surroundings.

Estimation of the Severity of a Flood

- As the local communication infrastructure often fails, the severity of a flood cannot be estimated immediately after its occurrence. The preliminary assessment of the severity of a flood should be based on water level and the estimate of the area flooded as assessed from satellite imageries. Field observation data will be used to modify this assessment once available.

EMERGENCY SEARCH AND RESCUE

- Neighborhood Community
  - The local community in the affected neighbourhood is always the first responder after a disaster. Experience has shown that over 80 per-cent of search and rescue is carried out by the local community before the intervention of the state machinery and specialised search and rescue teams. Thus, trained and equipped teams consisting of local people will be set up in flood prone areas to respond effectively in the event of floods.

- Search and Rescue Teams
  - Community level teams will be developed in each district with basic training in search and rescue. Training modules will be developed for trainers of community level search and rescue teams by the NDRF training institutes. On the ground, besides others, the NDRF battalions will also assist the state government/district authorities in training communities. They will be further assisted by the ATIs, CD, Home Guards and NGOs, Youth organisations such as the NCC, NSS and NYKS will provide support services to the response teams at the local level under the overall guidance and supervision of the local administration.

SPECIALISED TEAMS FOR RESPONSE

- National Disaster Response Force
  - In terms of the DM Act, 2005, eight battalions of the NDRF are being set up to provide specialized response to any threatening disaster situation or disaster. Out of these seven battalions are already in position. Each of these battalions will have 18 teams with high skill training and latest equipment for water rescue. In order to ensure prompt response to any flood situation, each of these battalions will also have Regional Resource Centres (RRCs) in high vulnerability areas, where boats and other water rescue equipment will be pre-positioned. The NDRF units will maintain close liaison with the state administration and will be available to them proactively, thus avoiding long procedural delays in deployment in the event of any serious threatening disaster situation.
- Fire and Emergency Services in the Urban Local Bodies
  - The fire and emergency services in the ULBs of various states are being used as an emergency-cum-fire services force. The fire and emergency services in the flood prone areas will develop adequate capacity to respond to serious flood situations, in addition to managing fires.

SPECIALISED TEAMS FOR RESPONSE

- Home Guards
  - The Home Guards serve as an auxiliary arm of the police force and support the district administration in various tasks. They will be trained for carrying out search, rescue and relief operations on occurrence of floods.
- Civil Defense
  - CD has been authorized in 225 designated towns in the country out of which 121 have already been activated where volunteers have been recruited and trained. There is a plan to revamp CD, extending its coverage to all the districts in the country and assigning it an important role in DM framework. According to the proposal for revamping, the primary role of CD will be community capacity building and creating public awareness in pre-disaster phase. The proposal envisages converting the town specific setup of CD to a district specific set up. It is proposed to have 18 persons employed on full time basis in each district-specific set up, out of which eight will be the trainers and their duty will be to train volunteers.
- Police Force
  - The police play an important role in the aftermath of floods in maintaining law and order, assisting in search and rescue, and in the transportation and certification of casualties. It is equally important that the police forces are properly equipped and trained.

EMERGENCY LOGISTICS

- Equipment
- Relief Camps
- Identification of the Deceased

EMERGENCY MEDICAL RESPONSE

- Emergency Treatment at Site of Floods
- Medical Facilities and Medical Treatment at Hospital
- Mortuary Facilities and disposal of Dead Bodies
- Public Health Issues in Aftermath of Floods
- Psychosocial Aspects

HAZARD & DISASTER MANAGEMENT FOR TIDAL WAVES

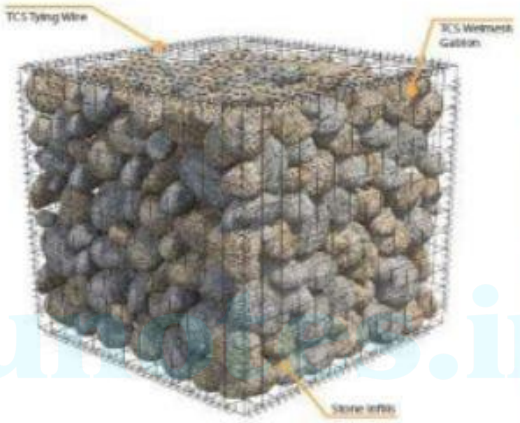
- COASTAL PROTECTION STRATEGIES
- A. Hard Engineering Strategies
  - Building or creating something which will interfere with coastal processes – usually to reduce the power of breaking waves against cliffs.
  - E.g., Groynes, Gabions, Rock Armour/Rip-Rap, Sea dike, Revetments, Breakwater, Sea wall
- B. Soft Engineering Strategies
  - With the natural processes of sea and sand.
  - E.g., Beach, Offshore Reef

Groynes

- # A barrier extending from the beach or offshore into the sea in the transverse direction to the
- sea shore.
- # Groynes are used to reduce the loss of beach grade sediment through long shore drift.
- # With proper groyne field design, beach erosion can be reduced due to trapped sediment
- on the up-drift side of the groyne.
- # Groynes can be constructed out of wood, stone or concrete depending on the size of native
- beach material.
- # Although acting to reduce the erosion on site, groynes typically cause sediment starvation
- down-drift, shifting the erosion further down the coastline.

Gabions

- Wire cages filled with stones/rocks stacked along the cliff base protect the shore.



Advantages	Disadvantages
✓ Easily installed ✓ Cheaper than sea wall	× Not very attractive × Needs frequent checking & repair × Not easy for people to get over to get to beach × May contain rats nests

Rock Armour/Rip-Rap

- Huge blocks of rocks is placed along the shore

Advantages	Disadvantages
✓ Popular option in recent years – seen to be effective ✓ Cheaper than sea wall	× Not very attractive × Not easy for people to get over to get to the beach (broken ankles) × Rats may live in spaces

Sea dike

- Large land-based sloped structures used to prevent overtopping during high tide and storm events.
- # Instead of providing protection against wave action, sea dikes fix the land-sea boundary in place to prevent inland flooding.
- # They are typically created out of sand, clay or mud often incorporating a grass cover layer

Revetments

- # Onshore sloped structures used to reduce the landward migration of the beach due to coastal erosion.
- # The Structure reduces the water energy and thus reduces the erosive power of the wave
- # They can be constructed out of concrete, stone or asphalt. The structure should be designed to have a crest sufficiently high to stop wave overtopping during a storm event

Breakwater

- # These are offshore sloped or vertical structures reducing incoming wave energy arriving at the coastline.
- # As well as reducing erosion, this also creates calmer waters for harbors and shipping.
- # They can be constructed out of concrete or stone and rock.

Sea wall

- # Vertical or near-vertical structures designed to limit erosion due to wave attack.
- # Typical construction materials include concrete, steel and timber.
- # Concrete curved superstructures can be incorporated to reduce wave overtopping of sea water.

Advantages	Disadvantages
✓ Provides hard face to cliff ✓ Easily installed ✓ Cheaper than sea wall ✓ Deflects wave power	× Not very attractive × Can be eroded from below easily × Needs frequent repair

Soft Engineering Strategies

- (a) Beach
- # Beach - a beach in itself acts as a coastal defense as it reduces wave impact and prevents
- inland flooding.
- # However the beach needs to be properly managed to ensure, it is wide and high enough to prevent from being overtopped during high sea levels. This can be done through beach replenishment where beach-grade sediments are used to „top-up" the beach, increasing its level of protections.
- (b) Offshore Reef
- # Man-made or natural reefs built just out to sea to for the waves to break on them and create calmer water at the coast.

NATURAL HAZARDS IN THE COASTAL STATES IN INDIA

- 1. Earthquakes
- 2. Cyclonic wind
- 3. Storm surge in cyclones
- 4. Flooding by incessant rain
- 5. Tsunami

APPROACH TOWARD MULTI HAZARD SAFETY MEASURES IN COASTAL AREAS –GENERAL MEASURES

- Adopting integrated multi-hazard approach with emphasis on cyclone and tsunami risk mitigation in coastal areas
- Implementation of early warning system for cyclones and tsunamis
- Streamlining the relief distribution system in disaster affected areas (preparation of a data base of people living in tsunami hazard prone areas)
- Design, practice and implementation of evacuation plans with emphasis on self reliance for sustenance with the locals (coastal community)
- Component on planning for reconstruction and rehabilitation should be added in disaster management plans at all levels
- Emphasis on mental health and to socio-psychological issues during post disaster period should be accorded in every plan
- Identification and strengthening of existing academic centers in order to improve disaster
- prevention, reduction and mitigation capabilities

Specific Measures for safety from Tsunamis/Storm Surges –Structural measures

- 1. Construction of cyclone shelters
- 2. Plantation of mangroves and coastal forests along the coast line
- 3. Development of a network of local knowledge centers (rural/urban) along the coast lines to provide necessary training and emergency communication during crisis time.
- 4. Construction of location specific sea walls and coral reefs in consultation with experts
- 5. Development of well-designed break waters along the coast to provide necessary cushion against cyclone and tsunami hazards
- 6. Development of tsunami detection, forecasting and warning dissemination centres
- 7. Development of a “Bio-Shield” - a narrow strip of land along coastline. Permanent structures, if any in this zone with strict implementation of suggested norms. Bio-Shield can be developed as coastal zone disaster management sanctuary, which must have thick plantation and public spaces for public awareness, dissemination and demonstration.

Non-Structural Measures:

- 1. Strict implementation of the coastal zone regulations (within 500 m of the high tide line with elevation of less than 10 m above mean sea level)

Table: Proposed Damage Risk Zone Classification on Sea Coasts

0-1 m above High tide Level	Very High Damage Risk Zone
1-3 m above High tide Level	High Damage Risk Zone
3-5 m above High tide Level	Moderate Damage Risk Zone
5-10 m above High tide Level	Low Damage Risk Zone
10m or more above high tide Level	No Damage Risk Zone

- 2. Mapping the coastal area for multiple hazards, vulnerability and risk analysis upto taluk/village level. Development of Disaster Information Management System (DIMS) in all the coastal states.
- 3. Aggressive capacity building requirements for the local people and the administration for facing the disasters in wake of tsunami and cyclone, 'based on cutting edge level'

- 4. Developing tools and techniques for risk transfer in highly vulnerable areas
- 5. Launching a series of public awareness campaign throughout the coastal area by various means includingAIR, Doordarshan & Other Media.
- 6. Training of local administration in forecasting warning dissemination and evacuation techniques
- 7. Awareness generation and training among the fishermen, coast guards, officials from fisheries department and port authorities and local district officials etc., in connection with evacuation and post tsunami storm surge management activities. Regular drills should be conducted to test the efficacy of the DM plans.
- 8. Studies focusing on the tsunami risk in India may be taken under NCRM project.

Actions Required in Coastal Areas for Protection against Tsunami / cyclone mitigation

- Revision of Coastal Zone Regulation Act in wake of tsunami storm surge hazards and strict implementation of the same. The current Coastal Regulations Zone (extract) is attached as Appendix A to this chapter. This responsibility may be given to respective state disaster management authorities. A special task force for this purpose may be constituted comprising the representatives from various departments of the government and other relevant organizations (e.g. Departments of Forestry, Fisheries. Soil Conservation, Town and Country Planning Organization, Navy, Coast Guard, IMD,ISRO/DOS etc.)

- Initiating disaster watch (bay watch) safety measures along important beaches in the country, providing round the clock monitoring, warning, lifeguard facilities & creation of website for missing personal etc.

- Organization of sensitization workshops on cyclone/tsunami risk mitigation in various states for senior bureaucrats / politicians for these states.

Actions Required in Coastal Areas for Protection against Tsunami / cyclone mitigation

- Organizing drills on regular basis to check the viability of all plans and to check the readiness of all concerned
- Training of professionals, policy planners and others involved with disaster mitigation and management programmes in the states
- Retrofitting of important buildings
  - I. Fire stations / police stations/ army structures/ hospitals
  - II. VIP residences / offices/ railways, airport, etc.
  - III. Schools/colleges
  - IV. Hazardous industries
  - V. Other critical structures (i.e. power stations, warehouses, oil and other storage tanks etc)
- Designing incentives: Providing legislative back up to encourage people to adopt cyclone, tsunami resistant features in their homes e.g. tax rebate in terms of house tax and/or income tax.
- Developing public -private partnerships.

Tsunami Effects and Design Solutions

EFFECT	DESIGN SOLUTION
Flooded basement	Choose sites at higher elevations
Flooding of lower floors	Raise the buildings above flood elevation
Flooding of mechanical electrical & communication system & equipment	Do not stack or install vital material or equipments on floors or basement lying below tsunami inundation
Damage to building materials & contents	Protect hazardous material storage facility located in tsunami prone area.
Contamination of affected areas with water borne pollutants	• Locate mechanical systems & equipments at higher location in the building • Use corrosion resistant concrete & steel for the portions of the building.
Hydrostatic forces (Pressure on walls by variation in water depth on opposite sides	• Elevate building above flood level. • Provide adequate openings to allow water to reach equal heights inside & outside of buildings. • Design for static water pressure on walls. • Consider suction tensions on walls under receding
Buoyancy floatation or uplift forces caused by buoyancy	• Elevate building to avoid flooding. • Anchor building to foundation to prevent floatation
Saturation of soil causing slope instability and/or loss of bearing capacity	• Evaluate bearing capacity & shear strength of soil that support building foundation & embankment slopes under condition of saturation. • Avoid slopes or setbacks from slope that may be destabilized when inundated.

Phenomenon of Currents, (wave break & bore)

EFFECT	DESIGN SOLUTION
Hydrodynamic forces (pushing forces on the front face of the building and drag caused by flow around the building	• Elevate building to avoid • Design for dynamic water forces on walls & building elements. • Anchor building to foundation.
Debris Impact	• Elevate building to avoid. • Design for Impact loads.
Scour	• Use deeper foundation (piles or piers). • Protect against scour and erosion around foundation.

Phenomenon of Drawdown

EFFECT	DESIGN SOLUTION
Embankment instability	• Design water front slopes, walls & buttresses to resist saturated soils without water in front • Provide adequate drainage.
Scour	• Design for scour & erosion of soil around foundation & piles.

SPECIFIC DESIGN PRINCIPLES FOR TSUNAMI

- (a) Know the Tsunami Risk at the site
  - • Distance from the sea
  - • Elevation above mean sea level
  - • Height of high tide above m. s. l.
  - • Maximum run-up of the tsunami above the site elevation
  - • Depth and speed of the tsunami wave for design purposes.
- (b) Avoid new developments in Tsunami Run-up Areas
  - • Role of land Use Planning
  - - Local Context
  - - Understanding Trade offs
  - - Review and update existing Safety elements
  - - Review and update existing Land Use Elements
  - - Review and update existing Zoning, and other regulations
  - • Land Use Planning Strategies

SPECIFIC DESIGN PRINCIPLES FOR TSUNAMI

- ((c) Site Planning Strategies to reduce Tsunami Risk
  - • Avoiding the impact of tsunami by building on high ground - necessary for vital installations.
  - • Slowing the tsunami wave by frictional techniques - forests, ditches, slopes and berms
  - • Deflecting the tsunami away by using angled walls - suitable for important installations
  - • Brute resistance through stiffened strong structural design - costly buildings
  - • High rise buildings with open ground storey, designed for wave forces - Hotels, offices etc
  - • Stilted buildings for various uses.
- (d) Tsunami Resistant Buildings - New Developments
  - • Locally applicable Tsunami Hazard Information on Design Intensities
  - • Performance Objectives
  - • Mandatory use of building Codes - Design Criteria
  - • Safety under Multi-hazard environment
  - • Qualified Engineers and Architects - knowledge about Earthquake, Wind and Tsunami
  - resistant planning and design
  - • Ensure quality construction

SPECIFIC DESIGN PRINCIPLES FOR TSUNAMI

- (e) Protection of existing buildings and infrastructure - Assessment, Retrofit, Protection measures
  - • Inventory of existing assets
  - • Assessment of Vulnerability and deficiencies to be taken care of through retrofitting
  - • Methods of retrofitting and use in design
  - • External protection methods from the onslaught of tsunami
- (f) Special Precautions in locating and designing infrastructure and critical facilities
  - • Considerations in relocating and redevelopment of infrastructure
  - • Considerations in relocating and redevelopment of critical facilities such as lifeline buildings (health, education, community etc.).

SPECIFIC DESIGN PRINCIPLES FOR TSUNAMI

- (g) Planning for Evacuation
  - • Vertical evacuation - High rise buildings, special shelters
  - • Horizontal evacuation - Locating high grounds, building high enough mounds
  - • Awareness about evacuation areas and routes
- (h) Planning for Rescue and Relief
  - • Role of District Disaster Management Committees.
  - • Role of Armed forces/Ministry of Defence in these tasks.

Tsunami Warning System

- Japan has a network of land/sea sensors that records seismic activity and feeds information to a national agency able to issue evacuation warnings within a minute of occurrence of any earthquake. Earthquake warning issued by Japan Meteorological Agency are relayed via satellite to the Municipal offices and automatically broadcast from several sets of loudspeakers.
- Pacific Ocean warning system at Hawaii issues warnings of tidal waves heading in a particular direction.
- Presently, land and sea-based sensors connected to satellite-based link are available.
- Satellite telemetry is used for data collection and dissemination; receive and display of Tsunami warning utilizing existing Geostationary operational Environmental Satellite (GOES) and Data Collection Interrogation
- System (DCIS). An earthquake activates seismic instrument, which transmits signal to the GOES platform which responds automatically transmitting an alert code to an active device at warning site.
- Developing Tsunami and earthquake data base verification, Tsunami model, preparation of hazard assessment maps for the coast line combing historical and modeling result, establishment of seismic and tidal sensors using satellite telemetry to provide early warning information.
- Extensive network of seismic and tidal station, as well as communication systems, to ensure that the warning information is prompt and accurate.