

## Hydro-Meteorological Disasters

### Flood<sup>1</sup>



Floods are among the most frequent and costly natural disasters. Conditions that cause floods include heavy or steady rain for several hours or days that saturates the ground. Flash floods occur suddenly due to rapidly rising water along a stream or low-lying area.

A flood is an excess of water (or mud) on land that's normally dry

and is a situation wherein the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or ponding of water at or near the point where the rain fell. This is a duration type event. A flood can strike anywhere without warning, occurs when a large volume of rain falls within a short time.

### Types of Floods<sup>2</sup>

**Flash Floods:** Floods occurring within six hours, mainly due to heavy rainfall associated with towering cumulus clouds, thunderstorms, tropical cyclones or during passage of cold weather fronts, or by dam failure or other river obstruction. This type of flood requires a rapid localized warning system.

**River Floods:** Floods caused by precipitation over a large catchment's area, melting of snow or both. Built up slowly or on a regular basis, these floods may continue for days or weeks. The major factors of these floods are moisture, vegetation cover, depth of snow, size of the catchment's basin, etc.

**Coastal Floods:-** Floods associated with cyclonic activities like Hurricanes, Tropical cyclones, etc. generating catastrophic flood from rainwater which often aggravate wind-induced storm and water surges along the coast.

**Urban Flood:** As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization decreases the ability to absorb water 2 to 6 times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water.

**Ice Jam:** Floating ice can accumulate at a natural or human-made obstruction and stop the flow of water thereby causing floods. Flooding too can occur when there the snow melts at a very faster rate.

**Glacial Lake Outbursts Flood (GLOF):** Many of the big glaciers which have melted rapidly and gave birth to the origin of a large number of glacier lakes. Due to the faster rate of ice and snow melting, possibly caused by the global warming, the accumulation of water in these lakes has been increasing rapidly and resulting sudden discharge of large volumes of water and debris and causing flooding in the downstream.

### **Characteristics of flood**

**Depth of water-** Building foundations and vegetation will have different degrees of tolerance to bring inundated water.

**Duration** – Damage to structures, infrastructure vegetation related to duration 1 of time with water inundation.

**Velocity** – High velocities of flow create erosive forces, hydrodynamic pressure, which destroy foundation supports and may occur on floodplains or in the main river channel.

**Frequency of occurrence** – The frequency of occurrence measured over period of time determines types of construction or agricultural activities on the floodplain.

**Seasonality** – Flooding during a growing season destroy crops while cold weather, floods seriously affect the community.

### **Causes of Floods<sup>3</sup>**

Inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas following heavy rainfall, leads to flooding. The tendency to occupy the flood plains has been a serious concern over the years. Because of the varying rainfall distribution, many a time, areas which are not traditionally prone to floods also experience severe

inundation. Areas with poor drainage facilities get flooded by accumulation of water from heavy rainfall. Excess irrigation water applied to command areas and an increase in ground water levels due to seepage from canals and irrigated fields also are factors that accentuate the problem of water-logging. The problem is exacerbated by factors such as silting of the riverbeds, reduction in the carrying capacity of river channels, erosion of beds and banks leading to changes in river courses, obstructions to flow due to landslides, synchronisation of floods in the main and tributary rivers and retardation due to tidal effects.

The primary causes for Floods are:

- Intense rainfall when the river is flowing full.
- Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities.
- Cyclone and very intense rainfall when the EL Nino effect is on a decline.
- Synchronization of flood peaks in the main rivers or their tributaries.
- Landslides leading to obstruction of flow and change in the river course.
- Poor natural drainage system.
- Backing water in tributaries at their confluence with the main river.

### **Flood prone areas<sup>4</sup>**

India is one of the most flood prone countries in the world. The principal reasons for flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm. Most of the floods occur during the monsoon period and are usually associated with tropical storms or depressions, active monsoon conditions and break monsoon situations.

Floods occur in almost all rivers basins in India. The main causes of floods are heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/rivers. Ice jams or landslides blocking streams; typhoons and cyclones also cause floods. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil. Areas with hardpan just below the surface of the soil are more prone to, floods as water fails to seep down to the deeper layers.

Brahmaputra, Ganga, Narmada, Tapti, Mahanadi, Krishna & Cauvery are the most flood prone areas. Survey by Rashtriya Barh Ayog in 1980 says that 40 million hectares areas are flood affected. Heavy rain in Himalayas during South west monsoon causes flood in the rivers of U.P., Bihar, W.Bengal & Assam while Central & Southern rivers get flooded by heavy rainfall due to depression in Bay of Bengal during south-west monsoon season. In most flood prone states, land depression, low-pressure areas are the two most important synoptic systems responsible for floods. In Bihar 100% and in U.P. 82% flood is caused due to land depression and well marked low pressure. In W.Bengal main reason for flood is cyclonic circulation. Whereas in Punjab, Gujarat, Rajasthan & Jammu & Kashmir the main reason is low pressure areas. Flood in Orissa and Andhra Pradesh is due to monsoon depression.

### **Flood Preparedness and Mitigation<sup>3</sup>**

Since ages, people have coped and learned to live with floods. They have generally settled in areas away from flood and have adapted agricultural practices which can sustain in flood waters. Traditional methods based on locally available resources have been used to minimize the damages during flood. With the increase in population, flood prone areas have been occupied and this is a principal factor in the huge losses presently seen. The various mitigation measures for flood can be categorized into structural and non structural measures.

#### **Regulation and Enforcement**

Unplanned and unregulated developmental activities in the flood plains of the rivers and encroachments into the waterways have led to increase in flood losses as well as flood risk. The colossal loss of lives and property due to the flooding of the towns and cities and the areas which get flooded almost every alternate year is a recent phenomenon and effective steps are required for regulating unplanned growth in the flood plains and preventing encroachment in the waterways.

#### **Capacity Development**

The capacity development covers the aspects of flood education, target groups for capacity development, capacity development of professionals, training, research and development and documentation with respect to flood management. The proposals for strengthening the existing systems are also given therein. An action plan for capacity development has also been formulated.

## **Flood Response**

An effective and prompt response to floods is very important for minimising the loss of lives and properties and providing immediate relief to the affected people. The role of communities and NGOs is vital in search, rescue and relief operations. Immediate medical assistance to the affected people and steps for prevention of outbreak of epidemics after the floods are essential components of flood response. As per provisions of the DM Act, 2005, the GOI has constituted National Disaster Response Force (NDRF) for the purpose of specialised response to disasters. Over and above this, a mechanism for coordinated approach and efforts are required for effective response.

## **Structural Measures**

### **Embankments**

This has been one of the major structural approaches in which the river is restricted to its existing course and prevented from overflowing the banks. Usually embankments are constructed with earth but at some places masonry and concrete walls are also used. However what is important is to note here that embankments are designed to provide a degree of protection against flood of a certain frequency and intensity or a maximum recorded flood depending on the location and economic justification.

During recent times, divergent views have emerged concerning effectiveness of embankment. While there are serious concerns over their usefulness over a long time frame, there have also been arguments in favor such as providing only road communication during flood seasons and shelter in low lying areas. Studies on effectiveness of embankments conducted around the world, have pointed out some of the problems such as poor congestion in protected areas, silting of rivers which not only means rising river bed level and consequent decrease in carrying capacity but also depriving neighboring agricultural land from fertile soil and ground water recharge. There have also been concerns on the issue of embankment capacity to withstand erosion.

### **Dams, Reservoirs and other Water Storage Mechanism**

Dams, reservoirs and other water storages, both natural and man-made, are an effective means for reducing the flood peaks in the rivers. The important role played by them in flood moderation and comprehensive mechanism for the operation and regulation of reservoirs, which takes into account the international, inter-state and inter-regional aspects, have been dealt with in the fifth

chapter. As large dams and reservoirs have potential for huge damage guidelines for ensuring safety thereof have also been detailed therein.

### **Channel Improvements**

The aim of Channel Improvements is to increase the area of flow or velocity of flow or both to increase carrying capacity. Normally this measure involves high cost and there are also problems of topographical constraints to execute such a measure.

### **De-silting and Dredging of Rivers**

The de silting approach is still to be perfected in the sense that various committees and expert groups appointed by Government of India are yet to recommend this measure as an effective mitigation strategy. However, selective de silting and dredging of rivers at outfalls/confluences or local reaches can be adopted.

### **Drainage Improvement**

This aims at construction of new channels or improving capacity of existing channels to decongest and prevent flooding. However, what is important is to ensure that such an approach do not cause congestion and flooding in downstream areas.

### **Diversion of Flood Water**

This involves diverting all or part of flood water into natural or artificial constructed channels which may be within or outside the flood plain. The diverted water may or may not be returned to the river at a down stream. Usually effective to prevent flooding around cities, the flood spill channel for Srinagar and the supplementary drain in Delhi are examples of this approach.

### **Catchments Area Treatment**

The aim in this approach is to provide protection to catchment areas through measures such as afforestation which minimize siltation of reservoirs and silt load in the rivers. This can be a very useful approach to control flood peaks and suddenness of run offs.

### **Sea Walls/Coastal Protection Works**

The construction of Sea walls and other such work, try to prevent flooding from Sea water. These are highly cost intensive apart from the fact that complexity of sea behavior and other environmental aspects should also be considered.

### **Non-Structural Measures**

#### **Flood Plain Zoning**

The basic idea here is to regulate land use in the flood plain in order to restrict the damages. It aims at determining the location and extent of areas for developmental activities so that damage is minimized. It lays down guidelines for various types of development so that adequate mitigation is built for the worst flood scenario. There can be different consideration for preparing flood plain zoning for example, one can locate parks, playgrounds etc. for area which have a up to 10 year frequency while prohibiting residential colonies, industries, etc. and allowing residential and other public utilities with specific design guidelines in areas which have a 25 year frequency.

### **Flood Forecasting and Warning**

A nationwide flood forecasting and warning system is developed by Central Water Commission (CWC) and this initiative has also been supplemented by states who make special arrangements for strategically important locations in their states. The forecasts can be of different types such as forecast for water level (stage forecast), discharge (flow forecast) and area to be submerged (inundation forecast). The forecast when carries definite risk information is called warning. The flood forecasting services involve collection of hydrological data (gauge, discharge), meteorological data such as rainfall.

### **Flood Proofing**

These are measures designed to minimize the impact when flood water comes such as raised platform for shelter to population, cattle etc., raised platform for drinking water hand pumps, bore wells above flood level, house/building architecture, provision for relocating vial installation such as communication, power etc.

### **Flood Safety Tips<sup>5</sup>**

#### **Do's and Dont's**

#### **Before and During**

- All your family members should know the safe routes to nearest shelter/raised pucca house.
- If your area is flood-prone, consider suitable flood resistant building materials.
- Tune to your local radio/TV for warnings and advice. Have an emergency kit ready.

- Keep dry food, drinking water and clothes ready. Drink preferably boiled water. Keep your food covered, don't take heavy meals.
- Do not let children and pregnant woman remain an empty stomach.
- Be careful of snakes, as snake bites are common during floods.

#### **After**

- Pack warm clothing, essential medication, valuables, personal papers, etc. in waterproof bags, to be taken with your emergency kit.
- Raise furniture, clothing and valuable onto beds, tables and in attic.
- Turn off the main electricity power supply. Do not use electrical appliances, which have been in flood water.
- Do not get into water of unknown depth and current.
- Do not allow children to play in, or near flood water.

#### **References:**

<sup>1</sup><http://www.redcross.org/prepare/disaster/flood>

<sup>2</sup>[http://www.saarc-sadkn.org/flood\\_types.aspx](http://www.saarc-sadkn.org/flood_types.aspx)

<sup>3</sup>Government of India, National Disaster Management Authority (2008): National Disaster Management Guidelines, Management of Floods

<sup>4</sup>Government of India, Ministry of Home Affairs, Disaster Management in India

<sup>5</sup>National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, Do's & Don'ts for Common Disasters.

## Drought<sup>1</sup>



It is difficult to provide a precise and universally accepted definition of drought due to its varying characteristics and impacts across different regions of the world, such as rainfall patterns, human response and resilience, and diverse academic perspectives.

Drought is a temporary aberration unlike aridity, which is a permanent feature of climate. Seasonal aridity (i.e. a well-defined dry season) also needs to be distinguished from drought. Thus drought is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually characterized in terms of its spatial extension, intensity and duration. Conditions of drought appear when the rainfall is deficient in relation to the statistical multi-year average for a region, over an extended period of a season or year, or even more.

Drought differs from other natural hazards such as cyclones, floods, earthquakes, volcanic eruptions, and tsunamis in that:

- No universal definition exists;
- Being of slow-onset it is difficult to determine the beginning and end of the event;
- Duration may range from months to years and the core area or epicentre changes over time, reinforcing the need for continuous monitoring of climate and water supply indicators;
- No single indicator or index can identify precisely the onset and severity of the event and its potential impacts; multiple indicators are more effective;
- Spatial extent is usually much greater than that for other natural hazards, making assessment and response actions difficult, since impacts are spread over larger geographical areas;
- Impacts are generally non-structural and difficult to quantify;

- Impacts are cumulative and the effects magnify when events continue from one season or year to the next.

## **Types of Drought<sup>1</sup>**

**Meteorological Drought** is defined as the deficiency of precipitation from expected or normal levels over an extended period of time. Meteorological drought usually precedes other kinds of drought. According to the legend, meteorological drought is said to occur when the seasonal rainfall received over an area is less than 25% of its long-term average value. It is further classified as moderate drought if the rainfall deficit is 26–50% and *severe drought* when the deficit exceeds 50% of the normal.

**Hydrological Drought** is best defined as deficiencies in surface and subsurface water supplies leading to a lack of water for normal and specific needs. Such conditions arise, even in times of average (or above average) precipitation when increased usage of water diminishes the reserves.

**Agricultural Drought**, usually triggered by meteorological and hydrological droughts, occurs when soil moisture and rainfall are inadequate during the crop growing season causing extreme crop stress and wilting. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth and the physical and biological properties of the soil. Agricultural drought thus arises from the variable susceptibility of crops during different stages of crop development, from emergence to maturity. In India, it is defined as a period of four consecutive weeks (of severe meteorological drought) with a rainfall deficiency of more than 50% of the long-term average (LTA) or with a weekly rainfall of 5 cm or less from mid-May to mid-October (the kharif season) when 80% of India's total crop is planted or six such consecutive weeks during the rest of the year (NRSC, Decision Support Centre).

## **Impacts of Drought<sup>1</sup>**

Drought produces wide-ranging impacts that span many sectors of the national economy. These impacts are felt much beyond the area experiencing physical drought. The complexity of these impacts arises because water is integral to our ability to produce goods and provide services.

Drought produces both direct and indirect impacts. Direct impacts or primary impacts are usually physical / material and include reduced agricultural production; increased fire hazard; depleted water levels; higher livestock and wildlife mortality rates; and damage to wildlife and fish habitats. When direct impacts have multiplier effects through the economy and society, they are referred to as indirect impacts. These include a reduction in agricultural production that may

result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced purchasing capacity and demand for consumption, default on agricultural loans, rural unrest, and reduction in agricultural employment leading to migration and drought relief programmes. The more removed the impact from the cause, the more complex is the link to the cause. These multiplier effects are often so diffuse that it is very difficult to generate financial estimates of actual losses caused by a drought.

The impacts of drought are generally categorized as economic, environmental, and social:

**Economic impacts** refer to production losses in agriculture and related sectors, especially forestry and fisheries, because these sectors rely on surface and subsurface water supplies. It causes a loss of income and purchasing power, particularly among farmers and rural population dependent on agriculture. All industries dependent upon the primary sector for their raw materials would suffer losses due to reduced supply or increased prices. Drought thus has a multiplier effect throughout the economy, which has a dampening impact on employment, flow of credit and tax collections. If the drought is countrywide, macroeconomic indicators at the national level are adversely impacted.

**Environmental impacts**, such as lower water levels in reservoirs, lakes and ponds as well as reduced flows from springs and streams would reduce the availability of feed and drinking water and adversely affect fish and wildlife habitat. It may also cause loss of forest cover, migration of wildlife and their greater mortality due to increased contact with agricultural producers as animals seek food from farms and producers are less tolerant of the intrusion. A prolonged drought may also result in increased stress among endangered species and cause loss of biodiversity. Reduced streamflow and loss of wetlands may cause changes in the levels of salinity. Increased groundwater depletion, land subsidence, and reduced recharge may damage aquifers and adversely affect the quality of water (e.g., salt concentration, increased water temperature, acidity, dissolved oxygen, turbidity). The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity of the landscape.

**Social impacts** arise from lack of income causing out migration of the population from the drought-affected areas. People in India seek to cope with drought in several ways which affect their sense of well-being: they withdraw their children from schools, postpone daughters' marriages, and sell their assets such as land or cattle. In addition to economic hardships, it causes

a loss of social status and dignity, which people find hard to accept. Inadequate food intake may lead to malnutrition, and in some extreme cases, cause starvation. Access and use of scarce water resources generate situations of conflict, which could be socially very disruptive. Inequities in the distribution of drought impacts and relief may exacerbate these social tensions further.

## **Prevention and Preparedness<sup>2</sup>**

Prevention and Preparedness means predisaster activities designed to increase the level of readiness and improvement of operational and institutional capabilities for responding to a drought. Drought prevention and preparedness involve water supply augmentation and conservation (e.g. rainwater harvesting techniques), expansion of irrigation facilities, effective dealing with drought, and public awareness and education. Transport and communication links are a must to ensure supply of food and other commodities during and just after a drought. Successful drought management requires community awareness on the mitigation strategies, insurance schemes for farmers, crop contingency plans, etc.

Basic to drought management in the Indian context is the delineation of drought prone areas. At the block level, the following indicators are generally used.

### **Drought Prone Area Delineation**

Criteria and data base:

- Rainfall (long term average - 30 to 50 yrs) (Short Term average – 5 to 10 years for giving real picture as a rainfall pattern may change over the period for e.g. Cherapunji);
- Cropping pattern (past 3 to 5 years);
- Available supplement irrigation (well, tank, ponds, ground water etc.);
- Satellite derived indicators (last 10 years);
- Soil map;
- Ground water availability map;
- Cattle population and fodder demand;
- Socio-economic data;
- Other water demands like for drinking, industrial use etc.; and
- Collection and creation of data base and spatial framework for analysis

### **Gradation of Drought Prone Areas**

(High, Moderate, Low): Areas should also be graded on the basis of degree of drought proneness since it would affect the steps required for greater preparedness. This would require multiple criteria approach that includes

- Sensitivity to Rainfall Variation;
- Frequency of Occurrence of Drought;
- Vulnerability of Community (people and livestock) to Drought

### **Monitoring of Drought**

Having delineated drought prone areas and their gradation one could move on to the criteria for monitoring relevant indicators. The monitoring indicators will be:

- Rainfall and other associated weather parameters
- Crop health (based on satellite derived NDVI and field reports)
- Available ground water (variation in ground water table) and surface water resources
- Migration and impact on community

### **Observational Network**

For such monitoring one would require a reasonably dense observational network.

- Automatic weather station (25 km x 25 km)
- Automatic rain-gauge (5 km x 5 km)
- Ground water table observation (5 km x 5 km in hard rock region and 10 km x 10 km in alluvial plains)
- Field reports from the block/mental level
- Satellite data of 50 m x 50 m resolution

### **Medium Range Weather Forecasting for Community Level Advisory**

Numerical weather prediction has emerged as one of the important discipline requiring increasing computing power. To have accurate timely forecasts, state-of-art computers are used all over the world. Currently forecasting in India suffers from following constraints:

- The information is too general in terms of space and time while forecasting needs are at local level
- The timing does not match user needs;
- Information received from different sources transmit conflicting messages;
- The language is not clearly understood by users.

## **Climate Change and Drought**

Forecasting weather related information could become more complex with climate change. Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals.

## **Mitigation**

Mitigation actions, programs, and policies are implemented during and before drought to reduce the magnitude of risk to human life, property, and productive capacity. Emergency response will always be a part of drought management, because it is unlikely that government and others will anticipate, avoid, or reduce all potential impacts through mitigation programs. A future drought event will also exceed the “drought of record” and the capacity of a region to respond. However, emergency response will be used lesser and only, if it is consistent with the longer-term drought policy goals and objectives. Considering the increase in the frequency of droughts in different parts of the country, it is necessary that there is a shift in public policy from drought relief to drought mitigation measures. These measures are important for adapting to climate change, restoring ecological balance, and bringing development benefits to the people.

## **Judicious use of surface and groundwater**

In drought prone areas rainwater is the main source of surface and ground water recharge. Because of more intense use of ground water in most parts of the country during the last few years, recharge of ground water did not take place. The early decade of 1990-2000, witnessed many advances in the airborne instrumentation, radars, flares and software. Water management issues of current concern, therefore, are: (a) less exploitation of groundwater for irrigation, (b) increased concentration of salts in the soil profile and groundwater, (c) increased concentration of specific ions like fluorides and nitrates in water and (d) lack of availability/reduced availability of drinking water for animals in natural storage structures such as ponds, lakes etc.

## **Cloud seeding in Drought Prone regions of India**

The South African cloud seeding experiment was carried out during 1991-1995 with new technology. The results showed statistical increase in rainfall in all types of clouds (i.e. small to large). This gave impetus to cloud seeding research in different parts of the globe. The interior

part of peninsular India is a rain shadow region. The seasonal monsoon rainfall in these areas is lower compared to all India mean monsoon rainfall. The rainfall variability is larger. The region is drought prone. In the prolonged monsoon-dry conditions, there are demands for the cloud seeding operations from the state governments. The cloud seeding programs with modern technology have been carried out by state governments of Karnataka, Andhra Pradesh and Maharashtra since 2003. The State Government of Andhra Pradesh, during 2003, in the context of erratic rainfall and prolonged dry spells, launched a cloud seeding programme to induce rain in the drought-hit Anantapur district. Two earlier experiments had been conducted in Rangareddy and Anantapur districts of Andhra Pradesh in the early 1990s. This was done again in 2007. An NGO in Karnataka carried out cloud seeding during the drought spell period of 2008. Cloud seeding does not produce rain. It enhances rainfall which otherwise would have fallen in area. The efficacy of the cloud seeding is debated as it is not often supported through properly designed experiments. The experimental requirements are to be considered in the cloud seeding programmes. Both guidelines and research relating to cloud seeding are needed. Claims concerning the efficacy of cloud seeding as a positive intervention need to be validated through more studies, as there is no conclusive evidence that cloud seeding is actually effective in producing rain.

### **Micro Irrigation Systems**

The overall development of the agriculture sector and the intended growth rate in GDP is largely dependent on the judicious use of the available water resources. While the irrigation projects (major and medium) have contributed to the development of water resources, the conventional methods of water conveyance and irrigation, being highly inefficient, has led not only to wastage of water but also to several ecological problems like water logging, salinisation and soil degradation rendering productive agricultural lands unproductive. It has been recognized that use of modern irrigation methods like drip and sprinkler irrigation is the only alternative for efficient use of surface as well as ground water resources. The DAC in 2006 launched a Centrally Sponsored Micro Irrigation Scheme under which out of the total cost of the MI System, 40% will be borne by the Central Government, 10% by the State Government and the remaining 50% will be borne by the beneficiary, either through his/her own resources or soft loan from financial institutions. The evapo-transpiration losses could be minimized and crop yield optimized by micro-irrigation systems.

### **Post Harvest Management**

India suffers an estimated food grain and agriculture produce loss of Rs 50,000 crores every year due to the lack of adequate post harvest infrastructure and inefficient supply chain management by the country's farmers. India loses about 35-40% of the fruits and vegetable produce due to improper Post Harvest Management. A loss estimated at Rs 40,000 crores per year. India wastes fruits and vegetables every year equivalent to the annual consumption of the United Kingdom. To avoid the Post Harvest Losses a chain of cold storages, need to be created along with Post Harvest Management practices like pre cooling, cold storages and refrigerated transport. Pre-harvest losses due to diseases and pests need to be minimized through better management practices. In the absence or lack of proper pre and post harvest crop management the impact of drought gets compounded.

### **Nutritional Aspects of Food Security**

The nutritional aspects of food security will be addressed by the Government through schemes like the Integrated Child Development Service (ICDS) and Mid-Day Meal scheme. The ICDS is implemented for pre-school children, while Mid-Day Meal has recently been introduced for school-going children. Since school dropout rate is high in drought affected areas, ICDS and Mid-Day Meal Scheme will be expanded to cover children out of school.

### **Water Conservation, Storage Structures and Management**

Water harvesting and conservation is very effective, as during the period of water resource depletion, the drought affected area still has significant potential for harvesting and conserving water if an integrated water resources management approach is adopted, and proper policies and investment actions are implemented using recent technologies. Drought mitigation measures have been of late more on issues related to water resource management. The scarce water resource during the drought period requires to be managed optimally. The requirement will be scientifically assessed by the State water resources departments and its subordinate offices. Water Conservation measures have been taken up on large scale by the Government. The initiative will be public driven program with incentives from the Government. Water conservation and management measures have to be prioritized during droughts. In areas facing successive hydrological droughts, regulatory measures to desist from cultivating heavy duty crops may be considered. Closing of the sluice gates of minor irrigation tanks and conserving water to provide drinking water to the livestock needs consideration in case of hydrological droughts. Water User

Groups have to be promoted and water conservation measures have to be taken up through consultative approach.

### **Availability of Inputs**

There is a need to ensure their timely availability of inputs with competitive prices so as to increase production and productivity and thereby enable agriculture to be the springboard for industrialization. Arrangements will be made through institutional agencies in the States like State Seeds Development Corporations (SDC), Marketing Federations (MARKFED), and Cooperative Oil Federations (OILFED). Credit will be provided promptly in the drought affected areas, and marketing and price support extended.

### **Afforestation with Bio-diesel species**

Forests are one of the most important natural resources that provide fuel, fodder, small timber, food and income to the tribals and the rural poor. In addition to forest conversion for human activities, permanent and shifting agriculture, and development purposes, illegal logging and forest fire are two major causes of deforestation. The degradation of forests due to various reasons like deforestation for shifting cultivation, over exploitation of Non-Timber Forest Produce has resulted in disappearance of roots and tubers in Anantapur District of Andhra Pradesh, and has affected the nutritional standards of the population. According to the statistics of the Forest Department, Government of A.P., for the year 2001, 19.49 million hectares of soil has been eroded due to deforestation.

### **Public Distribution System**

Currently, a targeted Public Distribution System with special focus on the groups living below the poverty line is in operation in the country. The Public Distribution System (PDS) is a scheme under which essential requirements, i.e., food grains and certain other non-food products are supplied to persons at subsidized costs through fair price shops (FPSs). In 1992, a revamped public distribution system (RPDS) came to be introduced and the RPDS was replaced by a Targeted Public Distribution System (TPDS) from June 1997. In this system, allocation of food grains is made to States on the basis of the number of persons living below the poverty line. The TPDS has the main object of ensuring that essential commodities are accessible to households which are BPL and to the 'poorest of poor' sections thus promoting household food security amongst economically poor sections. Efficient functioning of the PDS is a valuable component of drought management.

## **Crop Insurance**

An important instrument to combat the adverse financial impact of droughts on the farmers is agricultural insurance. Though the agricultural insurance schemes have not been very successful, the GoI has taken several initiatives towards increasing its coverage and reach. An All-India Comprehensive Crop Insurance Scheme (CCIS) for major crops was introduced in 1985. It was subsequently replaced by the National Agricultural Insurance Scheme (NAIS) in 1999. The Govt. of India also set up the Agriculture Insurance Company of India (AIC) in 2003 to serve the needs of farmers better and to move towards a sustainable actuarial regime. As the coverage of agricultural insurance in the country increases, insurance schemes for drought protection will become more viable.

## **Drought Safety Tips<sup>3</sup>**

### **Do's and Dont's**

- Never pour water down the drain, use it to water your indoor plants or garden.
- Repair dripping taps by replacing washers.
- Check all plumbing for leaks and get them repaired.
- Choose appliances that are more energy and water efficient.
- Develop and use cop contingency plan to meet drought situation
- Plant drought-tolerant grasses, shrubs and trees.
- Install irrigation devices which are most water efficient for each use, such as micro and drip irrigation.
- Consider implementing rainwater harvesting wherever it is suitable
- Avoid flushing the toilet unnecessarily
- Avoid letting the water run while brushing your teeth, washing your face or shaving.

**References:**

- <sup>1</sup>Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation (2009): Manual for Drought Management.
- <sup>2</sup>Government of India, National Disaster Management Authority (2008): National Disaster Management Guidelines, Management of Drought.
- <sup>3</sup>National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, Do's & Don'ts for Common Disasters.

## Cyclone<sup>1,2</sup>



Tropical Cyclone (TC), also known as ‘Cyclone’ is the term used globally to cover tropical weather systems in which winds equal or exceed ‘gale force’ (minimum of 34 knot, i.e., 62 kmph). These are intense low pressure areas of the earth atmosphere coupled system and are extreme weather events of the tropics.

A tropical cyclone is a storm system characterised by a large low pressure centre and numerous thunderstorms that produce strong winds and flooding rain. Tropical cyclones feed on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air. The term ‘tropical’ refers to both the geographic origin of these systems, which form almost exclusively in tropical regions of the globe, and their formation in maritime tropical air masses. The term ‘cyclone’ refers to such storms’ cyclonic nature, with counter clockwise rotation in Northern Hemisphere and clockwise rotation in the Southern Hemisphere. Depending on its location and strength, a tropical cyclone is called by many other names, such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression and simply cyclone. While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surges. They develop over large bodies of warm water, and lose their strength if they move over land. This is the reason for coastal regions receiving a significant damage from a tropical cyclone, while inland regions are relatively safe from their effect. Heavy rains, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 40 kilometres from the coastline. Although their effects on human populations can be devastating, tropical cyclones can also relieve drought conditions. They also carry heat and energy away from the tropics and transport it toward temperate latitudes, which make them an important part of the global atmospheric circulation mechanism. As a result, tropical cyclones help to maintain equilibrium in the earth’s troposphere, and to maintain a relatively stable and warm temperature worldwide.

A strong tropical cyclone usually harbours an area of sinking air at the centre of circulation. This area is called ‘eye of the cyclone’. Weather in the eye is normally calm and free of clouds, although sea may be extremely violent. The eye is normally circular in shape, and may vary in size from 3 km to 370 km in diameter. Surrounding the eye is the region called ‘Central Dense Overcast (CDO)’, a concentrated area of strong thunderstorm activity. Curved bands of clouds and thunderstorms trail away from the eye in a spiral fashion. These bands are capable of producing heavy bursts of rain and wind, as well as tornadoes. If one were to travel between the outer edge of a hurricane to its centre, one would normally progress from light rain and wind, to dry and weak breeze, then back to increasingly heavier rainfall and stronger wind, over and over again with each period of rainfall and wind being more intense and lasting longer.

### Classification of Tropical Cyclones<sup>3</sup>

The criteria followed by Meteorological Department of India (IMD) to classify the low pressure systems in the Bay of Bengal and in the Arabian Sea as adopted by World Meteorological Organisation (WMO) are as under:

Type of Disturbances	Associated Wind Speed in the Circulation
Low pressure Area	Less than 17 knots (<31 kmph)
Depression	17 to 27 knots (31 to 49 kmph)
Deep Depression	28 to 33 knots (50 to 61 kmph)
Cyclonic Storm	34 to 47 knots (62 to 88 kmph)
Severe Cyclonic Storm	48 to 63 knots (89 to 118 kmph)
Very Severe Cyclonic Storm	64 to 119 knots (119 to 221 kmph)
Super Cyclonic Storm	120 knots and above (222 kmph and above)

### Destruction caused by Cyclones<sup>3</sup>

There are three elements associated with cyclones which cause destruction during its occurrence. These are:

**Strong Winds/Squall:** Cyclones are known to cause severe damage to infrastructure through high speed winds. Very strong winds which accompany a cyclonic storm damages installations, dwellings, communications systems, trees etc., resulting in loss of life and property. Gusts are short but rapid bursts in wind speed are the main cause for damage. Squalls on the other hand,

are longer periods of increased wind speed and are generally associated with the bands of thunderstorms that make up the spiral bands around the cyclone.

**Torrential rains and inland flooding:** Torrential rainfall (more than 30 cm/hour) associated with cyclones is another major cause of damages. Unabated rain gives rise to unprecedented floods. Rain water on top of the storm surge may add to the fury of the storm. Rain is a serious problem for the people which become shelter less due to cyclone. Heavy rainfall from a cyclone is usually spread over wide area and cause large scale soil erosion and weakening of embankments.

**Storm Surge:** A Storm surge can be defined as an abnormal rise of sea level near the coast caused by a severe tropical cyclone; as a result of which sea water inundates low lying areas of coastal regions drowning human beings and life stock, causes eroding beaches and embankments, destroys vegetation and leads to reduction of soil fertility.

Brief details about damages caused by wind of different speed during cyclones are as under

<b>Wind Speed Intensity</b>	<b>Damages expected.</b>
<b>Low Pressure Area</b>	Less than 17 knots (<31 kmph)
<b>Depression</b>	17 to 27 knots (31 to 49 kmph)
<b>Deep Depression</b>	28 to 33 knots (50 to 61 kmph)
<b>Cyclonic Strom</b>	34 to 47 knots (62 to 88 kmph)
<b>Severe Cyclonic Strom</b>	48 to 63 knots (89 to 118 kmph)
<b>Very Severe Cyclonic Strom</b>	64 to 119 knots (119 to 221 kmph)
<b>Super Cyclonic Strom</b>	1120 knots and above (222kmph and above)

#### **Cyclone warning system in India<sup>4</sup>**

The India Meteorological Department is responsible for providing tropical cyclone warnings in India. The tropical cyclone warning service is one of the most important functions of the India Meteorological Department and it was the first service undertaken by the Department which is more than 135 years old.

#### **Organization**

Tropical cyclone warnings in India are provided through three Area Cyclone Warning Centres (ACWCs) located at Kolkata, Chennai and Mumbai and three Cyclone Warning Centres at Bhubaneswar, Visakhapatnam and Ahmedabad. The entire cyclone warning work is coordinated

by the Deputy Director General of Meteorology (Weather Forecasting) at Pune and Deputy Director General of Meteorology (Services) at New Delhi.

### **Tracking of tropical cyclones**

Tracking of the tropical cyclones in India is done with the help of:

- Conventional surface and upper air observations from inland and island stations, coastal Automatic Weather Station (AWS), ships and buoy observations;
- Cyclone detection radar including Doppler Weather Radar;
- Satellite cloud pictures from the Geostationary Satellite (INSAT 3A & Kalpana1).

### **Tropical cyclone warnings**

The bulletins and warnings issued in connection with tropical cyclones in India may be divided into the following broad categories:

- Warning bulletins for shipping on the high seas.
- Warning bulletins for ships plying in the coastal waters.
- Port warnings.
- Fisheries warnings. (Fishermen & Fisheries Officials)
- Four stage warnings for the State and Central Government officials.
- Warnings for recipients who are registered with the department (Designated/registered users).
- Aviation.
- Warnings for the general public through All India Radio, Doordarshan and the Press.
- Warning for Indian Navy.
- Bulletins for Print / Electronic media.

### **Forecasting of Tropical Cyclones<sup>1</sup>**

The track forecast of TCs is prepared with the help of track forecast models of different types, including numerical techniques. Currently, IMD uses a limited run of the quasi-lagrangian dynamic model for track prediction along with other synoptic, climatological and empirical techniques. Intensity forecasts are made by using satellite techniques. For prediction of storm surge, different dynamical techniques are used. The forecast advisories received from different international agencies such as the Joint Typhoon Warning Centre (JTWC), Pearl Harbour, USA; United Kingdom Meteorological Office (UKMO); European Centre for Medium Range Weather Forecasting (ECMWF); and National Centre for Medium-Range Weather Forecasting

(NCMRWF) are also considered while finalising the forecast. The current accuracy of track forecast is about  $\pm 140$  km for a 24 hour forecast and  $\pm 250$  km for a 48-hour forecast. The error increases with increase in the duration of the forecast projection. This translates into warnings covering very large areas if issued more than 24 hours ahead. This limits the lead time of the warning to 24 hours. The accuracy of these forecasts need to be improved significantly. Globally, with the use of multi-ensemble and mesoscale models, accuracy in the range of  $\pm 60$ – $80$  km for a 24-hour forecast has been achieved.

IMD will lead the concentrated national effort to achieve improvements involving:

- Selection of a suitable model and establishing a system of generating the most representative initial state 3-D atmospheric fields with the implementation of an appropriate data assimilation system for satellite data inputs (scatterometer winds, high resolution satellite derived winds, satellite derived temperature and moisture fields, etc.);
- Track prediction using several advanced techniques, including the super ensemble method;
- Extensive validation using data of several past cyclones, and
- Developing institutional interfaces with IMD, NCMRWF, CWC, NRSA and other agencies/institutions.

### **Real time Data Reception, Processing and Assimilation Capabilities**

To generate a most representative 3-D structure of the atmosphere for forcing cyclone forecast models, the following are to be carried out:

- All the observational data from various heterogeneous platforms will be collected and transmitted to operational forecast centres for their utilisation in improving cyclone warning efforts.
- Appropriate automated data processing and quality control algorithms will be developed by agencies like IMD, NCMRWF and research institutes connected with meteorological data processing and forecasts.
- Improved high resolution meso-scale data assimilation systems involving 3-D and 4-D variational assimilation techniques will be developed.
- Cyclone specific, most representative, initial state and boundary fields will be generated.

### **Prediction of Severe Weather and Storm Surges**

To predict the time of onset of severe weather and storm surges at specific locations, detailed knowledge of the wind and precipitation structure of the TC (e.g., TC size, gale wind radius) have to be known besides the forecast track. Observations in recent years from advanced sensors (e.g., Tropical Rainfall Measuring Mission (TRMM), Special Sensor Microwave/Imager (SSM/I), Advanced Microwave Sounding Unit (AMSU), and (QuickSCAT) on the new generation of meteorological satellites have greatly enhanced our knowledge on the structural characteristics of wind and precipitation fields associated with cyclones.

### **Cyclone Forecasting and Emergency Management Networks**

Some countries have set up dedicated video/audio facilities and websites to communicate with other emergency organisations and technical groups. A consensus assessment of the cyclone forecast is arrived at through broad based consultation and coordination.

### **Parametric Wind Field and Cyclone Risk Models**

Parametric wind models form the basis of the TC hazard component of many risk models. The next-generation parametric wind model would provide a more realistic wind field and improve the TC hazard component of a risk model, which can lead to and thereby improve loss and cost estimates associated with TC landfall. Recent wind field observations collected with Global Positioning System (GPS) dropsondes have many characteristics that are not represented by standard parametric models.

### **Structural Mitigation Measures<sup>1</sup>**

An important aspect of cyclone risk reduction is to ensure availability of adequate numbers of shelters, community centres/school buildings, places of worship, etc., which can be utilised for moving people from vulnerable areas to safety. Besides this, the structural safety of various lifeline infrastructure such as roads/culverts/bridges, communication and transmission towers, power houses, water towers and hospitals will be ensured, so that the communication system at all levels remains useable, the electricity and water supply systems do not break down and adequate medical attention is possible.

It has been identified that design and maintenance considerations are the main focal points to be addressed which would improve the cyclone preparedness. This will cover:

- Buildings, including multi-purpose cyclone shelters;
- Road links, culverts and bridges; canals, drains, and surface water tanks, etc.;
- Saline embankments

- Communication towers and power transmission networks.

It is very important to provide safe shelters to protect human life at the time of cyclones. Many cyclone shelters constructed earlier were not connected by all-weather roads with nearby habitats from where affected people need to be shifted during emergency evacuation.

There is a need to improve the existing road network and provide at least one link road, in all weather conditions, for each village that is accessible during cyclone or flooding periods as well. The importance of coastal canals need not be over-emphasised as it serves as an alternative to road communication in the event of a cyclone or flood. Failure of even well-engineered structures such as communication and transmission towers during past cyclones brings the importance of the structural safety of such structures to the forefront.

## **Safety Tips<sup>5</sup>**

### **Do's and Don'ts**

#### **Before and During**

- Listen to radio or TV weather reports and alert everyone through a loud speaker or by going home to home.
- Identify safe shelter in your area. These should be cyclone resistant and also find the closest route to reach them.
- Keep your emergency kit and basic food supply, medicines, torch and batteries etc. ready.
- Doors, windows, roof and walls should be strengthened before the cyclone season through retrofitting and repairing. Store adequate food grains and water in safe places.
- Conduct Mock Drills for your family and the community.
- Do not venture into the sea. Stay Indoors under the strongest part of the house if not moved to the cyclone shelter.
- Remain indoors until advised that the cyclone has passed away.

#### **After**

- Do not go out till officially advised that it is safe. If evacuated, wait till advised to go back.
- Use the recommended route to return to your home. Do not rush.
- Be careful of broken powers lines, damaged roads and house, fallen trees etc.

## References:

- <sup>1</sup>Government of India, National Disaster Management Authority, National Disaster Management Guidelines, Management of Cyclone.
- <sup>2</sup>Guidelines for Planning and Construction of Roads in Cyclone Prone Areas CRRRI Report – July 2013, Sponsored by National Disaster Management Authority, Govt. of India
- <sup>3</sup>[http://ncrmp.gov.in/ncrmp/Cyclone\\_Impact.html](http://ncrmp.gov.in/ncrmp/Cyclone_Impact.html)
- <sup>4</sup>Secretariat of The World Meteorological Organization, Geneva Switzerland, World Meteorological Organization Technical Document (2012): Tropical Cyclone Operational Plan for The Bay of Bengal and the Arabian Sea.
- <sup>5</sup>National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, Do's & Don'ts for Common Disasters.

## Avalanche<sup>1</sup>



Snow cover on a slope tends to slide down the slope because of gravity. Conditions affecting stability include the gravitational force component of the snow and resisting forces, such as the frictional resistance of the slope or the anchoring effect of shrubs. In general, avalanches are caused when

this balance is lost and when the forces exceed the resistance. Avalanches are rarely observed closely since they normally occur during a short time period of one or two minutes. **Major Causes** - Major causes of avalanches can be classified into fixed (prime factors) and variable factors (exciting factors), such as weather conditions and the weight of the snow cover, Avalanches occur when these factors are combined. The types and scale of avalanches can differ depending on the combination of these various factors and their scale.

### Avalanches Prone Areas in India

The Himalayas are well known for the occurrence of snow avalanches particularly Western Himalayas i.e. the snowy regions of Jammu and Kashmir, Himachal Pradesh and Western Uttar Pradesh.

- Jammu and Kashmir - Higher reaches of Kashmir and Gurez valleys, Kargil and Ladakh and some of the major roads
- Himachal Pradesh - Chamba, Kullu- Spiti and Kinnaur vulnerable areas
- West Uttar Pradesh - Parts of Tehri Garhwal and Chamoli districts are vulnerable areas.

There are three types of snow avalanche zones;

- Red Zone - The most dangerous zone where snow avalanches are most frequent and have an impact pressure of more than 3 tonnes per square metre.
- Blue Zone - Where the avalanche force is less than 3 tonnes per square metre and where living and other activities may be permitted with connection of safe design but such areas may have to be vacated on warning.
- Yellow Zone - Where snow avalanche occur only occasionally.

## **Types of Avalanches<sup>2</sup>**

- Loose Snow Avalanche
- Slab Avalanche
- Ice Fall Avalanche
- Cornice Fall Avalanches
- Wet Avalanches
- Glide Avalanches
- Slush Avalanches

### **1. Loose Snow Avalanche**

Loose snow avalanches usually start from a point and fan outward as they descend, and because of this they are also called "point releases." Very few people are killed by sluffs because they tend to be small and they tend to fracture beneath you as you cross a slope instead of above you as slab avalanches often do. The avalanche culture tends to minimize the danger of sluffs, sometimes calling them "harmless sluffs." But, of course, this is not always the case. Houses have been completely destroyed by "harmless sluffs," and if caught in one, it can easily take the victim over cliffs, into crevasses or bury them deeply in a terrain trap such as a gully. Most of the people killed in sluffs are climbers who are caught in naturally-triggered sluffs that descend from above-especially in wet or springtime conditions. Sluffs can actually be a sign of stability within the deeper snow when new snow sluffs down without triggering deeper slabs.

### **2. Slab Avalanche**

Slab Avalanches generally occur when a packed portion of snow became loose. The slab is difficult to see and avoid for one cannot determine when the snow will move. Most of the time, a person can still travel on it before it falls. This type of avalanche is the primary cause of the most number of casualties among travelers.

### **3. Ice Fall Avalanche**

When glaciers flow over a cliff they form the ice equivalent of a waterfall-an icefall. Falling blocks of ice create an avalanche of ice, which often entrain snow below it or triggers slabs. Especially in big mountains, icefall avalanches can be large and travel long distances. Despite this, icefall avalanches kill few people compared to dry slabs that people trigger themselves. Most of the deaths from icefall avalanches occur to climbers in big mountains who just happen to be in the wrong place at the wrong time.

Icefall avalanches occur more or less randomly in time. However, in warmer climates, more ice tends to come down in the heat of the day than at night. Also, on a longer time scale, glaciers tend to surge, meaning that they actually have very slow waves that travel through them that produce a surge of movement for a few days to a month, followed by less movement for several more days or even months. For instance, sometimes an icefall seems very dormant for several months, then suddenly, it produces lots of activity for several days to a month.

The best way to deal with icefall avalanches, of course, is to avoid traveling on them or beneath them. And when you choose to travel beneath them, do so quickly. At the risk of being too obvious--never camp under icefalls. But sometimes bad weather prevents climbers from seeing icefall hazard when they set up camp, or bad weather forces them to camp in the wrong spot. Many accidents with icefall avalanches happen this way.

#### **4. Cornice Fall Avalanches**

Cornices are the fatal attraction of the mountains, their beauty matched only by their danger. Cornices are elegant, cantilevered snow structures formed by wind drifting snow onto the downwind side of an obstacle such as a ridgeline. Similar to icefall avalanches, the weight of a falling cornice often triggers an avalanche on the slope below, or the cornice breaks into hundreds of pieces and forms its own avalanche-or both. Be aware that cornice fragments often "fan out" as they travel downhill, traveling more than 30 degrees off of the fall line. Cornices tend to become unstable during storms, especially with wind, or during times of rapid warming or prolonged melting. Each time the wind blows, it extends the cornice outward, thus, the fresh, tender and easily-triggered part of the cornice usually rests precariously near the edge while the hard, more stable section usually forms the root.

#### **5. Wet Avalanches**

Most avalanche professionals make a hard separation between wet snow avalanches and dry snow avalanches, because wet and dry avalanches are so different. Forecast for wet and dry avalanches vary differently, much of the mechanics are different, they move differently, and it's only natural for us to think of them as two separate beasts altogether. But really, there's a continuum between wet and dry avalanches. For instance, there are damp avalanches, and often, large, dry avalanches start out dry and end up wet by the time they get to the bottom because either the energy of the descent heats the snow up or they travel into a region of warmer snow. Like dry snow avalanches, wet avalanches can occur as both sluffs and slabs.

## **6. Glide Avalanches**

Glide occurs when the entire snowpack slowly slides as a unit on the ground, similar to a glacier and should not be mistaken for the catastrophic release of a slab avalanche that breaks to the ground. Glide is a slow process that usually occurs over several days. Glide occurs because melt water lubricates the ground and allows the overlying snowpack to slowly "glide" downhill. Usually, they don't every produce an avalanche but occasionally they release catastrophically as a glide avalanche. So the presence of glide cracks in the snow does not necessarily mean danger. It's often difficult for a person to trigger a glide avalanche but at the same time it's not smart to be mucking around on top of them and especially not smart to camp under them. They are found more often in wet climates and when they occur in dry climates they do so in spring when water percolated through the snow or sometimes during mid winter thaws. Like an icefall, they come down randomly in time.

## **7. Slush Avalanches**

An oddity in most of the avalanche world, slush avalanches usually occur in very northern latitudes such as the Brooks Range of Alaska or in northern Norway. They're unusual because they occur on very gentle slopes compared with other avalanches, typically 5-20 degrees and they rarely occur on slopes steeper than 25 degrees. A typical slush avalanche occurs in impermeable permafrost soil, which allows water to pool up, and occurs during rapid saturation of a thin, weak snowpack. When water saturates the snowpack, it catastrophically loses its strength and the resulting slush often runs long distances on very gentle terrain. Once again, very few people are killed by slush avalanches possibly because so few people live in high latitude Permafrost Mountains. But they can certainly be dangerous to people camped in the wrong spot or structures built in.

There are two basic types of avalanches, loose snow avalanches and slab avalanches. These are further sub-divided according to whether the snow involved is dry, damp or wet, whether the snowslide originates in a surface layer or involves the whole snow cover (slides to the ground), and whether the motion is on the ground, in the air, or mixed. Loose snow avalanches form in snow masses with little internal cohesion among the individual snow crystals. When such snow lies in a state of unstable equilibrium on a slope steeper than its natural angle of repose, a slight disturbance sets progressively more and more snow in downhill motion. If enough momentum is

generated, the sliding snow may run out onto level ground, or even ascend an opposite valley slope. Such an avalanche originates at a point and grows wider as it sweeps up more snow in its descent. The demarcation between sliding and undisturbed snow is diffuse, especially in dry snow. Though very common, most dry, loose snow avalanches are small and few achieve sufficient size to cause damage. With the onset of melting, wet loose snow avalanches become common. Most of the latter, too, are small, but they are more likely to occasionally reach destructive size, especially when confined to a gully.

Slab avalanches originate in snow with sufficient internal cohesion to enable a snow layer, or layers, to react mechanically as a single entity. The degree of this required cohesion may range from very slight in fresh, new snow (soft slab) to very high in hard, wind drifted snow (hard slab). A slab avalanche breaks free along a characteristic fracture line, a sharp division of sliding from stable snow whose face stands perpendicular to the slope. The entire surface of unstable snow is set in motion at the same time, especially when the cohesive snow lies on top of a weak layer. A slab release may take place across an entire mountainside, with the fracture racing from slope to slope to adjacent or even distant slide paths. The mechanical conditions leading to slab avalanche formation are found in a wide variety of snow types, new and old, dry and wet. They may be induced by the nature of snow deposition (wind drifting is the prime agent of slab formation), or by internal metamorphism. Slab avalanches are often dangerous, unpredictable in behaviour, and account for most of the damage.

Avalanches composed of dry snow usually generate a dust cloud when the sliding snow is whirled into the air. Such slides, called powder snow avalanches, most frequently originate as soft slabs. Under favourable circumstances, enough snow crystals are mixed with the air to form an aerosol which behaves as a sharply bounded body of dense gas rushing down the slope ahead of the sliding snow. This wind blast can achieve high velocities, to inflict heavy destruction well beyond the normal bounds of the avalanche path.

### **Anatomy of an avalanche<sup>2</sup>**

An avalanche has three main parts. The starting zone is the most volatile area of a slope, where unstable snow can fracture from the surrounding snow cover and begin to slide. Typical starting zones are higher up on slopes, including the areas beneath cornices and "bowls" on mountainsides. However, given the right conditions, snow can fracture at any point on the slope.

The avalanche track is the path or channel that an avalanche follows as it goes downhill. When crossing terrain, be aware of any slopes that look like avalanche "chutes." Large vertical swaths of trees missing from a slope or chute-like clearings are often signs that large avalanches run frequently there, creating their own tracks. There may also be a large pile-up of snow and debris at the bottom of the slope, indicating that avalanches have run.

The run out zone is where the snow and debris finally come to a stop. Similarly, this is also the location of the deposition zone, where the snow and debris pile the highest. Although underlying terrain variations, such as gullies or small boulders, can create conditions that will bury a person further up the slope during an avalanche, the deposition zone is where a victim will most likely be buried.

### **Causes of Snow Avalanches<sup>3</sup>**

Avalanches form as soon as the force of gravity on the snow cover exceeds its mechanical strength. To be caused, an avalanche needs a steep slope, snow cover, a weak layer in the snow cover, and a trigger to initiate movement. Snow avalanches may occur on any slope where enough snow is deposited in the right circumstances. Snow does not accumulate significantly on steep slopes; also, snow does not flow easily on flat slopes. Most avalanches of dangerous size therefore originate on slopes with inclinations of between 30 degrees and 45 degrees. On slopes from 45 degrees to 50 degrees, sluffs and small avalanches are common, but snow seldom accumulates to sufficient depths to generate large snow slides. Convex slopes are more susceptible to avalanches than concave slopes.

Avalanches are released (spontaneously or artificially) by an increase in stress (e.g., by fresh snow) and/or a decrease in strength (e.g., by warming or rain). Though internal metamorphism or stress development may sometimes initiate a snow rupture, avalanches are often dislodged by external triggers. Ice fall, falling cornices, earthquakes, rock falls, thermal changes, blizzards, and even other avalanches are common natural triggers. Avalanches can also be triggered by loud sounds such as shouts, machine noise, and sonic booms. In the absence of external triggers, unstable snow may revert to stability with the passage of time as long as no avalanche occurs. The rheology of snow cover is similar to that of ice as both are visco-elastic materials that exhibit creep behaviour over time. Snow deforms continually without fracturing as the load on top of it increases. However, the loading rate is critical. Heavy snow fall over a short duration

leads to a greater probability of avalanche occurrence. A snow fall of 1m in one day is far more hazardous than 1m over three days.

When the snow pack becomes unstable, it is released suddenly and descends rapidly downslope, either over a wide area or concentrated in an avalanche track. Avalanches reach speeds of up to 200 km an hour and can exert forces great enough to destroy structures coming in their way and uproot or snap off large trees. It may be preceded by an ‘air blast’ capable of damaging constructions and forest cover.

The complete path of an avalanche is made up of a starting zone at the top where the unstable snow breaks away from the more stable part of the snow cover, a run-out zone at the bottom where the moving snow and entrained debris stop, and a track that runs between the two zones. The air blast zone is usually in the vicinity, but not necessarily continuous with the lower track or run-out zone. In some cases it may even run way up the slope across the valley from the avalanche path.

### **Global Profile<sup>2</sup>**

Scientists estimate that there are more than 1 million avalanches each year ranging from snow falling off a roof to entire mountainsides of snow traveling for miles. Each year avalanches kill 150 people worldwide and some 25 people in the United States.

#### **Avalanche Fatalities by Geography and Year**

<b>Continent</b>	<b>1996/97</b>	<b>1997/98</b>	<b>1998/99</b>	<b>1999/00</b>	<b>1999/00</b>
North America	33	48	49	35	21
Europe	31	20	95	54	30
Asia	109	45	42	11	3
Latin America	2	3	-	7	-
Australia/New Zealand	3	-	-	2	-
Russia & ex-CIS	4	57	8	19	-
Middle East (Turkey, Iran etc)	6	47	4	20	12
<b>Total</b>	<b>188</b>	<b>220</b>	<b>198</b>	<b>148</b>	<b>66</b>

*Source: <http://www.ifyouski.com/avalanche/nivologie>*

### **Indian Profile<sup>2</sup>**

In India Snow avalanches have long posed a hazard and risk to indigenous population of the Himalaya and Trans-Himalaya mountains. In states like J&K, Himachal Pradesh and

Uttarakhand, avalanches are one of the major natural hazards which take its toll in terms of human and properties such as communication line, highway, etc.

### **The Impact of Snow Avalanches<sup>3</sup>**

The forces generated by moderate or large avalanches can damage or destroy most manmade structures. The debris from even small avalanches is enough to block a highway or rail-road. Avalanches are extremely destructive due to the great impact forces of the rapidly moving snow and debris and the burial of areas in the run-out zone. Structures not specifically designed to withstand these impacts are generally totally destroyed. Where avalanches cross highways, passing vehicles can be swept away and destroyed, killing their occupants.

In general, land use within an avalanche area should not include buildings intended for winter and early spring occupancy. Ordinarily, use of avalanche areas in the summer does not constitute any hazard. Structures including power lines, highways, railroads, and other facilities that are placed in avalanche paths and run-out zones should be designed for expected impact even if other preventive measures are implemented.

### **Early Warning Systems against Snow Avalanche Hazards<sup>3</sup>**

There are two basic methods of anticipating an avalanche hazard. One is the examination of the snow cover structure for patterns of weakness, particularly those leading to slab avalanches. The second method is the analysis of the meteorological factors affecting snow depositions. In practice the two methods overlap and both are used. Emphasis on either one or the other depends on the local climate, pattern of snowfall, snow type, and avalanche characteristics. Both apply principally to winter avalanches in dry snow. Forecasting wet spring avalanches depends on knowledge of the heat input to the snow surface.

Rising temperature during a storm accompanied by rising new snow density tends to cause avalanching, while falling temperatures have the opposite effect. New snow precipitation intensity is a significant factor, as it represents the rate at which the slopes are being overloaded.

Wet snow avalanches are generated by the intrusion of percolating water (rain or snow melt) in the snow cover. The rapid rise in temperature quickly alters snow behaviour, while the water itself reduces snow strength. Water accumulating on an impervious crust provides an especially good lubricating layer for slab release. The most extensive wet snow avalanching occurs during winter rains or the first prolonged melt period in spring, when water intrudes into previously

subfreezing snow. Snowmelt due to solar radiation is the most common cause of wet snow avalanches.

### **Avalanche Control Strategies<sup>3</sup>**

The need for study of snow bound areas has increased manifold with the increasing necessity of developing communication routes, development of winter tourism, construction of hydroelectric projects and transmission lines in snow bound areas. Snow avalanches have long posed a threat to the indigenous populations of the Himalayan and Trans-Himalayan mountains. Land use intensification due to population growth, new transportation routes, defence related activities and tourism are raising this level of risk.

Obviously, the most desirable and effective protection against avalanches is to situate buildings, roads, and other valuable developmental projects in areas free from avalanches. However, as the population grows and more hazardous sites are considered for development, advanced planning and strictly enforced zoning and construction practices appear to be the best solutions. In some cases, even these are not adequate to completely eliminate the risk of avalanches, and acceptable risks must be defined, especially in the case of roads, power lines and railroads. These risks can, however, be reduced considerably if appropriate structural controls are employed.

Since avalanche prone areas can be identified, the safest and probably best mitigation procedure is to avoid construction of buildings or any type of structure involving winter use in these areas. Agricultural and recreational activities that take place during the non-avalanche months are relatively safe. Other uses that could be considered are those that do not involve permanent unprotected structures in the avalanche path or those that could be moved or closed down during high avalanche-risk periods.

### **Related Links**

- <http://www.preventionweb.net/english/professional/publications/v.php?id=1484>
- <http://www.avalanche-center.org/>
- <http://pistehors.com/backcountry/wiki/Avalanches/Learning-Lessons-From-Avalanche-Accidents>
- <http://www.aber.ac.uk/iges/cti-g/>
- [http://geosurvey.state.co.us/avalanche/US\\_World\\_stats/2002-03/US2002-03.html#ikarstats](http://geosurvey.state.co.us/avalanche/US_World_stats/2002-03/US2002-03.html#ikarstats)
- <http://www.meteo.fr/meteonet/temps/activite/mont/mont.htm>
- <http://www.slf.ch/welcome-en.html>

- <http://www.brunel.ac.uk/depts/geo/iainsub/Disasters/aval.html>
- <http://pistehors.com/>
- <http://pistehors.com/backcountry/wiki/Avalanches/Learning-Lessons-From-Avalanche-Accidents>
- <http://projectdisaster.com/?m=20080127>
- [http://www.powdermag.com/features/onlineexclusive/waddington\\_avalanche/](http://www.powdermag.com/features/onlineexclusive/waddington_avalanche/)
- <http://www.secretsofsurvival.com/survival/avalanche.aspx>
- <http://www.pbs.org/wgbh/nova/avalanche/>
- <http://www.pbs.org/wgbh/nova/avalanche/>
- <http://www.theunion.com/article/20070402/NEWS/104020095>
- <http://www.doralpub.com/doral/srchandres.html>
- <http://nsidc.org/snow/avalanche/>
- <http://www.bbc.co.uk/science/horizon/1999/avalanche.shtml>
- [http://www.worldmapper.org/posters/worldmapper\\_map252\\_ver5.pdf](http://www.worldmapper.org/posters/worldmapper_map252_ver5.pdf)

## **Safety Tips<sup>2</sup>**

Before crossing a slope where there is any possibility of an avalanche, fasten all your clothing securely to keep out snow. Loosen your pack so that you can slip out of it with ease and remove your ski pole straps. Make sure that your avalanche beacon is on and switched to "transmit" rather than "receive." Cross the slope one at a time to minimize danger.

### **If you are caught in an avalanche**

- Yell and let go of ski poles and get out of your pack to make yourself lighter. Use "swimming" motions, thrusting upward to try to stay near the surface of the snow. When avalanches come to a stop and debris begins to pile up, the snow can set as hard as cement. Unless you are on the surface and your hands are free, it is almost impossible to dig yourself out. If you are fortunate enough to end up near the surface (or at least know which direction it is), try to stick out an arm or a leg so that rescuers can find you quickly.
- If you are in over your head (not near the surface), try to maintain an air pocket in front of your face using your hands and arms, punching into the snow. When an avalanche finally stops, you may have only a few seconds before the snow sets up and hardens.

Many avalanche deaths are caused by suffocation, so creating an air space is one of the most critical things you can do. Also, take a deep breath to expand your chest and hold it; otherwise, you may not be able to breathe after the snow sets. To preserve air space, yell or make noise only when rescuers are near you. Snow is such a good insulator they probably will not hear you until they are practically on top of you.

- Above all, do not panic. Keeping your breathing steady will help preserve your air space and extend your survival chances. If you remain calm, your body will be better able to conserve energy.

### **Rescuing a victim**

- Try to watch the victim as they are carried down the slope, paying particular attention to the point you last saw them. After the avalanche appears to have finished and settled, wait a minute or two and observe the slope carefully to make sure there is no further avalanche danger. If some danger does still exist, post one member of your party in a safe location away from the avalanche path to alert you if another avalanche falls.
- When traveling with a large party, you may want to send someone for help immediately while the rest of you search. If you are the only survivor, do a quick visual search. If you don't see any visual clues, and you don't have transceivers, then go for help
- Begin looking for clues on the surface (a hand or foot, piece of clothing, ski pole, etc.), beginning with the point where they were last seen. As you move down the slope, kick over any large chunks of snow that may reveal clues. Since equipment and items of clothing may be pulled away from a victim during an avalanche, they may not indicate their exact location, but can help determine the direction the avalanche carried them. Mark these spots as you come across them. Be sure that all rescuers leave their packs, extra clothing, etc., away from the search area so as not to clutter or confuse search efforts.
- Once the victim is found, it is critical to unbury them as quickly as possible. Survival chances decrease rapidly depending on how long a victim remains buried. Treat them for any injuries, shock, or hypothermia if necessary.
- If you lost sight of the victim early during the avalanche, or if there are no visible clues on the surface, mark where the victim was last seen. Look at the path of the snow and try

to imagine where they might have ended up. For those wearing avalanche transceivers, switch them to "receive" and try to locate a signal.

- For those using probes, begin at the point the victim was last seen at. Or if you have a good idea of where they were buried, begin in that area. Stand in a straight line across the slope, standing shoulder to shoulder. Repeatedly insert the probes as you move down slope in a line. Pay particular attention to shallow depressions in the slope and the uphill sides of rocks and trees, since these are terrain traps where they may have been buried.
- It may be necessary to probe certain areas more than once if you don't locate the victim the first time around, but this takes more time and decreases the victim's chances for survival. Similar to using transceivers, this method of rescue is much more effective if those involved have experience or have practiced finding buried victims using probes.
- After searching for clues, or using transceivers and/or probes, still does not reveal the location of the victim, it may be time to rely on outside help. Nearby ski resorts will be staffed with personnel experienced to handle these situations. They will have equipment to locate the victims and dig them out (if your party did not bring shovels or probes), and they may also have avalanche dogs that can help find victims. Ski area patrollers will also have first aid equipment, but unfortunately, by the time they can usually reach out-of-bounds avalanche accidents, too much time has elapsed to save the victim.

## **References:**

<sup>1</sup>[www.admis.hp.nic.in/himachal/home/HomeGuards/pdfs/Avalanches.pdf](http://www.admis.hp.nic.in/himachal/home/HomeGuards/pdfs/Avalanches.pdf)

<sup>2</sup>[http://www.saarc-sadkn.org/avalanche\\_types.aspx](http://www.saarc-sadkn.org/avalanche_types.aspx)

<sup>3</sup>Government of India, National Disaster Management Authority, (2009): National Disaster Management Guidelines, Management of Landslides and Snow Avalanche

## Heat Wave



A heat wave is typically defined as a period of excessively hot weather. Heat wave is thought of as being generally uncomfortably hot for the population and may adversely affect human health for those vulnerable to such conditions. However, threshold conditions for a heat wave vary across India and around the world<sup>1</sup>.

A heat wave is a prolonged period of excessively hot weather, which may be

accompanied by high humidity. There is no universal definition of a heat wave; the term is relative to the usual weather in the area. Temperatures that people from a hotter climate, consider normal can be termed a heat wave in a cooler area if they are outside the normal climate pattern for that area. The term is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century. Severe heat waves have caused catastrophic crop failures, thousands of deaths from hyperthermia, and widespread power outages due to increased use of air conditioning.

The definition recommended by the World Meteorological Organization is when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C (9 °F), the normal period being 1961 - 1990.<sup>2</sup>

### Criteria for Heat Waves<sup>2</sup>

**Severe heat wave:** Departure of maximum temperature by 5°C for regions where normal temperature is above 40°C; +7°C for regions where normal maximum is less than 40°C.

**Heat Wave:** Departure of maximum temperature by 3 to 4°C or more for regions above 40°C.

**Heat Index:** A number in degrees Fahrenheit (F) that tells how hot it feels when relative humidity is added to the air temperature. Exposure to full sunshine can increase the heat index by 15 degrees.

**Heat Cramps:** Muscular pains and spasms due to heavy exertion. Although heat cramps are the least severe, they are often the first signal that the body is having trouble with the heat.

**Heat Exhaustion:** It typically occurs when people exercise heavily or work in a hot, humid place where body fluids are lost through heavy sweating. Blood flow to the skin increases, causing blood flow to decrease to the vital organs. This results in a form of mild shock. If not treated, the victim's condition will worsen. Body temperature will keep rising and the victim may suffer heat stroke.

**Heat Stroke:** Heat stroke life-threatening condition. The victim's temperature control system, which produces sweating to cool the body, stops working. The body temperature can rise so high that brain damage and death may result if the body is not cooled quickly.

### **Effects<sup>2</sup>**

- Heat-related illness is Hyperthermia, also known as heat stroke.
- Heat Cramps
- Heat syncope is believed to result from intense sweating, which leads to dehydration
- Severe Sunburn
- Mortality

### **Preparedness<sup>2</sup>**

To prepare for extreme heat, you should:

- Install window air conditioners snugly; insulate if necessary.
- Check air-conditioning ducts for proper insulation.
- Install temporary window reflectors (for use between windows and drapes), such as aluminum foil-covered cardboard, to reflect heat back outside.
- Weather-strip doors and sills to keep cool air in.
- Cover windows that receive morning or afternoon sun with drapes, shades, awnings, or louvers. (Outdoor awnings or louvers can reduce the heat that enters a home by up to 80 percent.)

### **Heat Wave Safety<sup>3</sup>**

#### **Do's and Don'ts**

##### **Before**

- Install temporary window reflectors, such as aluminum foil-covered cardboard, to reflect heat back outside.
- Cover windows that receive morning or afternoon sun with drapes, shades.

- Listen to local weather forecasts and make yourself aware of upcoming temperature changes.
- Know those in your neighborhood who are elderly, young, sick or overweight. They are more likely to become victims of excessive heat and may need help.
- Get trained in first aid to learn how to treat heat-related emergencies.

### **During**

- Never leave children or pets alone in closed vehicles. Stay indoors as much as possible and limit exposure to the sun.
- Stay on the lowest floor out of the sunshine.
- Eat well-balanced, light and regular meals.
- Drink plenty of water; even if you do not feel thirsty.
- Persons with epilepsy or heart, kidney, or liver disease; are on fluid-restricted diets; or have a problem with fluid retention should consult a doctor before increasing liquid intake.
- Protect face and head by wearing a hat or cloth.

### **References:**

<sup>1</sup>CAWCR Technical Report No. 060, (2013): The Centre for Australian Weather and Climate Research, A partnership between the Bureau of Meteorology and CSIRO.

<sup>2</sup>[http://www.saarc-sadkn.org/heat\\_wave.aspx](http://www.saarc-sadkn.org/heat_wave.aspx)

<sup>3</sup>National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, Do's & Don'ts for Common Disasters.

## Cold Wave



A cold wave is a weather phenomenon that is distinguished by a cooling of the air. Specifically, as used by the U.S. National Weather Service, a cold wave is a rapid fall in temperature within a 24 hour period requiring substantially increased protection to agriculture, industry, commerce, and social activities. The precise criterion for a

cold wave is determined by the rate at which the temperature falls, and the minimum to which it falls. This minimum temperature is dependent on the geographical region and time of year.<sup>1</sup>

### Cold wave in India<sup>2</sup>

Occurrences of extreme low temperature in association with incursion of dry cold winds from north into the sub continent are known as cold waves. The northern parts of India, specially the hilly regions and the adjoining plains, are influenced by transient disturbances in the mid latitude westerlies which often have weak frontal characteristics. These are known as western disturbances. The cold waves mainly affect the areas to the north of 20°N but in association with large amplitude troughs, cold wave conditions are sometimes reported from states like Maharashtra and Karnataka as well. In recent years due to deterioration of the air quality in urban locations of India the deaths and discomfort from cold waves have been substantial. Uttar Pradesh and Bihar rank the highest in terms of casualties from cold wave and this could be due to poor level of development and lack of shelters to the outdoor workers and farmers.

### Criteria for cold wave

**Severe Cold Wave:** -5 C deviation from normal for regions where normal temperature is less than 10.

**Cold Wave:** Departure of minimum temperature by -3 to -4 C from normal where normal minimum temperature is less than 10 C.

### Impacts of Cold Wave<sup>3</sup>

- Exposure to extreme and especially unexpected cold can lead to hypothermia and frostbite, which require medical attention due to the hazards of tissue damage and organ failure. They can cause death and injury to livestock and wildlife. It is said that death of older people are reported more during cold waves. If a cold wave is accompanied by heavy and persistent snow, grazing animals may be unable find grasslands and die of hypothermia or starvation;
- Extreme winter cold often causes poorly insulated water pipelines and mains to freeze. Even some poorlyprotected indoor plumbing ruptures as water expands within them, causing much damage to property.
- Demand for electrical power and fuels rises dramatically during such times, even though the generation of electrical power may fail due to the freezing of water necessary for the generation of hydroelectricity. Some metals may become brittle at low temperatures. Motor vehicles may fail as antifreeze fails and motor oil gels, resulting even in the failure of the transportation system.
- Fires, paradoxically, become even more of a hazard during extreme cold. Water mains may break and water supplies may become unreliable, making firefighting more difficult. The air during a cold wave is typically denser, and any fire hazard can become intense because the colder, denser air contains more oxygen;
- Winter cold waves that aren't considered cold in some areas, but cause temperatures significantly below average for an area, are also destructive. Areas with subtropical climates may recognize unusual cold, perhaps barely-freezing, temperatures, as a cold wave. In such places, plant and animal life is less tolerant of such cold as may appear rarely;
- Abnormal cold waves that penetrate into tropical countries in which people do not customarily insulate houses or have reliable heating may cause hypothermia and even frostbite;
- Cold waves that bring unexpected freezes and frosts during the growing season in mid-latitude zones can kill plants during the early and most vulnerable stages of growth, resulting in crop failure as plants are killed before they can be harvested economically. Such cold waves have caused famines. At times as deadly to plants as drought, cold

waves can leave a land in danger of later brush and forest fires that consume dead biomass.

### **Counter Measures<sup>3</sup>**

- Most people can dress appropriately and can even layer their clothing should they need to go outside or should their heating fail. They can also stock candles, matches, flashlights, and portable fuel for cooking and wood for fireplaces or wood stoves, as necessary. However caution should be taken as the use of charcoal fires for cooking or heating within an enclosed dwelling is extremely dangerous due to carbon monoxide poisoning;
- In some places (like Siberia), extreme cold requires that fuelpowered machinery used even parttime must be run continuously. Internal plumbing can be wrapped, and persons can often run water continuously through pipes;
- Energy conservation, difficult as it is in a cold wave, may require such measures as gathering people (especially the poor and elderly) in communal shelters. Even the homeless may be arrested and taken to shelters, only to be released when the hazard abates. Hospitals can prepare for the admission of victims of frostbite and hypothermia; schools and other public buildings can be converted into shelters;
- Exposure to cold mandates greater caloric intake for all animals, including humans. People can stock up on food, water, and other necessities before a cold wave. Some may even choose to migrate to places of milder climates, at least during the winter. Suitable stocks of forage can be secured before cold waves for livestock, and livestock in vulnerable areas might be shipped from affected areas or even slaughtered.
- Vulnerable crops may be sprayed with water that will paradoxically protect the plants by freezing and absorbing the cold from surrounding air. (The freezing of water releases heat that protects the fruit.)

### **Safety Tips<sup>4</sup>**

#### **Do's and Don'ts**

#### **Before and During**

- Keep ready the Emergency Kit along with snow shovels, wood for your fireplace and adequate clothing.
- Listen to local Radio Station for weather updates.

- Stay indoors; minimize travel.
- Keep dry. Change wet clothing frequently to prevent loss of body heat.
- Watch for symptoms of frostbite like numbness, white or pale appearance on fingers, toes, ear lobes, and the tip of the nose.
- Maintain proper ventilation when using kerosene heaters or coal oven to avoid toxic fumes.
- Go to a designated public shelter, if your home loses power or heat during extreme cold.
- Protect yourself, from frostbite and hypothermia by wearing warm, loose fitting, lightweight clothing in layers.

### **References:**

<sup>1</sup>[http://www.saarc-sadkn.org/clod\\_wave.aspx](http://www.saarc-sadkn.org/clod_wave.aspx)

<sup>2</sup>Government of India, Ministry of Home Affairs, Disaster Management in India

<sup>3</sup>National Disaster Management Authority, Govt. of India (2012): Hand Book for Training and Capacity Building of Civil Defence and Sister Organisations.

<sup>4</sup>National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, Do's & Don'ts for Common Disasters.