Information on Natural Disasters Part- I

Introduction

Astrology is the one that gave us the word ódisasterô Many believe that when the stars and planets are in malevolent position in our natal charts bad events or bad things would happen. Everyone one of us loves to avoid such bad things or disasters. The disaster is the impact of both natural and man-made events that influence our life and environment that surrounds us. Now as a general concept in academic circles, the disaster is a consequence of vulnerability and risk. The time often demands for appropriate reaction to face vulnerability and risk. The vulnerability is more in densely populated areas where if, a bad event strikes leads to greater damage, loss of life and is called as disaster. In other sparely populated area the bad event may only be a risk or hazard. Developing countries suffer the greatest costs when a disaster hits ï more than 95 percent of all deaths caused by disasters occur in developing countries, and losses due to natural disasters are 20 times greater as a percentage of GDP in developing countries than in industrialized countries. A disaster can leads to financial, environmental, or human losses. The resulting loss depends on the capacity of the population to support or resist the disaster. The term natural has consequently been disputed because the events simply are not hazards or disasters without human involvement.

Types of disasters

Any disaster can be classified either as ôNaturalô or óman-madeô The most common natural disasters that are known to the man kind are hailstorms, thunderstorm, very heavy snowfall, very heavy rainfalls, squalls, gale force winds, cyclones, heat and cold waves, earthquakes, volcanic eruptions, floods, and droughts which cause loss to property and life. The human induced or man-made disasters are war, accidents. Some of the disasters can be associated with human activities such as industrialization, deforestation, urbanization which invariably produce air pollution, water pollution those in turn cause global warming, climate change, depletion of glaciers, depletion of ozone layer, increase in ultraviolet radiation, avalanches, flash floods and water-logging in low lying areas.

Status of disaster management in India

The Ministry of Agriculture, Government of India has set up a High Powered Committee functioning under the Prime Minister of India to review disaster management machinery in the country and to formulate a comprehensive model plan for disaster management at the National, State and District levels. This committee was constituted under the chairmanship of Shri J.C.Pant, former secretary to Government of India with 11 members including Director General of Meteorology, India Meteorological Department as one of the members. The HPC has framed five sub-groups for Disaster management Plan wherein the responsibility of India Meteorological Department lies in identification of weather and climate related hazards and disasters. The basic components of the comprehensive programme would be Prevention, Mitigation and Preparedness the awake of any likely disaster.

Natural disasters of importance and relevance

The decade 1990-1999 was declared as the International Decade For Natural Disaster Reduction (IDNDR). Government of India declared the current decade as the "National Decade for Disaster Reduction" (NDDR). Nearly 80% of disasters effect humans. Between 1988-1997 50,000 lives lost and caused 60 billon dollars economic loss. Latest World disaster report, 2003 suggests increase in weather related disasters. Average 200 disasters per year during 1993-1997 increased to 331 per year during 1998-2002.

Earthquakes

The most important and most disastrous natural event that considerably effects the human population and their property is ñEarthquakeò. The earthquakes strike without any forewarning and cause enormous damage to the human dwellings, roads and bridges, dams and culverts and also take millions of lives and affect millions more. The earthquakes are now known to be caused either by relative motion of rocks within the earthôs crust or due to tectonic plate collisions. When an Earthquake occurs, waves of elastic compression spread out through solid earth similar to the waves that spread across a pond. When these waves arrive at the surface they shake it violently near the source of the Earthquake and mildly at distant points. The ground shaking is responsible for all the damage. During the Earthquakes most of the damage is due to horizontal motion and vertical motion can be felt only at the epicenter. The earthquake magnitude

is generally indicated on scale called õRitcher scaleö Worldwide about 18 earthquakes magnitude (M) 7.0 or larger occurs every year. Actual annual numbers since 1968 range from lows of 6-7 events/year in 1986 and 1990 to highs of 20-23 events/year in 1970, 1971 and 1992. As the earthquakes are not frequent and data on earthquakes is very sparse. The stress build up in the rocks need to be monitored and as such warnings to be issued within a short time. The warnings may often turn in to a hoax due to the complicity of the problem. Creating awareness, delineation of the earthquake disaster prone areas can help in mitigation of the disaster. India has been categorized into different seismic zones depending on the susceptibility to earthquake.

Landslides

Earthõs surface is curved into different landforms such as mountains, hills, valleys etc. Every mountain or hill has its own slope stability. Gravity is the main factor for the landslides even though a trigger is a must before any landslide can occur. The landslide is a geological phenomenon where rock debris, mud falls from the slopes under the influence of the trigger and gravity. The landslides can be categorized as shallow landslides, deep-seated landslides, earth flows, mudflows etc. It seen that the landslides can occur due to natural causes like erosion due to flow of rivers and glaciers, saturated soil to persistent rains, heavy rainfalls, earthquakes and volcanic eruptions. The landslides are also caused by manmade activity such as blasting or heavy machinery traffic or vibration. In India, Arunachal Pradesh, Sikkim, West Bengal and Himachal Pradesh are prone to landslides.

Areas that are generally prone to landslide hazards

a. Existing old landslides.

b. Base of slopes.

c. Base of minor drainage hollows.

d. Base or top of an old fill slope.

e. Base or top of a steep cut slope.

f. Developed hillsides where leach field septic systems are used.

Areas that are typically considered safe from landslides

a. Hard, non-jointed bedrock that has not moved in the past.
b. Relatively flat-lying areas away from sudden changes in slope angle.
c. Top or along the nose of ridges, set back from the tops of slopes.

Forest Fires

Forests worldwide are prone to disasters like forest fires. The forest fires destroy valuable forest wealth, creates imbalance in the bio-diversity and ecosystem by destroying the various species of flora and fauna. The forest fires do often occur during summer months during which the forest floor is covered with lots of dry leaves and twinges which become ignited due to various natural and man made causes. The natural causes of forest fires are intense heat, lightening, higher wind speeds. The study of forest fires indicates that the highest number of forest fires is due to lightening rather than self-combustion. The man made causes are throwing of fire on to dry leaves, putting on fire the nearby agricultural lands before onset of rains for the purpose of farming.

Broad classification of forest fires

a. Natural or controlled forest fire.

b. Forest fires caused by heat generated in the litter and other biomes.

c. Forest fires purposely caused by local inhabitants.

Types of Forest Fire

a. **Surface Fire**-A forest fire may burn primarily as a surface fire, spreading along the ground as the surface litter (senescent leaves and twigs and dry grasses etc) on the forest floor and is engulfed by the spreading flames.

b. **Crown Fire**- The other type of forest fire is a crown fire in which the crown of trees and shrubs burn, often sustained by a surface fire. A crown fire is particularly very dangerous in a coniferous forest because resinous material given off burning logs burn furiously. On hill slopes, if the fire starts downhill, it spreads up fast as heated air

adjacent to a slope tends to flow up the slope spreading flames along with it. If the fire starts uphill, there is less likelihood of it spreading downwards.

Global warming and Climate Change

The predicted effects of global warming on the environmental and for human life are numerous and varied. It is generally difficult to attribute specific natural phenomena to long-term causes, but some effects of recent climate change may already be occurring. Raising sea levels, glacier retreat Arctic shrinkage, and altered patterns of agriculture are cited as direct consequences, but predictions for secondary and regional effects include extreme weather events, an expansion of tropical diseases, changes in the timing of seasonal patterns in ecosystems and drastic economic impact. Concerns have led to political activism advocating proposals to mitigate eliminate or adapt to it.

Droughts and famines

A drought is an extended period of months or years when a region notes a deficiency in its water supply. Generally, this occurs when a region receives consistently below average rainfall. It can have a substantial impact on the ecosystem and agriculture of the affected region. Although droughts can persist for several years, even a short, intense drought can cause significant damage and harm the local economy. In India, states like Rajasthan and Gujarat are chronically drought prone, states like Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Punjab, Haryana, Western parts of Madhya Pradesh, central and Eastern parts of Maharastra, Telegana and Rayalaseema parts of Andhra Pradesh are frequently drought prone. The remaining states are least drought prone.

A famine is a widespread shortage of food that may apply to any faunal species, which phenomenon is usually accompanied by regional malnutrition, starvation, epidemic, and increased mortality. Although most famines coincide with regional shortages of food, famine in some human populations has occurred amid plenty or on account of acts of economic or military policy that have deprived certain populations of sufficient food to ensure survival. Historically, famines have occurred because of drought, flooding such as the flooding this year in America, crop failure, pestilence, and man-made causes such as war or misguided economic policies. Bad harvests, overpopulation and epidemic diseases help to cause famines. During the 20th century, an estimated 70 million people died from famines across the world, of which an estimated 30 million died during the famine of 1958ï 61 in China. The other most notable famines of the century included the 1942ï 1945 disaster in Bengal, famines in China in 1928 and 1942, the disaster in Cambodia in the 1970s, the Ethiopian famine of 1983ï 85 and the North Korean famine of the 1990s. The droughts and famines are synonymous associated with starvation, malnutrition, disease and death.

Classification of droughts

Meteorological Drought

The meteorological drought is defined based on the percentage departure of the rainfall from its long-term average (30 years) as follows

Drought	% Departure
Mild	00 to ï 25
Moderate	-26 to -50
Severe	-51 or less

Hydrological drought

It is known that the persistent meteorological drought leads to this hydrological drought. This type of drought is seen when the surface and sub-surface water depletes considerably for certain period of time. It is this period during which the reservoirs, lakes, ponds, rivers run out of water and fail to supply sufficient water to meet the user demand.

Agricultural drought

The agricultural drought results whenever the daily rainfall values fall below Evapo-transpiration and subsequently the soil moisture depletes affecting the plant growth. However, there is no universally accepted definition for drought. Van Rooy (1965) developed drought anomaly Index (DAI) based on rainfall departure and mean of the ten lowest values in rainfall series. It is given as

$I = -3 (P_A$ ï $P_N)/(m - P_N)$ where ô$P_A$ôis the actual rainfall, ô$P_N$ôis the normal rainfall and ómôis the mean of the ten lowest rainfall values in the series. As per Thronthwaite (1947), the droughts can also be categorized as below.

Permanent drought

This type of drought is generally experienced at places where the crop-growth is possible only with the help of irrigation and irrigation is needed throughout the crop season. The area in this location possesses only sparse vegetation.

Seasonal drought

This type of drought occurs at places where distinct wet and dry seasons are seen. Plants remain dormant in dry season and bear fruit/seed during wet season following growth. The crop-growing season can be adjusted as per the wet season. The following residual soil moisture period can also be utilized for growing.

Contingent drought

The contingent drought arises out of the erratic and irregular behavior of the rainfall during wet season.

Invisible drought

This type of invisible drought occurs when the rains do not supply enough water to soil to counter the Evapo-transpiration. This results in soil moisture deficiency for prolonged periods The study of droughts of 1965 and 1966 Kharif in India made by Chowdhury et.al (1977) by working out the aridity anomaly Index as follows.

Drought	**Aridity Anomaly Index (AAI)**
Mild drought	less than or equal to 25
Moderate drought	26 to 50
Severe drought	greater than 50

Floods

India has got two very distinct monsoons, namely, southwest monsoon and Northeast monsoon. The southwest monsoon covers a period of four months from June to September and the northeast monsoon covers a period of three months from October to December. During southwest monsoon season, India gets its 75% of annual total rainfall and the remaining in rest of the seasons. During Northeast monsoon season only Tamilnadu, Kerala, Parts of Andhra Pradesh gets good amount of rainfalls. The characteristic of southwest monsoon is its systematic onset and withdrawal pattern. India Meteorological Department in the year 1943 prepared a chart showing normal dates of onset of southwest monsoon over India taking long term averages of 5-day accumulated rainfall of about 180 stations. As a result of strong southwest monsoon, all most all the rivers in India carry huge volume of water thereby posing flood threat. The most common factor that leads to large-scale floods in many parts of India is the very heavy rainfall. In the Indian River system persistent heavy downpour in upper catchment area leads to floods. Floods occur because of the inadequate capacity to contain huge volume of water within the banks of the river. Some other reasons exist, such as, silting, erosion of the banks due to flow, blockage in the river course due to natural causes like landslides or Earthquakes or due to man-made causes like blasting or vibration. Once occur these floods cause enormous damage and spread diseases. Ramaswamy (1987) has compiled and documented many cases of severe floods in Indian River systems like Ganga and Brahmaputra. The large-scale synoptic scale systems have been identified that are primarily associated with severe floods. In India, statistics indicate that the area vulnerable to floods is 40 million hectares and the average area affected by floods annually is about 8 million hectares. The average annual total damage to crops houses and public utilities during the period 1953- 1995 was about Rs.9720 million.

Types of floods

a. Snow melt floods
b. Flash floods
c. Storm surge floods

Flood preparedness

Within the overall master plan for the state, there has to be a contingency plan for each district, involving steps required to be taken before the onset of floods during the floods and post- flood management.

a. "Pre Monsoon Inspection" of all railway tracks, canals and drains by respective departments, which could include silt and details clearance from seasonal rivulets.
b. Regular clearance of the drains from silt and weeds to make the drainage system fully functional and restoration of natural drainage blocked by roads, railway tracks and canal,
c. Regular maintenance of embankments of rivers canals, distributors etc. and regular check of the canals and siphons and clearing them from silt.
d. Clearing of storm water and sewerage drains in towns before monsoon.
e. Constitution of committees comprising of heads of all emergency services, medical, police, transportation and district administration to ensure proper co-ordination during the crisis. A contingency plan for evacuation, sheltering and food supply in flood prone areas.

f. Effective management of water cycle.

g. Strengthening of river embankments.

h. Diversion of flood waters through viable mechanism to other needy areas.

List of important disasters

S.N	Type of Hazard	Place	Time	Estimated death toll
1	Bhola cyclone	Bangladesh	13th November 1970	500,000
2	India Cyclone	India	25th November 1839	Ó300,000
3	Earthquake/tsunami	Indian Ocean	26th December 2004	283,100
4	Heat wave	Europe	2003	37,451
5	Drought	India	1876ï 1878	5,250,000
6	Landslide	Venezuela	1999	20,006
7	Limnic Eruption	Cameroon	1986	1,746

8	Tornado	Bangladesh	April 26, 1989	1,300
9	Earthquake	India	2001	20,000
10	Earthquake	Indonesia	May 2006	5,782
11	Earthquake	Sichuan	May 2008	
12	Assam Tornado	IndiaAssam	1963	139
13	Hunter region storms	Australia	2007	~20
14	India heat wave	India	2003	1,900
15	India heat wave	India	1998	2,541
16	Solomon Islands earthquake	Solomon Islands	2007	52
17	Java earthquake	Indonesia	2006	549
18	Mount St. Helens	United States	May 18, 1980	57
19	Kolkatta Tornado	India	1838	213
20	Mount Nyiragongo	D.R.Congo	January 17, 2002	245
21	Mount Pinatubo	Philippines	April 2 1991	700
22	Bangladesh cyclone	Bangladesh	1988	5,708
23	Kendrapara cyclone	India	1999	9,803
24	Andhra Pradesh cyclone	India	1977	14,202
25	Calcutta cyclone	India	1942	40,000
26	Calcutta Cyclone	India	1864	60,000
27	Bombay cyclone	Bombay, India	June 6, 1882	100,000
28	Calcutta cyclone	India	1737	300,000
29	Blizzard during snow storm	China	2008	133
30	Blizzard with snow storm	Afghanistan	2008	1,317
31	Greek forest fires	Greece	2007	74
32	China floods	China	1931	2,500,000ï 3,700,000
33	Cyclone 02B	India	1990	957
34	Maharasthra-Gujarat cyclone	India	1998	2,871
35	Cyclone Sidr	Bangladesh	2007	3,477

Information on natural disasters Part-II

Introduction

Disasters are hard to predict. Every year worldwide enormous economic and human losses are taking place owing to the disasters. Disaster is generally defined as any event that significantly influences or effects the human settlements directly or indirectly. In the year 1995, the economic losses due to weather related disasters reached all most all to

a 50 billion dollar mark. For all this, humans are blamed because their activities for settlement and survival exerting huge impact on our ecological and environmental balance. The disasters struck on varied spatial and temporal time scales. Earthquakes when struck cause destruction up to hundreds of kilometers in a few seconds. Similarly, a volcanic eruption that pumps enormous amounts of various gases, smoke & dust in to the atmosphere can lead to changes that may last for a few hundred years. Floods can cause inundation of agricultural lands, cause water logging which may last from a week to months. A risk may turn into a hazard and further catapult into a disaster either naturally or due to human error. The natural disasters are to certain extent predictable and especially the events like heat waves, cold waves, cyclones, typhoons, hurricanes, tornadoes, volcanic eruptions, floods and heavy rainfalls. However, landslide and Earthquake still elusive and understanding human vulnerability to these events and complete awareness about these events may be helpful in the mitigation of these events. When it comes to the prediction of natural disasters, one may has specify the location, time and magnitude of such event well in advance to ensure proper reaction to these events.

Generation of time series

For prediction of disasters lengthy time series is required thereby increasing the need for regular observational data. The regular observations can be collected by ground-based instruments and also by the remote sensing equipment on board of both geo-stationary and polar synchronous satellites. These instruments provide us precise measurements and sampled data. However, in many cases the data is spare due to the financial implications in maintaining a good network of observational stations on ground and deployment of satellites in to the space for the purpose. The sparse data pose a problem or threat to prediction/forecasting. With the advent of technological development, a comprehensive monitoring system evolved which comprises automatic weather stations, High resolution GPS radiosondes, Aerosondes, Disdrometers, Advanced very high resolution radio meters, High speed wind profilers, Advanced lightening detection systems, Spectrophotometers, telemetric seismographs, Sonars, Lidars and Radars. These instruments regularly generate data for analysis and prediction. However, in certain scientific studies, model generated data by way of re-analysis are used to overcome the data shortage. The data generated from various

model can be validated suitably for various applications including prediction and forecasting.

Types of Prediction

Empirical Prediction

In empirical prediction, the previous pattern of the event is considered to predict the future occurrence of similar event. This type of prediction needs a long time series. Calibration need to done based on conditions. Prediction can be given as probability.

Model based prediction

Computer models based on simulation with both linear and non-linear effects considered. This type of prediction requires good understanding of the dynamical processes involved with the event. Requires appropriate application of mathematical theory. Complexity increases with the non-linearity and chaos associated with the event. Super computing capabilities required. Complete parameterization of various processes essential for model based predictions.

Prediction/forecasting of some disasters

Earthquakes

Epicenters occur chiefly in a few narrow zones or belts. As indicated by the study of Earthquakes the most important belts are

a. The circum-pacific belt
b. The alpine belt
c. The Pamir-Baikal zone in central Asia
d. The Atlantic ï Arctic belt
e. The central Indian Ocean belt
f. The Eastern Asia area between Alpine and Pamir-Baikal zone.
g. The Northern Pacific Ocean basin near Hawaiian Island

The most stable zones on the Earth's surface are Central Shields of all the continents. The occurrence of any Earthquake is not an isolated event. It is likely to be preceded by a few foreshocks small in magnitude and followed by many aftershocks with decreasing frequency and magnitude. Due to continuous micro-seismic activity, it becomes extremely difficult to judge the foreshocks and aftershocks. Statistics indicate that the frequency of occurrence of the earthquakes decreases with increasing depth and the frequency of earthquake increases with the decreasing magnitude. Moreover, the extreme events can be studied using Gumbel's theory. The expectancy of the extreme events in terms of time interval can be computed using empirical relations.

Many methods are in use for prediction of the earthquakes like animal behavior, star and planetary positions, unusual clouds, radon and hydrogen gas content in soil and water, water levels in ponds, lakes and wells and frequency of earlier earthquakes. More recently, the VAN method named after the researchers' initials is a way of earthquake prediction proposed by Professors Varotsos, Alexopoulos and Nomicos in the 1980s. The method is based on the detection of "seismic electric signals" (SES) via a telemetric network of conductive metal rods inserted in the ground. It is continually refined as to the manner of identifying SES from within the abundant electric noise the VAN sensors are picking up. Researchers have claimed to be able to predict earthquakes of magnitude larger than 5, within 100 km of radius, in a 2-hour to 11-day time frame. The specific prediction of location, date and time of any earthquake of given magnitude is a distant hope still now. The study of pattern of previous earthquakes remains as a hope. The direct approaches such as monitoring the fault zones, plate boundary for stress accumulation can be used for earthquake prediction. Following methods are also used for prediction of Earthquakes.

Time series methods

1. Moving average
2. Extrapolation
3. Linear prediction
4. Trend estimation
5. Growth curve

Econometric methods

1. Linear and non-linear regression
2. Autoregressive moving average

3. Autoregressive integrated moving average.

Earthquake risk evaluation and protection

1. Property losses mainly due to the poor and weak construction.
2. Fire risks are often associated with the Earthquakes.
3. Risk of water supply stoppage due to breakage of pipelines.
4. Risk of development of fissures and landslides
5. Risk of damage to communications

For the purpose of safety

1. Enactment of legislation or regulation for construction of earthquake resistance buildings
2. Shutting of gasoline, oil pipelines either automatic or manual
3. Combined disaster management plan from police, fire, communication and relief organization in earthquake prone areas.

Forest fires

The fire weather forecasts are issued in places where economic activity mainly centered around or based on forests. Earlier scientific studies indicated that the absence of rainfall, prolonged summers, less humidity in the atmosphere, high velocity winds trigger and aggravate the forest fires. Several methods were developed for the purpose of forest fire forecasts. The most common methods are

i) Burning Index

This burning Index is a graphical aid based on the relative humidity, rainfall and wind velocity.

Type of Warning	Relative Humidity in percentage	Rainfall in millimeters	Wind velocity in KMPH
Good Fire Days	< 40	< 0.25	> 20
Poor Fire Days	>60	>1.0	-
Indifferent Days	-	-	-

ii) Based on Litter moisture

The fire forecasts are also issued depending the humidity and litter moisture and the classification is as follows

Type of Warning	Relative Humidity in percentage	Litter moisture in percentage
No Fire Danger	>70	>26
Possible Fire Danger	<69	19-25
Slight Fire Danger	50-59	14-18
Moderate Fire Hazard	40-49	11-13
Fire Danger	30-39	8-10
Extreme Fire Danger	29	2-7

iii) Combustibility Index

This is another method widely used for the forest fire forecasts and the index is given by

$G = S^{m}_{n=1}$ T.d where T is the temperature in degree centigrade and d is the saturation vapor deficit. The Index gives the following warnings.

Type of Warning	Index value
No Danger	300
Slight Fire	301 to 500
Moderate Fire	501-1000
Fire Danger	1001-4000
Extreme Fire Danger	>4000

Droughts

Drought prediction is quiet challenging and is known that it is difficult for most locations. For prediction of drought rainfall and temperature prove quiet useful. Generally empirical methods are employed to predict droughts. With the improvement in seasonal and annual rainfall forecasting system and forecasting of other meteorological parameters would help in computing the indices that would be useful in prediction of droughts. Generally, the variability in the annual as well as seasonal rainfall makes the problem complex and some tele-connections with oceanic phenomenon and Indian summer monsoon rainfall quiet helpful in drought prediction. For example, during the period 1900-2000, 22 years were identified as El-nino years. Drought years were also identified as years in which the seasonal rainfall is deficient. The number of years of deficient

rainfall was 16. The Drought years that coincided with El-nino years were 9. The remaining (7) drought years were not coincided with Elnino. Advance warnings regarding the Elnino and other oceanic-atmospheric phenomenon that has some bearing on Indian Summer Monsoon Rainfall (ISMR) would help in forecasting seasonal rains and in turn drought. The Madden-Julian Oscillation is one of the phenomena that need to be monitored for the purpose. A variety of indicators can be used for drought monitoring and issuing of early warnings. Most of the indicators are based on meteorological parameters. However, for a fully effective advance warning mechanism the hydrological parameters need to be coupled with meteorological parameters.

The droughts can be expressed quantitatively using many indices. These indices enable us to evaluate drought hazard over a location for periodic assessment of latest drought.

i) Ardity Index (Thronthwaite and Mather, 1957)

Aridity index is nothing but the ratio of annual water deficit to annual water need expressed by evapotranspiration.

I_a = (SWD/SPE) X 100 where

WD = water deficit

PE = Potential Evapo-transpiration

ii) Water Balance technique

India Meteorological Department use water balance technique and calculates weekly aridity anomaly index for a large number stations and depicts the same on India map with different colors.

I_a = (PE ï AE)/PE where

PE = Potential Evapotranspiration

AE = Actual Evaporation obtained from water balance technique

iii) Satellite derived Vegetation Index

The vegetation index is compiled from the daily NOAA satellite data

The Normalized Difference Vegetative Index is given by

VI = (CH2 ï CH1)/(CH2+CH1) WHERE

VI = Vegetative Index

CH1 = reflected radiation in visible channel

CH2 = reflected radiation in near Infrared Channel

iv) Potential Evapotranspiration method

This Index is calculated using rainfall and potential evapotranspiration with monthly and annual values throughout the world.

ARI = (R/PE) X 100 where

ARI = Agricultural Rainfall Index

R = Rainfall; PE = Potential Evapotranspiration

v) Foley's drought Index

A method used to determine temporal pattern of dryness and wetness of given region. The deficiencies or excesses of monthly rainfall over area compared with respective long-term average are integrated to produce a graph of cumulative anomalies called a residual mass curve. Foley divides each monthly anomaly by the average rainfall, further divides by 1000 to give units. Dividing by annual average makes the index dimensionless. When rainfall condition is below average in succession the total deficiency increases and the mass curve tend to fall. The steepness of the mass curve indicates the severity of the drought.

vi) Palmer drought Index

This drought Index gives a single numerical value that takes into consideration rainfall, potential evapo-transpiration, soil moisture and run-off. The basic concept of this method is that certain amount of rainfall required for normal operation during certain period of time. The rainfall depends on the climate of the area and on present and past weather conditions. The method is complex but gives rational approach to the problem. Firstly, the anomaly index is ó Zô is calculated by multiplication of moisture anomaly index and a weighting factor given as Z= K.d where

K = weighting factor and d= moisture anomaly index expressed as P - $P_{c.}$

Where $P_{c.}$ = aPE + bPR+cPRO - dPL

The coefficients in the above equation can be obtained by month-to-month water balance technique.

á aô is ratio of evapotranspiration and the potential evapotranspiration.

á bô is the ratio of recharge and the potential recharge.

ócô is the ratio of runoff and potential runoff.

ódô is the ratio of loss and potential loss. The Climatologically appropriate for existing conditions (CAFEC) precipitation (P_c) is nothing but more or less equal to the normal precipitation adjusted to present and past weather conditions.

Finally, the Palmer Index for the ói^{th}ô month ôXô expressed as

ôX_iô = 0.897 X_{i-1} + Z_i/3.0.

Floods

Floods can disrupt life and economic activity in some cases with devastating effect. In recent years, economic losses due to flooding increased significantly. Yet, the floods can be beneficial if and only if thorough flood management is practiced. Population growth, increased economic activity by humans, increased vulnerability to floods. The changes in land use pattern for sustainability, changes in the intensity and duration of rainfall and other forms of precipitation as a result of global warming and climate change increased the frequency of flash floods and seasonal floods.

Consequent on the recommendations of High Level Ministers Committee on Floods and Flood relief in 1972, Flood Meteorological Offices (FMO) were set up at 10 locations in India. During Flood season, FMOs provide meteorological support to the Central Flood Forecasting Division (CFFD) of Central Water Commission (CWC) by issuing Hydro-meteorological Bulletins. FMOs also keep round the clock-watch during Flood Alert Situations.

Flood forecasting mainly depends on the identification of peak flood discharges. The lead-time available depends on rainfall-runoff relationship and stream flow pattern at a particular location. Recent developments in Geographical Information Systems (GIS) and Computer Modeling (CM) help scientists to predict floods well in advance for a given river basin. Storm analysis, heavy rainfall analysis, rainfall-depth-duration would offer flash flood prediction capabilities because of the temporal and spatial variability of the most important parameters, namely, average rainfall intensity, time and its duration coupled with soil infiltration characteristics play a vital role in analysis. Various simulation methods for erosion and snowmelt could be useful. Timely warnings of flash floods would save lots of lives and also the property and enhance disaster preparedness. The most important hydrological information comes from stage and discharge of the river at any given point even though the discharge is difficult to measure continuously the

problem can be solved using pre-established relationship the two using rating curves. Once this hydrological data is available it is very useful for other engineering works like construction and operation of bridges, dams, levees, waste-water treatment plants in addition to the flood forecasting.